PCT REQUERIMENTO

(Original em Formato Electrónico)

0	**Reservado para o Organismo receptor**	
0-1	Pedido internacional No.	**PCT/BR2022/050461**
0-2	Data do depósito internacional	**24 Novembro 2022 (24.11.2022)**
0-3	Nome do Organismo receptor e "Pedido internacional PCT"	**RO/BR**

0-4	**Formulário PCT/RO/101 Requerimento PCT**	
0-4-1	Preparado Utilizando	**ePCT-Filing** **Version 4.10.010 MT/FOP 20221109/1.1**
0-5	**Petição** O abaixo assinado solicita que o presente pedido internacional seja processado de acordo com o Tratado de Cooperação em matéria de Patentes	
0-6	**Organismo receptor (especificado pelo requerente)**	**Instituto Nacional da Propriedade Industrial (Brasil) (RO/BR)**
0-7	**Referência do processo do requerente ou do mandatário**	**3610-0016**
I	**Título da invenção**	**SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT**
II	**Requerente**	
II-1	Esta pessoa é:	**Apenas requerente**
II-2	Requerente para	**Todos os Estados designados**
II-4	Nome	**FIENILE AGRONEGÓCIOS LTDA**
II-5	Endereço	**Praça Dom Eduardo, n. 255 - sala 01, Centro** **38700-124 Patos de Minas-MG** **Brasil**
II-6	Nacionalidade (nome do Estado)	**BR**
II-7	Domicílio (nome do Estado)	**BR**
II-8	No. de telefone	**+55 11 2149-4500**
II-10	Endereço de correio electrónico	**internacionalglpi@glpi.com.br**
II-10(a)	Autorização relativa ao correio electrónico O Organismo receptor, a Autoridade responsável pela pesquisa internacional, a Secretaria Internacional e a Autoridade responsável pelo exame preliminar internacional têm autorização para utilizar este endereço de correio electrónico para enviar, se tal desejarem esses organismos, notificações relativas a este pedido internacional:	**exclusivamente sob a forma electrónica (nenhuma notificação será enviada em papel)**

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(Original em Formato Electrónico)

III-1	**Requerente e/ou inventor**	
III-1-1	Esta pessoa é:	**Apenas inventor**
III-1-3	Inventor para	**Todos os Estados designados**
III-1-4	Nome (APELIDO, nome próprio)	**GROSSI, Gustavo Alexandre**
III-1-5	Endereço	**Fazenda São Matheus - Bairro Zona Rural 38500-000 Monte Carmelo-MG Brasil**
III-1-10	Endereço de correio electrónico	**internacionalglpi@glpi.com.br**
IV-1	**Mandatário ou representante comun; ou endereço para a correspondência** A pessoa abaixo-identificada é/foi, por este meio, designada para actuar em nome do(s) requerente(s) perante as Autoridades Internacionais competentes, na qualidade de:	**Mandatário**
IV-1-1	Nome (APELIDO, nome próprio)	**NAKATA, Carolina**
IV-1-2	Endereço	**AV. BRIGADEIRO FARIA LIMA, 1485 - 11o ANDAR - TORRE NORTE 01452-002 São Paulo-SP Brasil**
IV-1-3	No. de telefone	**55 11 2149-4500**
IV-1-4	No. de fax	**55 11 3819-0455**
IV-1-5	Endereço de correio electrónico	**internacionalglpi@glpi.com.br**
IV-1-5(a)	Autorização relativa ao correio electrónico O Organismo receptor, a Autoridade responsável pela pesquisa internacional, a Secretaria Internacional e a Autoridade responsável pelo exame preliminar internacional têm autorização para utilizar este endereço de correio electrónico para enviar, se tal desejarem esses organismos, notificações relativas a este pedido internacional:	**exclusivamente sob a forma electrónica (nenhuma notificação será enviada em papel)**
IV-1-6	No. do registo do requerente junto do Organismo	**API 1798/SP**
IV-2	**Mandatário(s) adicional**	**agente(s) adicional/ais com o mesmo endereço do primeiro mandatário**
IV-2-1	Nome(s)	**MURAKAMI, Juliano Ryota(API 2187/SP); DE SOUZA, Thiago Arpagaus(OAB/SP 273.398)**
V	**DESIGNAÇÕES**	
V-1	**O depósito deste requerimento constitui, de acordo com a Regra 4.9.a), a designação de todos os Estados Contratantes vinculados pelo PCT na data do depósito internacional, para os fins da concessão de qualquer tipo de protecção disponível e, se for caso disso, para os fins da concessão tanto de patentes regionais como de patentes nacionais.**	
VI-1	**Reivindicação de prioridade de um pedido nacional anterior**	
VI-1-1	Data do depósito	**14 Abril 2022 (14.04.2022)**
VI-1-2	Número	**1020220072728**
VI-1-3	País ou membro da OMC	**BR**

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VI-2	**Incorporação por referência:** quando um elemento do pedido internacional mencionado no Artigo 11.1)iii)d) ou e) ou uma parte da descrição, das reivindicações ou dos desenhos mencionados na Regra 20.5.a) ou um elemento ou parte da descrição, das reivindicações ou dos desenhos mencionados na Regra 20.5bis.a), não estiver de outro modo incluído no pedido internacional mas estiver totalmente incluído no pedido anterior cuja prioridade é reivindicada na data em que um ou mais elementos mencionados no Artigo 11.1)iii) tenham sido recebidos pela primeira vez pelo Organismo receptor, esse elemento ou parte é, sob reserva de confirmação de acordo com a Regra 20.6, incorporada por referência neste pedido internacional para os fins da Regra 20.6.		
VII-1	**Autoridade Responsável pela Pesquisa Internacional Escolhida**	**Instituto de Patentes e Marcas dos Estados Unidos (USPTO) (ISA/US)**	
VIII	**Declarações**	Número de declarações	
VIII-1	Declaração relativa à identidade do inventor	-	
VIII-2	Declaração relativa ao direito do requerente, na data do depósito internacional, de pedir e obter uma patente	-	
VIII-3	Declaração relativa ao direito do requerente, na data do depósito internacional, de reivindicar a prioridade do pedido anterior	-	
VIII-4	Declaração de autoria da invenção (apenas para os fins da designação dos Estados Unidos da América)	-	
VIII-5	Declaração relativa a divulgações não prejudiciais ou excepções à falta de novidade	-	
IX	**Lista de controle**	Número de folhas	Ficheiro(s) electrónico(s) anexado(s)
IX-1	Requerimento (incluindo as folhas de declaração)	**4**	✓
IX-2	Descrição	**33**	✓
IX-3	Reivindicações	**6**	✓
IX-4	Resumo	**1**	✓
IX-5	Desenhos	**8**	✓
IX-6a	Listagem de sequências fazendo parte da descrição	-	-
IX-7	TOTAL	**52**	

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	Itens anexos	Documento(s) em papel anexado(s)	Ficheiro(s) electrónico(s) anexado(s)
IX-8	Folha de cálculo das taxas	-	✓
IX-11	Cópia da procuração geral	-	✓
IX-13	Documento(s) de prioridade	-	**Item/Itens VI-1**
IX-19	Outro	**Direito a redução de taxa**	✓
IX-19	Outro	**Documentos no formato pré-conversão Declaração (Instrução 706): Isto é uma cópia completa e exacta do pedido internacional antes da sua conversão ao formato de documento electrónico no qual o pedido é depositado.**	✓
IX-20	**Figura dos desenhos que deve acompanhar o resumo**	**4**	
IX-21	**Língua do depósito do pedido internacional**	**Inglês**	
X-1	**Assinatura do requerente, do mandatário ou do representante comun**	**/Carolina NAKATA/**	
X-1-1	Nome (APELIDO, nome próprio)	**NAKATA, Carolina**	
X-1-3	Qualidade (se tal qualidade não for evidente para quem ler o requerimento)	**Mandatário**	

RESERVADO PARA O ORGANISMO RECEPTOR

10-1	**Data efectiva de recepção do alegado pedido internacional**	**24 Novembro 2022 (24.11.2022)**
10-2	**Desenhos:**	
10-2-1	Recebida	
10-2-2	Não recebida	
10-3	**Data efectiva de recepção, corrigida devido à recepção ulterior, mas dentro do prazo, de documentos ou desenhos que completam o alegado pedido internacional**	
10-4	**Data da recepção, dentro do prazo, das correcções exigidas de acordo com o Artigo 11.2) do PCT**	
10-5	**Autoridade responsável pela pesquisa internacional**	**ISA/US**
10-6	**Transmissão da cópia de pesquisa diferida até ao pagamento da taxa de pesquisa**	

RESERVADO PARA A SECRETARIA INTERNACIONAL

11-1	**Data da recepção da via original pela Secretaria Internacional**	

Resumo

"SISTEMA E MÉTODO DE SUPLEMENTAÇÃO LUMINOSA ARTIFICIAL"

O sistema (100) compreende: um dispositivo modular de irrigação (101) posicionado sobre um campo (200) no cultivo de uma cultura (202a) e compreendendo um dispositivo de acionamento para o deslocamento do dispositivo modular (101) sobre o campo (200); um dispositivo de aspersão compreendendo uma pluralidade de aspersores; uma pluralidade de fontes de iluminação artificial (10a, 10b, 10c, 10d, 10e) dispostas ao longo do dispositivo modular (101) a uma distância predeterminada acima da parte aérea da cultura (202a), compreendendo uma pluralidade de diodos emissores de luz *(LED)* do tipo espectro total *(full-spectrum)*; e uma pluralidade de células fotovoltaicas que alimentam a pluralidade de fontes de iluminação (10a, 10b, 10c, 10d, 10e), o sistema (100) compreendendo ainda: um processador em comunicação com o dispositivo de aspersão, o dispositivo de acionamento um dimerizador ou polarizador das fontes de iluminação (10a, 10b, 10c, 10d, 10e), e com a pluralidade de células fotovoltaicas em que o processador é configurado para: a) ajustar (501), no intervalo do espectro eletromagnético, o balanço entre as bandas espectrais emitidas pela pluralidade de diodos; e b) determinar e inicializar: uma rotina de irrigação (502); e uma rotina de suplementação luminosa artificial (503), independentes entre si, sendo que as etapas a) e b) são determinadas pelo processador considerando pelo menos um dentre: o tipo de cultura (202a) sob cultivo; o estágio fenológico da cultura (202a); o fotoperíodo e as condições meteorológicas sob as quais o campo (200) está submetido; e um ou mais objetivos de desenvolvimento da cultura (202a).

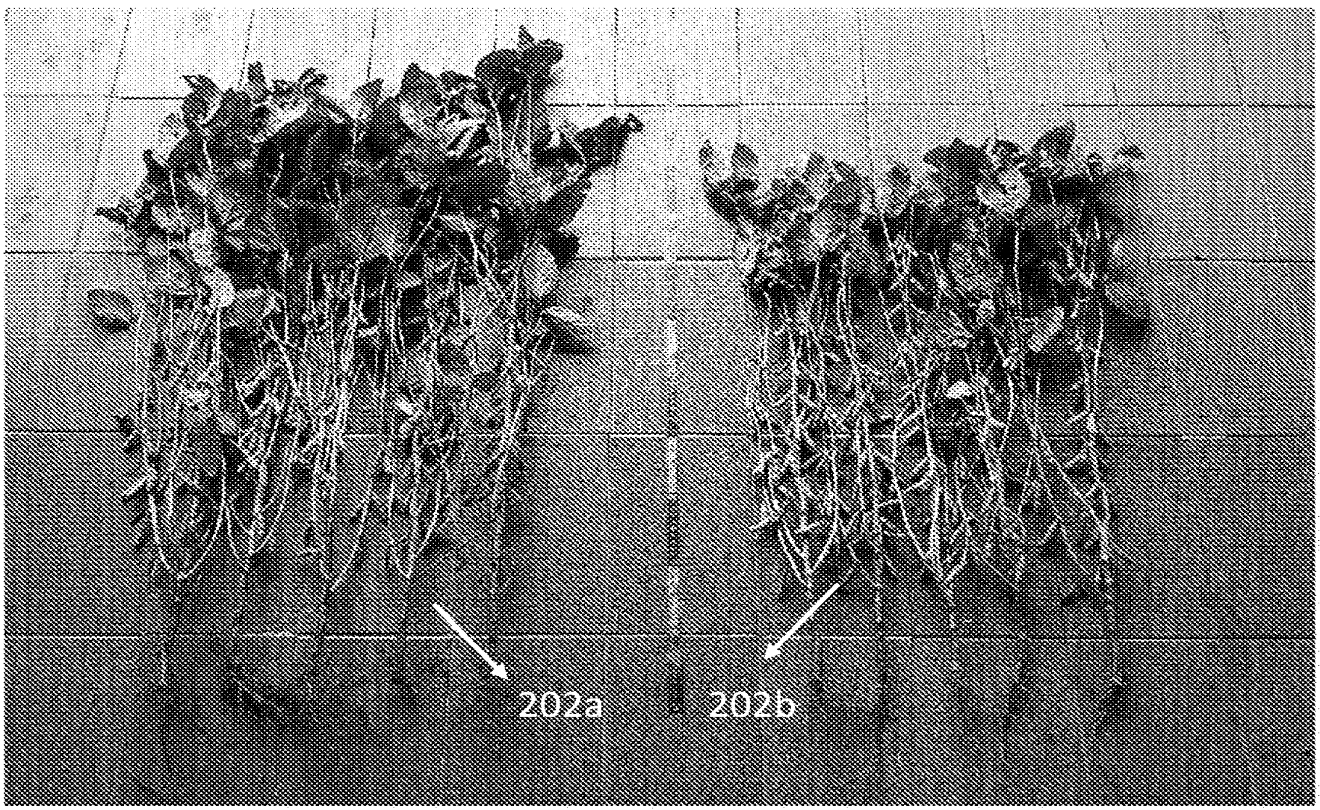

Figura 8

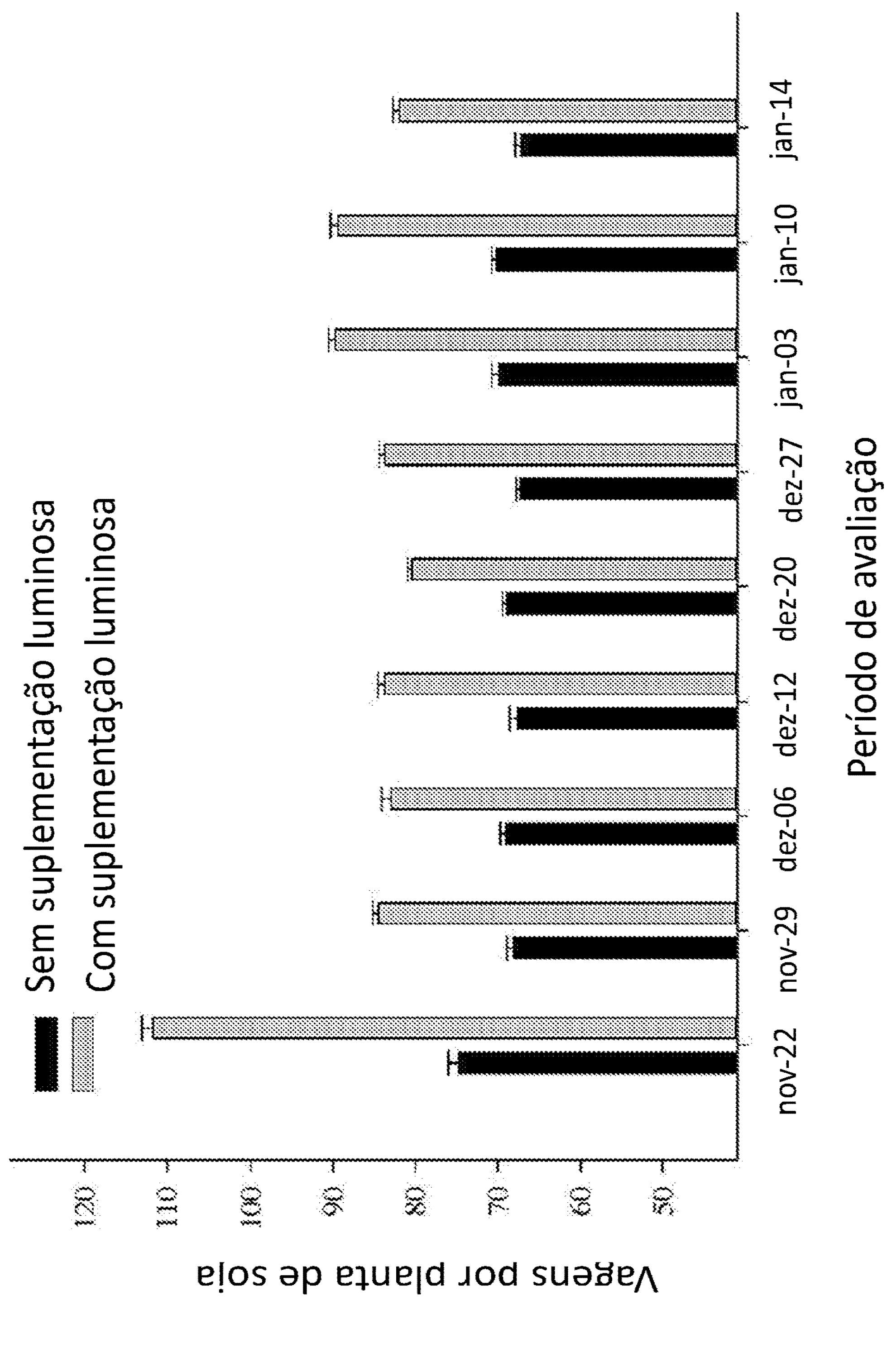
Sem suplementação luminosa
Com suplementação luminosa
Vagens por planta de soja
120
110
100
90
80
70
60
50
nov-22
nov-29
dez-06
dez-12
dez-20
dez-27
jan-03
jan-10
jan-14
Período de avaliação

Figura 7

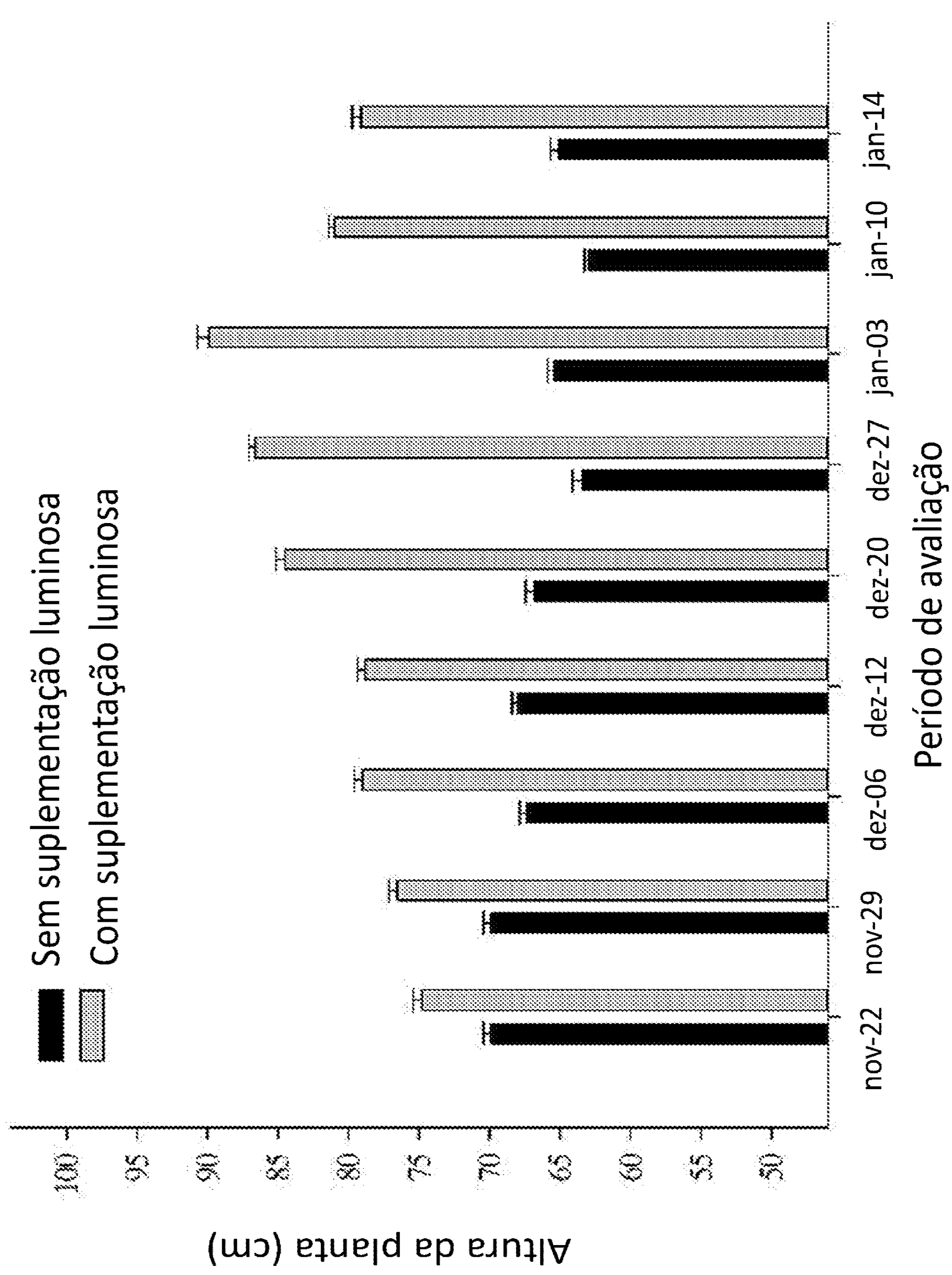
Sem suplementação luminosa
Com suplementação luminosa
Altura da planta (cm)
100
95
90
85
80
75
70
65
60
55
50
nov-22
nov-29
dez-06
dez-12
dez-20
dez-27
jan-03
jan-10
jan-14
Período de avaliação

Figura 6

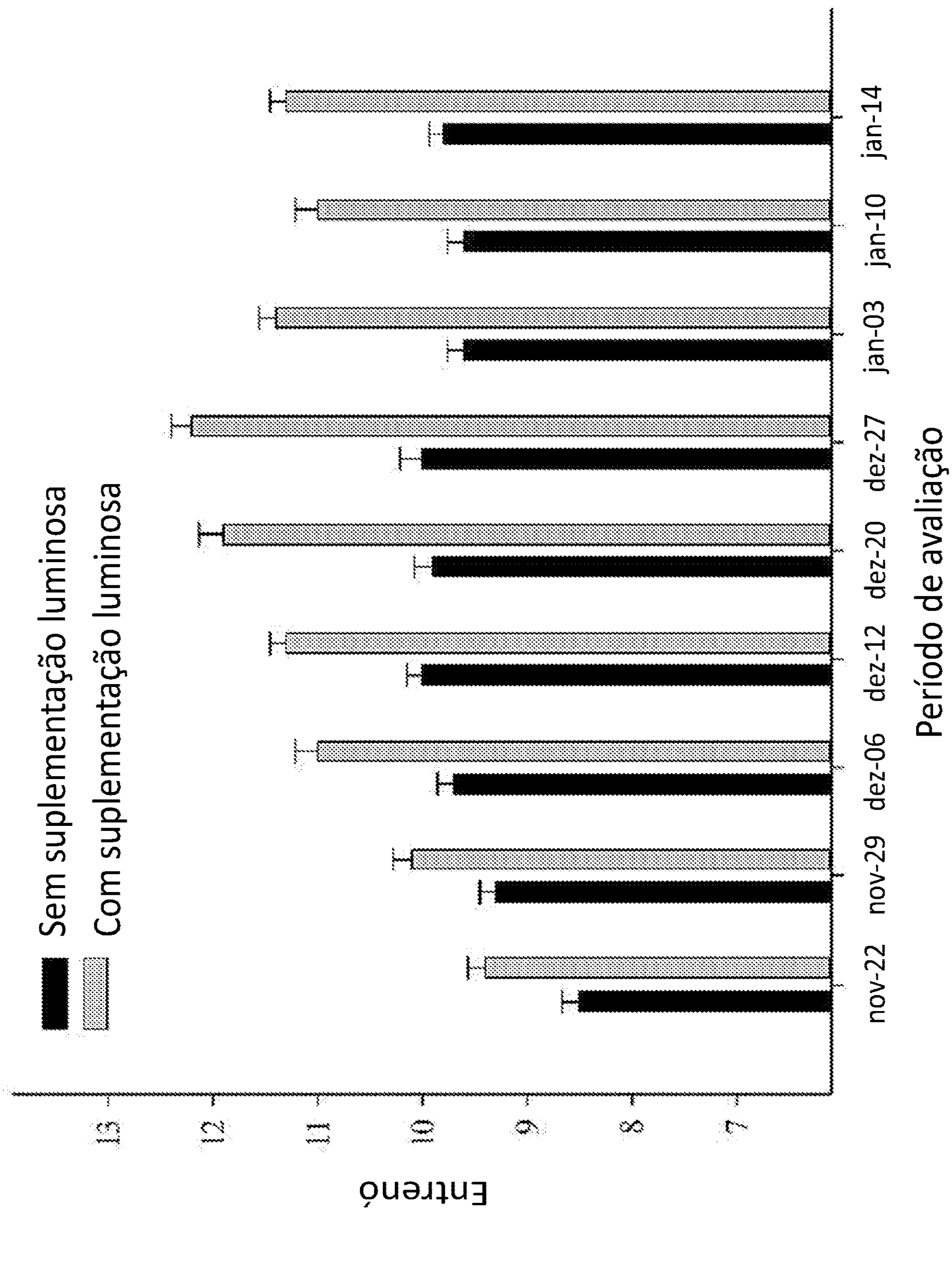
Sem suplementação luminosa
Com suplementação luminosa
Entrenó
13
12
11
10
9
8
7
nov-22
nov-29
dez-06
dez-12
dez-20
dez-27
jan-03
jan-10
jan-14
Período de avaliação

Figura 5

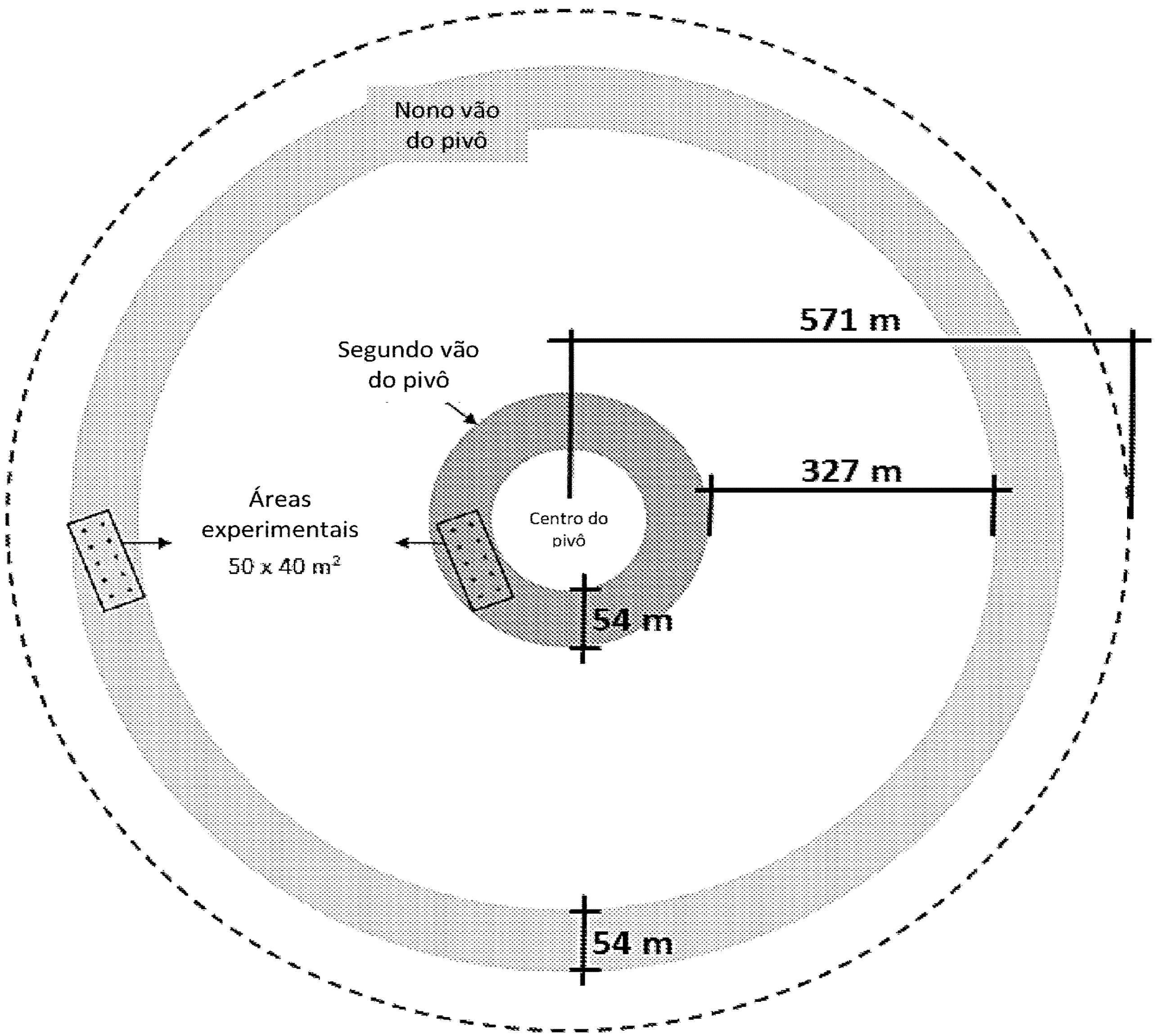
Nono vão
do pivô
571 m
Segundo vão
do pivô
327 m
Áreas
experimentais
50 x 40 m²
Centro do
pivô
54 m
54 m

Figura 4

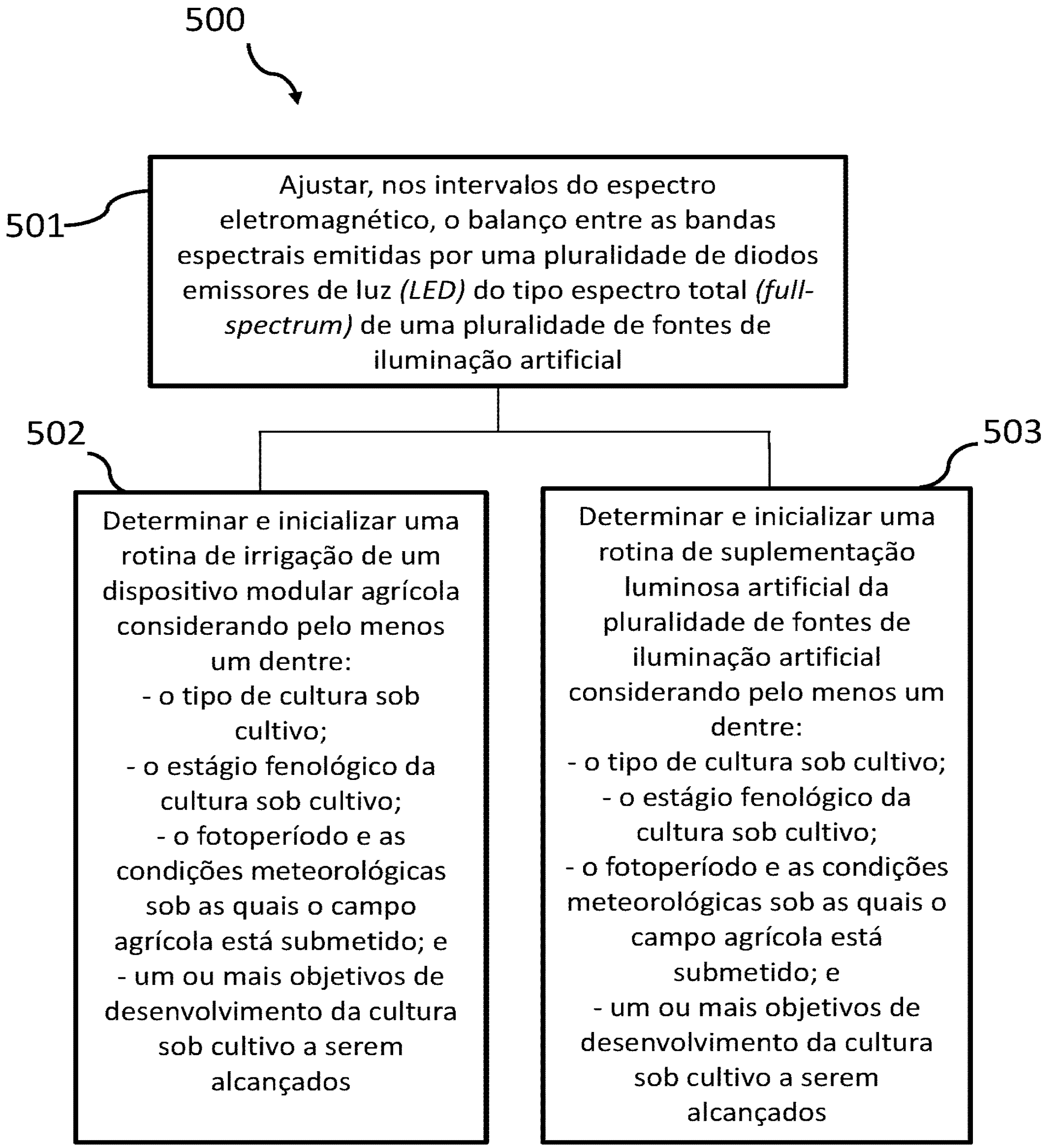
500
501
Ajustar, nos intervalos do espectro eletromagnético, o balanço entre as bandas espectrais emitidas por uma pluralidade de diodos emissores de luz *(LED)* do tipo espectro total *(full-spectrum)* de uma pluralidade de fontes de iluminação artificial
502
Determinar e inicializar uma rotina de irrigação de um dispositivo modular agrícola considerando pelo menos um dentre:
- o tipo de cultura sob cultivo;
- o estágio fenológico da cultura sob cultivo;
- o fotoperíodo e as condições meteorológicas sob as quais o campo agrícola está submetido; e
- um ou mais objetivos de desenvolvimento da cultura sob cultivo a serem alcançados
503
Determinar e inicializar uma rotina de suplementação luminosa artificial da pluralidade de fontes de iluminação artificial considerando pelo menos um dentre:
- o tipo de cultura sob cultivo;
- o estágio fenológico da cultura sob cultivo;
- o fotoperíodo e as condições meteorológicas sob as quais o campo agrícola está submetido; e
- um ou mais objetivos de desenvolvimento da cultura sob cultivo a serem alcançados

Figura 3

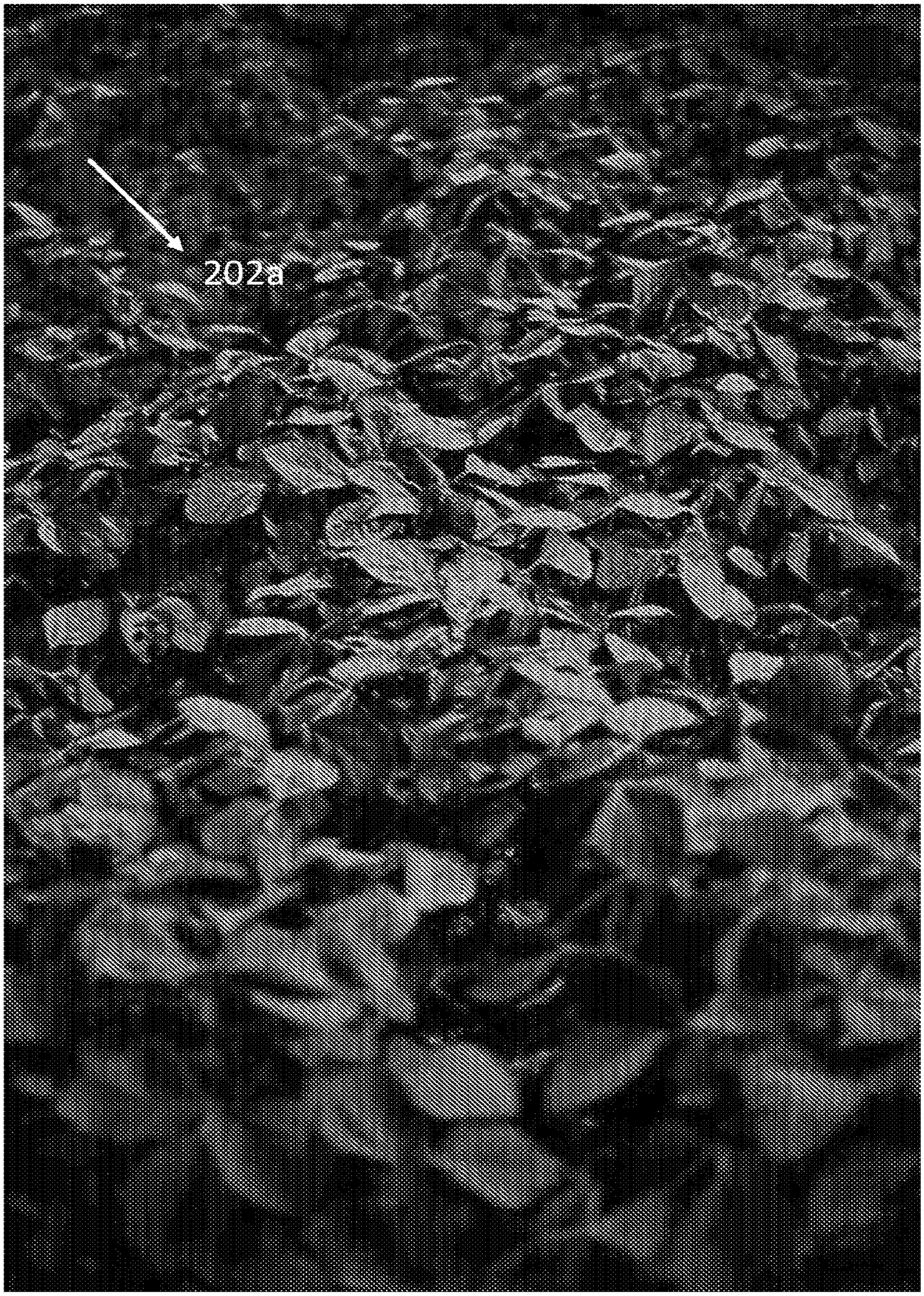

Figura 2

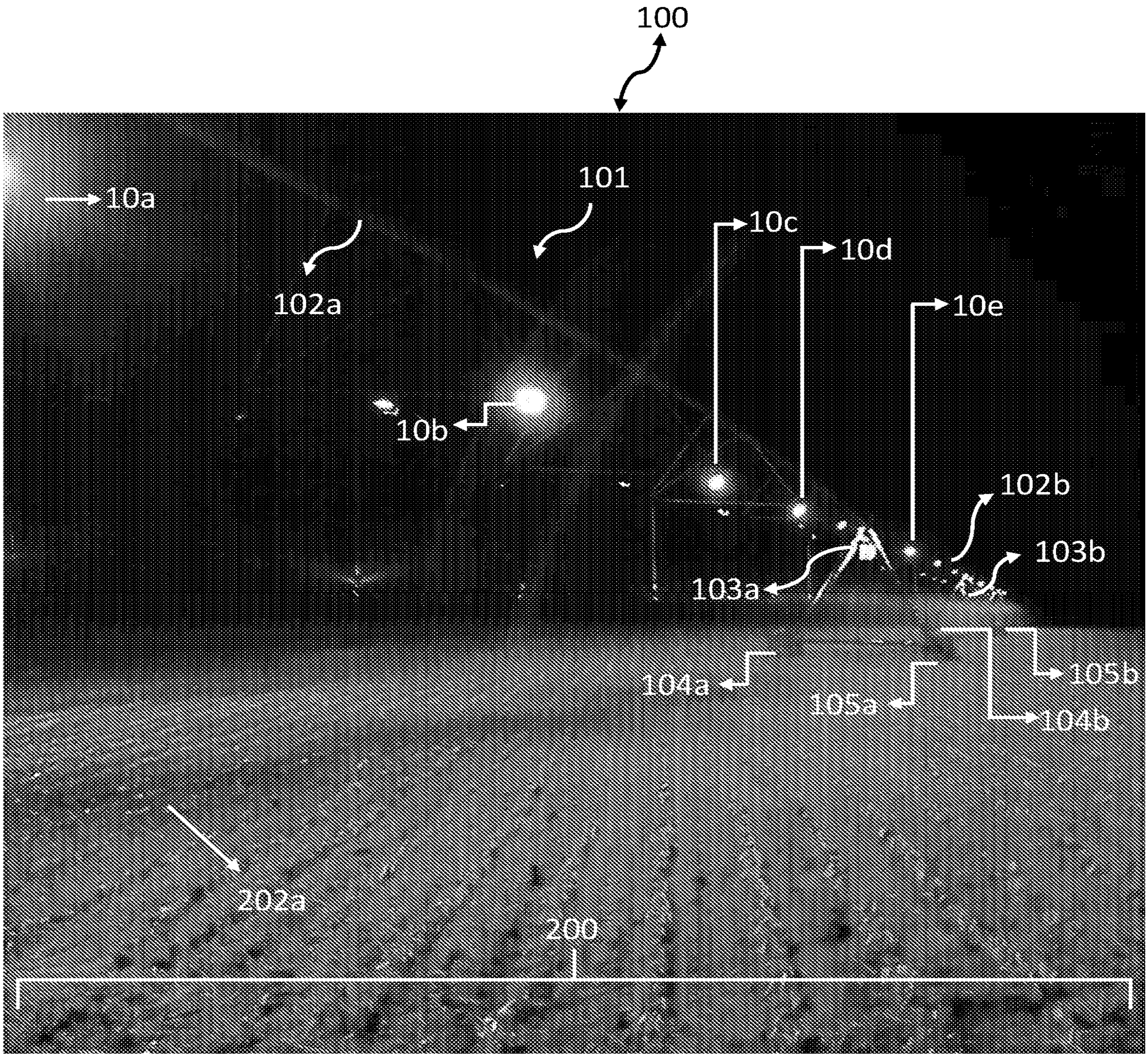
100
10a
101
102a
10c
10d
10e
10b
102b
103b
103a
104a
105a
105b
104b
202a
200

Figura 1

campo agrícola (200) está submetido; e

- um ou mais objetivos de desenvolvimento da cultura (202a) sob cultivo a serem alcançados.

- uma rotina de suplementação luminosa artificial (503),

em que as rotinas de irrigação (502) e de suplementação luminosa artificial (503) são independentes entre si, sendo que as etapas a) e b) são determinadas pelo processador considerando pelo menos um dentre:

- o tipo de cultura (202a) sob cultivo;

- o estágio fenológico da cultura (202a) sob cultivo;

- o fotoperíodo e as condições meteorológicas sob as quais o campo agrícola (200) está submetido; e

- um ou mais objetivos de desenvolvimento da cultura (202a) sob cultivo a serem alcançados.

2. MÉTODO DE SUPLEMENTAÇÃO LUMINOSA ARTIFICIAL (500), para o cultivo de uma cultura (202a) em um campo agrícola (200), caracterizado por compreender as etapas de:

a) ajustar (501), nos intervalos do espectro eletromagnético, o balanço entre as bandas espectrais emitidas por uma pluralidade de diodos emissores de luz *(LED)* do tipo espectro total de uma pluralidade de fontes de iluminação artificial (10a, 10b, 10c, 10d, 10e); e

b) determinar e inicializar:

- uma rotina de irrigação (502) de um dispositivo modular de irrigação agrícola (101); e

- uma rotina de suplementação luminosa artificial (503) da pluralidade de fontes de iluminação artificial (10a, 10b, 10c, 10d, 10e),

em que as rotinas de irrigação (502) e de suplementação luminosa artificial (503) são independentes entre si, sendo que as etapas a) e b) são determinadas considerando pelo menos um dentre:

- o tipo de cultura (202a) sob cultivo;

- o estágio fenológico da cultura (202a) sob cultivo;

- o fotoperíodo e as condições meteorológicas sob as quais o

REIVINDICAÇÕES

1. SISTEMA DE SUPLEMENTAÇÃO LUMINOSA ARTIFICIAL (100) caracterizado por compreender:

- um dispositivo modular de irrigação agrícola (101) posicionado sobre um campo agrícola (200) no cultivo de uma cultura (202a) e compreendendo:

- um dispositivo de acionamento para o deslocamento do dispositivo modular de irrigação agrícola (101) sobre o campo agrícola (200);

- um dispositivo de aspersão compreendendo uma pluralidade de aspersores;

- uma pluralidade de fontes de iluminação artificial (10a, 10b, 10c, 10d, 10e) dispostas ao longo do dispositivo modular de irrigação agrícola (101) em pontos equidistantes e a uma distância predeterminada acima das partes aéreas da cultura (202a), compreendendo uma pluralidade de diodos emissores de luz *(LED)* do tipo espectro total; e

- uma pluralidade de células fotovoltaicas que alimentam a pluralidade de fontes de iluminação artificial (10a, 10b, 10c, 10d, 10e),

o sistema de suplementação luminosa artificial (100) compreendendo ainda:

um processador em comunicação com o dispositivo de aspersão, o dispositivo de acionamento, um dimerizador ou polarizador da pluralidade de fontes de iluminação artificial (10a, 10b, 10c, 10d, 10e) e com a pluralidade de células fotovoltaicas, em que o processador é configurado para:

a) ajustar (501), nos intervalos do espectro eletromagnético, o balanço entre as bandas espectrais emitidas pela pluralidade de diodos emissores de luz *(LED)*; e

b) determinar e inicializar:

- uma rotina de irrigação (502); e

apresentar modificações em sua forma de implementação, de modo que o escopo de proteção da invenção se limita tão somente pelo teor das reivindicações anexas, incluindo aí as possíveis variações equivalentes.

[081] Os custos de produção das culturas 202a gerados pelo sistema de suplementação luminosa artificial 100, de acordo com a presente invenção, dependem de vários fatores. Esses fatores incluem a eficiência da estrutura disponível, por exemplo: maquinário e administração da fazenda; e a tecnologia implementada, por exemplo: materiais genéticos, fertilizantes e o uso de sistemas agrícolas precisos. Outros fatores incluem características do sistema de irrigação, por exemplo: a altura do pivô de irrigação 101 que afeta a dissipação da luz, a suplementação luminosa artificial em áreas de irrigação estática, a estruturação do solo, por exemplo: sem limitação física ou química, e com microbiota saudável, o fornecimento de energia, por exemplo: fiação, constância e estabilidade, além de *internet of things (IOT)* e manejo de culturas 202a. Assim, o custo e a rentabilidade no presente exemplo refletem um cenário específico da produção de soja que pode variar caso a caso. Apesar desta observação, a suplementação luminosa artificial, de acordo com a presente invenção, apresenta uma oportunidade para melhorar a produção das culturas 202a.

[082] Em conclusão, no contexto do exemplo no qual a presente invenção foi implementada, foram necessárias aproximadamente 40 horas de suplementação luminosa artificial por planta de soja durante o ciclo da cultura 202a para positivamente afetar o número de entrenós, vagens, altura da planta e o ciclo da cultura 202a.

[083] A suplementação luminosa artificial, de acordo com a presente invenção, aumentou a produtividade de grãos de soja em 57,3% e sua rentabilidade em 180% em relação aos processos de cultivo sem suplementação luminosa artificial, e provou-se uma técnica viável e promissora para melhorar de forma sustentável a produção de culturas na mesma área agrícola em que são cultivadas atualmente.

[084] Apesar da descrição das realizações particulares acima fazer referência a determinadas realizações, a presente invenção pode

processos fisiológicos, época de semeadura, lâmina de irrigação, doses de fertilizantes, manejo de pragas de insetos e doenças de plantas e seus impactos nas relações do solo com o meio ambiente. Além disso, a inclusão de informações climáticas pode esclarecer a relação entre a produção agrícola e as oscilações climáticas e que, por sua vez, podem ser usadas para aumentar a resiliência do sistema alimentar global e a segurança alimentar contra choques climáticos inesperados.

[079] Atualmente, há um rápido aumento contínuo na digitalização e integração de tecnologias na agricultura que está alinhada com a sustentabilidade dos ecossistemas a serem aprimorados. Essas mudanças provavelmente impulsionarão as culturas modernas para um nível mais alto de produtividade. Neste sentido, Antes de projetar fatores de cultivo, como o material genético a ser semeado, vários fatores devem ser avaliados. Esses fatores incluem o manejo fitossanitário e o nível de tecnologias implementadas em outros fatores primários como a disponibilidade de nutrientes, abastecimento de água e luz (geralmente de uma fonte natural). Embora o uso da suplementação luminosa artificial em escala de campo 200 seja um desafio para controlar, a presente invenção torna possível o controle da suplementação luminosa artificial para produção de culturas 202a em grandes áreas comerciais 200.

[080] A presente invenção também tem um grande potencial para diminuir o desmatamento de novas áreas nativas para fins de produção agrícola. Embora a produtividade da cultura 202a possa ser aumentada com uma implementação adequada de suplementação luminosa artificial ao longo do ciclo da cultura 202a, o estado da técnica não revela as interações entre os diferentes fatores, por exemplo, solo, planta, clima, manejo, desempenho da cultura 202a, construção do rendimento e a relação custo-benefício.

[075] Neste exemplo, o rendimento extra de 57,3% gerado pela suplementação luminosa artificial não pode ser atribuído apenas às horas de suplementação luminosa artificial fornecida a cada cultura de soja 202a (cerca de 40 horas). Tal como mencionado anteriormente, além da extensão do ciclo da soja por meio da suplementação luminosa artificial, outros fatores devem ser levados em conta, tais como a fotomorfogênese, a alteração do fotoperíodo e do ciclo circadiano da cultura 202a, a sobre regulação ou sub regulação de fito-hormônios e fitocromos, bem como a alteração no metabolismo secundário da cultura 202a, os quais são fatores responsivos ao tratamento de suplementação luminosa artificial.

[076] Os insumos agrícolas, como fertilizantes, inoculantes de plantas e produtos fitossanitários, aplicados durante o ciclo da cultura 202a; 202b, destinam-se exclusivamente a maximizar a produção agrícola e os retornos econômicos. Embora tais insumos tenham efeitos adversos na dinâmica do solo, esses efeitos são frequentemente negligenciados. No entanto, a suplementação luminosa artificial para cultivos de campo 200 de acordo com a presente invenção, tem o potencial de reduzir a necessidade desses insumos, principalmente fertilizantes.

[077] A eficiência da fertilização neste exemplo provavelmente resultou do aumento significativo da biomassa dos brotos seguido da suplementação luminosa artificial. O aumento da biomassa dos brotos, por sua vez, causa um aumento proporcional na biomassa das raízes. Este desenvolvimento radicular melhorado aumenta a eficiência da absorção de nutrientes da raiz, aumentando assim a eficiência do fertilizante.

[078] A presente invenção é utilizada como um modelo de resposta para entender e aplicar de modo reprodutível as consequências e interações de aspectos nutricionais, microbiológicos, ambientais e econômicos em torno da produção agrícola ao integrar informações valiosas sobre

altura da planta de soja; Vagens por planta: número de vagens por planta de soja. **: diferenças significativas a 0,01.

[071] A cultivar de soja avaliada tem um ciclo de aproximadamente 17 semanas. No dia 115 após a semeadura, as plantas de soja da área sem suplementação luminosa artificial 202b (2.000 m^2) foram colhidas; no entanto, a colheita das plantas de soja na área com suplementação luminosa artificial 202a foi feita três semanas depois, representando um ciclo de crescimento 17,6% mais longo.

[072] A produtividade estimada da área sem suplementação luminosa artificial foi de cerca de 4.500 kg ha^{-1} (75 sacas ha^{-1}; 1 saca = 60 kg), enquanto o tratamento com suplementação luminosa artificial foi de cerca de 7.080 kg ha^{-1} (118 sacas ha^{-1}). A produtividade de grãos sob suplementação luminosa artificial foi 57,3% superior, e 109,5% acima da média da produtividade brasileira de soja (3.379 kg ha^{-1}).

[073] O custo médio para produzir a soja desde o manejo do solo até a colheita é de cerca de 55 sacas de soja por hectare. O custo médio exigido pela suplementação luminosa artificial foi de cerca de 7 sacas ha^{-1}. Assim, a rentabilidade da soja tradicionalmente produzida (sem suplementação luminosa artificial) e a soja produzida com suplementação luminosa artificial foi de cerca de 20 e 56 sacas ha^{-1}, respectivamente.

[074] A extensão do ciclo da cultura da soja 202a em três semanas devido à suplementação luminosa artificial também aumentou o período de atividade fotossintética da planta 202a. Este ciclo prolongado aumentou o acúmulo de biomassa via fotossíntese diária natural; processo ausente no ciclo regular da cultivar de soja (17 semanas) onde não há suplementação luminosa artificial 202b. Essa conjunção de fatores resultou em plantas de soja mais altas, com mais entrenós, mais vagens e, consequentemente, mais de 57% a mais de produtividade de grãos.

para normalidade da distribuição de resíduos (p > 0,01). L: Estatística de Levene para homogeneidade das variâncias dos dados (p > 0,01). $^{+}$: normalidade dos resíduos (KS) ou homogeneidade das variâncias (L) cumpridas.

[068] Todos os dados de área sob a curva de progresso das variáveis da soja (número de entrenós, altura da planta e vagens por planta) atenderam aos pressupostos da ANOVA (normalidade da distribuição dos resíduos e homogeneidade das variâncias). Além disso, os coeficientes de variação, CV (%), foram muito baixos (< 2%). Assim, foi adequado proceder com a ANOVA, que indicou diferenças significativas (p < 0,01) entre os tratamentos (com suplementação luminosa artificial e sem suplementação luminosa artificial).

[069] A área sob a curva de progresso dos entrenós por planta de soja, a altura da planta e o número de vagens por planta do tratamento com suplementação luminosa foram 15,6, 23,3 e 25,3% superiores ao tratamento sem suplementação luminosa artificial.

[070] O cálculo e a interpretação da correlação de Pearson requerem que os dados sejam normalmente distribuídos e sem valores atípicos; esses requisitos foram atendidos, conforme apresentados na Tabela 1. Todas as correlações observadas na Tabela 3 foram fortes (r > 0,9) e obtiveram significância estatística (p < 0,01).

TABELA 3

	Entrenós	Altura da planta	Vagens por planta
Entrenós	1	0.962**	0.970**
Altura da planta		1	0.990**
Vagens por planta			1

Tabela 3. Correlação de Pearson (r) entre a área sob a curva de progresso das variáveis estudadas. Entrenós: número de entrenós de soja; Altura da planta:

suplementação luminosa artificial não incluíram valores atípicos com base nos boxplots de todas as variáveis e tratamentos. Essa observação indica que as respostas foram agrupadas em torno de uma média com baixo erro padrão. As variáveis da soja e seus respectivos erros padrão durante as nove semanas são apresentados nas Figuras 5, 6 e 7, onde as linhas sobre as barras indicam o erro padrão.

[066] O número de entrenós por planta de soja, a altura da planta e o número de vagens por planta do tratamento com suplementação luminosa artificial 202a foram maiores quando comparados à amostra sem suplementação luminosa artificial 202b. Essas respostas superiores das plantas alvo do tratamento com suplementação luminosa artificial 202a também podem ser observadas na Figura 8, onde à esquerda são representadas plantas de soja alvo do tratamento com suplementação luminosa artificial 202a aos 80 dias após a semeadura, no estágio fenológico R5.3, ao passo que à direita são representadas plantas de soja sem tratamento com suplementação luminosa artificial 202b, no estágio fenológico R6 – R7. Cada trecho azul na fita métrica representa 0,1 m.

[067] A análise de variância da área sob a curva de progresso e os pressupostos (normalidade e homogeneidade) são apresentados na Tabela 2.

TABELA 2

SV	DF	Entrenós	Altura	Vagens por planta
Erro de suplementação luminosa	1 18	375**	1,590**	2,649**
CV (%)		1.67	1.17	0.98
KS	20	0.935+	0.985+	0.964+
L	1+18	1.139+	0.106+	0.262+

Tabela 2. Análise de variância (teste F) e estatística das premissas da área sob a curva de progresso das variáveis de número de entrenós de soja, altura de planta e número de vagens por planta de soja. **: diferenças significativas a 0,01. CV (%): coeficiente de variação. KS: Estatística de Kolmogorov-Smirnov

de progresso das variáveis avaliadas foram computadas para determinar se havia uma relação linear entre elas.

[062] As áreas utilizadas para cada tratamento (2.000 m^2), foram colhidas aos 115 e 136 dias após a semeadura para a amostra não suplementada por iluminação artificial e para a amostra suplementada por iluminação artificial, respectivamente. A produtividade de grãos em cada área foi expressa em kg ha^{-1}.

ANÁLISE ESTATÍSTICA

[063] Valores extremos (atípicos) na área sob a curva de progresso de cada variável foram identificados usando gráficos boxplot dos resíduos. Quando valores atípicos foram identificados, estes foram substituídos usando um valor médio do conjunto de dados que não inclui o valor atípico. Os boxplots foram gerados no software SPSS Statistics®, que também foi utilizado para calcular os coeficientes de correlação de Pearson e as premissas básicas para a análise de variância (normalidade da distribuição de resíduos por Shapiro-Wilk e homogeneidade de variâncias por Levene, ambos em $p > 0,01$).

[064] A análise de variância (ANOVA, teste F) foi realizada após confirmação de seus pressupostos e considerando um design experimental inteiramente randomizado. Quando foram observadas diferenças significativas ($p < 0,05$) na ANOVA, a área sob a curva de progresso do número de entrenós, altura das plantas 202a e vagens por planta 202a foram comparados usando o teste de médias de Tukey ($p < 0,05$) para distinguir os tratamentos com suplementação luminosa artificial e sem suplementação luminosa artificial. As análises de ANOVA e teste de Tukey foram realizadas por meio do programa estatístico SISVAR®. O software Sigma Plot® v.12 foi utilizado para gerar os gráficos.

RESULTADOS

[065] Os dados das avaliações semanais de todas as variáveis (número de entrenós de soja, altura das plantas e número de vagens por planta de soja) para ambos os tratamentos com suplementação luminosa artificial e sem

suplementação luminosa artificial pode ser consequência de uma série de reações metabólicas e morfológicas da cultura 202a, tais como a fotomorfogênese (modificação morfológica da cultura 202a estimulada pela luz, que poderia favorecer a fotossíntese durante o dia), a alteração do fotoperíodo e do ciclo circadiano da cultura 202a (modificação da rotina da cultura 202a em relação ao período de presença natural de luz), a regulação do metabolismo secundário da cultura 202a (regulação das defesas naturais da cultura 202a a estresses) e das atividades de fitocromos (substâncias foto responsivas e moduladoras de respostas na cultura 202a).

[058] Supreendentemente, como será visto adiante, concluiu-se que através dessas reações ou estímulos (e de outras possíveis causas ou uma ação conjunta dessas respostas) causadas pela suplementação luminosa artificial, bem como o correto manejo do solo e dos recursos hídricos, a cultura 202a acaba por produzir mais biomassa através de uma fotossíntese mais eficiente durante o dia.

[059] A medição média de cada variável avaliada foi estimada a partir de uma avaliação representativa das plantas 202a em 10 pontos amostrais em cada área (2.000 m^2) sendo cada ponto amostral avaliado considerado uma replicação.

[060] A influência da suplementação luminosa artificial ou não suplementação luminosa artificial em cada variável foi avaliada usando a área sob a curva de progresso de cada variável. A área sob a curva de progresso foi calculada pela integração trapezoidal:

$$\text{área sob a curva de progresso} = \Sigma(\text{dti} \times ((\text{Yi} + \text{Yi} + \text{d}) / 2)) \quad \text{(I)}$$

[061] Onde dti é o intervalo de tempo entre cada duas observações de Yi e Yi + d. A área sob a curva de progresso das variáveis foi calculada com base em nove avaliações. Correlações entre a área sob a curva

iluminação artificial". A esquematização do pivô de irrigação 101 de acordo com o experimento pode ser visto a partir da figura 4, na qual as culturas 202a sob o vão verde do pivô de irrigação 101 receberam suplementação luminosa artificial, ao passo que os retângulos indicam a posição de ambos os tratamentos, com e sem suplementação luminosa artificial, e os pontos em cada retângulo indicam os pontos de amostragem.

AVALIAÇÕES DA SOJA

[055] As avaliações do entrenó, altura das plantas 202a do nível do solo até o nó mais alto do folíolo e vagens por planta 202a foram feitas semanalmente a partir dos estágios fenológicos da soja R3, no início da vagem, ao R7, no início da maturidade da soja. Durante essas nove semanas, as avaliações foram feitas uma vez por semana; nenhuma avaliação adicional foi possível após R7 porque as plantas no tratamento sem suplementação luminosa artificial atingiram a maturidade fisiológica mais cedo do que as plantas no tratamento de suplementação luminosa artificial.

[056] Neste sentido, é importante salientar que o atraso da maturidade fisiológica induzido pelo tratamento de suplementação luminosa artificial, ou em outras palavras, a extensão do ciclo da cultura 202a, ocorre com períodos variáveis a depender de determinados fatores, tais como a cultura 202a sob cultivo, a região de cultivo e o estágio de início e suspensão da suplementação luminosa artificial e o próprio manejo da cultura pelo produtor.

[057] A cultura de soja 202a, por exemplo, estendeu seu ciclo entre 5 e 20 dias, a depender da cultivar, do manejo da luz e do local de cultivo. Essa extensão, contudo, não foi proeminente em culturas gramíneas testadas, tais como milho, sorgo e trigo, sendo de apenas poucos dias em relação às áreas onde a suplementação luminosa artificial não foi aplicada. Sem querer se ater a nenhuma teoria específica, esta extensão de ciclo como efeito da

completo e em dias muito nublados. Aproximadamente 480 horas de suplementação luminosa artificial foram aplicadas em toda a área durante o ciclo da cultura da soja 202a. Como o pivô de irrigação 101 completa uma volta completa sobre a área de cultivo 200 em 12,8 horas em rotina circular, cada planta 202a recebeu cerca de 40 horas de suplementação luminosa artificial durante seu ciclo.

[053] A suplementação luminosa artificial iniciou-se no estágio fenológico da soja V3 - V4 da terceira a quarta folha trifoliada totalmente expandida e terminou no estágio fenológico R5 - R6 no início do grão cheio. A escolha do estágio fenológico vegetativo V3 – V4 para o início da suplementação luminosa artificial permite com que a cultura 202a feche a entrelinha no campo agrícola 200 e comece a cobrir a área de cultivo. Surpreendentemente descobriu-se que caso a suplementação luminosa artificial seja aplicada antes deste estágio, aumenta-se as chances de proliferação de plantas infestantes, tais como ervas daninhas, que podem competir significativamente com a cultura 202a por recursos como água, nutrientes e luz, prejudicando o desempenho da produção e aumentando os gastos com herbicidas. Por sua vez, a escolha do término da suplementação luminosa artificial no estágio fenológico reprodutivo R5 - R6 deve-se ao fato de que neste estágio, a cultura de soja 202a atinge seu desenvolvimento final. Entretanto, salienta-se que a suplementação luminosa artificial poderia continuar após o estágio R5 - R6, adicionalmente favorecendo a cultura 202a, contudo, os benefícios não seriam superiores aos custos relativos à suplementação luminosa artificial para além desse estágio. Finalmente, os seis vãos externos do pivô de irrigação 101, correspondente a uma área de 69,5 ha, não receberam suplementação luminosa artificial.

[054] Entre a primeira e a segunda torre de deslocamento 103a; 103b, delimitou-se uma área homogênea de 50 por 40 m, correspondente a uma área de 2.000 m^2 para ser avaliada como o tratamento "suplementado por

[049] Na área experimental, insetos, pragas, doenças de plantas e plantas daninhas foram controladas com produtos registrados para soja conforme indicações do fabricante. Todas as áreas foram monitoradas antes e após a primeira aplicação e os produtos reaplicados conforme necessário. Os manejos das culturas 202a e irrigação hídrica também foram semelhantes entre os tratamentos de suplementação luminosa artificial e sem suplementação luminosa artificial.

TRATAMENTOS E INVESTIGAÇÃO EXPERIMENTAL

[050] O pivô de irrigação 101 onde a presente invenção foi implementada possui dez vãos e um raio de cerca de 571 m. Nos quatro vãos internos do pivô de irrigação 101, que corresponde a uma área de 33,5 ha, foi instalada a pluralidade de fontes de iluminação artificial 10a, 10b, 10c, 10d, 10e compreendendo a pluralidade de placas de diodos emissores de luz *(LED)* do tipo espectro total *(full-spectrum)*. As principais bandas espectrais RGB foram cerca de 59% vermelho, 33% verde e 8% azul. Uma faixa de luz contínua de aproximadamente 40 m de largura por 230 m de comprimento foi projetada abaixo da extensão dos quatro vãos internos do pivô de irrigação 101.

[051] Cada placa de diodos emissores de luz, (*LED)* tem uma potência que varia entre 50 e 200 W. Cerca de 600 W h^{-1} ha^{-1} foram consumidos durante o processo de suplementação luminosa artificial. As placas de diodos emissores de luz *(LED)* foram posicionadas cerca de 3 metros acima das partes aéreas das plantas 202a e distribuídas para garantir uma potência de luz igualmente distribuída, independentemente das diferentes velocidades de movimento dos vários vãos do pivô de irrigação 101. O fluxo luminoso por unidade de área ao nível das partes aéreas da soja 202a foi de cerca de 30 lx.

[052] O sistema de suplementação luminosa artificial 100, de acordo com a presente invenção, foi ligado todas as noites após o pôr do sol

TABELA 1

pH H_2O	Ca	Mg	Al	H+Al	CTC	V	P	K	M.O.S
1-2.5	---------cmolc dm^{-3}---------					%	------mg dm^{-3}------		g kg^{-1}
------------0-0.2 m Profundidade do solo ------------									
6.9	6.03	2.87	0	1.26	10.44	88	188	96	2.9
------------0.2-0.4 m Profundidade do solo ------------									
6.8	5.70	2.78	0	1.08	9.77	89	158	82	2.3

B	Co	Cu	Fe	Mn	Mo	Si	Zn
------------mg dm^{-3}------------							
------------0-0.2 m Profundidade do solo ------------							
0.19	1.7	9.0	14.0	1.9	2.9	12.4	12.8
------------0.2-0.4 m Profundidade do solo ------------							
0.14	1.3	7.7	17.0	3.5	2.3	11.4	11.1

Tabela 1. Caracterização química do solo em 0 a 0,2 e 0,2 a 0,4 m de camada de solo, em que CTC = capacidade de troca de cátions em pH = 7; V = saturação de bases; e M.O.S = matéria orgânica do solo.

[047] Apesar de possuir uma grande proporção de argila no solo e uma alta fertilidade, 3.000 kg ha^{-1} de remineralizante de solo (pó de rocha) (FMX® Tratto. Aparecida de Goiânia, Brasil) foi aplicado em toda a área experimental 200, 30 dias antes da semeadura da soja 202a; 400 kg ha^{-1} de organomineral 06-30-05 (% de N, P_2O_5, K_2O) (Valoriza Agro Ltda. Patos de Minas, Brasil) e 150 kg de KCl foi aplicado na época da semeadura, e 2 L ha^{-1} de Mn foi pulverizado nas partes aéreas das plantas 202a, 40 dias após a emergência da cultura 202a.

[048] A cultivar de soja 202a avaliada neste experimento foi a Desafio 8473 RSF (Brasmax® GDM. Cambé, Brasil) de crescimento indeterminado, grupo de maturidade 7.4. Foram semeadas quatorze sementes por metro quadrado (280.000 plantas por hectare); as plantas 202a foram colhidas aproximadamente 4 meses depois. A temperatura média diária do ar durante o período experimental variou de 24 a 34 °C.

[043] De acordo com o exemplo, cerca de 40 horas de suplementação luminosa artificial foram aplicadas nas plantas de soja 202a durante o ciclo da cultura da soja 202a. A área sob os vãos externos do pivô de irrigação 101 não receberam suplementação luminosa artificial. O número de entrenós, a altura das plantas de soja 202a, bem como a quantidade de vagens por planta de soja 202a foram avaliadas semanalmente para calcular a área sob a curva de progresso. A produtividade de grãos na colheita também foi avaliada. Como será aparente mais adiante, a área sob a curva de progresso do número de entrenós, altura das plantas de soja 202a e vagens por planta de soja 202a foram afetadas positivamente pelo sistema e método de suplementação luminosa artificial 100; 500, de acordo com a presente invenção.

[044] O ciclo regular da soja 202a, sem suplementação luminosa artificial, é de cerca de 15 a 17 semanas; no entanto, a colheita da soja ocorreu três semanas depois. Como será entendido adiante, a suplementação luminosa artificial aumentou o rendimento de grãos de soja em 57,3% e a lucratividade em 180% quando comparado à colheita sem suplementação luminosa artificial.

METODOLOGIA: ÁREA EXPERIMENTAL E CULTIVO DE SOJA

[045] O experimento foi implantado em uma fazenda comercial em Monte Carmelo, Minas Gerais, Brasil. Localizada a uma latitude e longitude de 18º 57″ Sul, 47° 25″ Oeste, a 980 m acima do nível do mar, a fazenda utiliza pivô de irrigação 101. O bioma mais comum e representativo da região é o Cerrado. O clima da região é Cw; subtropical úmido com inverno seco.

[046] A análise física do solo, de 0 a 0,4 m de profundidade, indicou 450, 100 e 450 g kg^{-1} de areia, silte e argila, respectivamente. As características químicas do solo até a profundidade de 0,4 m são apresentadas na Tabela 1.

[041] Por sua vez, a figura 3 ilustra o método de suplementação luminosa artificial 500 para o cultivo de uma cultura 202a em um campo agrícola 200, compreender as etapas de: ajustar 501, nos intervalos do espectro eletromagnético, o balanço entre as bandas espectrais emitidas por uma pluralidade de diodos emissores de luz *(LED)* do tipo espectro total *(full-spectrum)* de uma pluralidade de fontes de iluminação artificial 10a, 10b, 10c, 10d, 10e; e determinar e inicializar: uma rotina de irrigação 502 de um dispositivo modular de irrigação agrícola 101; e uma rotina de suplementação luminosa artificial 503 da pluralidade de fontes de iluminação artificial 10a, 10b, 10c, 10d, 10e, em que as rotinas de irrigação 502 e de suplementação luminosa artificial 503 são independentes entre si, sendo que o ajuste 501 e as rotinas de irrigação e suplementação luminosa artificial 502; 503 são determinadas considerando pelo menos um dentre: o tipo de cultura 202a sob cultivo; o estágio fenológico da cultura 202a sob cultivo; o fotoperíodo e as condições meteorológicas sob as quais o campo agrícola 200 está submetido; e um ou mais objetivos de desenvolvimento da cultura 202a sob cultivo a serem alcançados.

EXEMPLO 1

[042] Referência é feita a um exemplo no qual a presente invenção foi implementada a fim de constatar sua eficácia. O referido exemplo avaliou as respostas relativas à produtividade das plantas de soja 202a em uma área comercial aberta 200 (escala de campo) cultivada sob condições de suplementação luminosa artificial, de acordo com a presente invenção. O pivô de irrigação 101 que irriga a área comercial 200, recebeu uma pluralidade de fontes de iluminação artificial 10a, 10b, 10c, 10d, 10e, de acordo com a presente invenção, em um vão interno do pivô 101 para a suplementação luminosa artificial das plantas de soja 202a.

[038] Especificamente culturas consideradas de dias curtos tais como a soja *(Glycine max)*, são largamente influenciadas por fatores abióticos como o fotoperíodo e a temperatura. Seu florescimento e ciclo reprodutivo regular ocorrem sob um fotoperiodismo curto, ou seja, em dias cujo tempo de ausência de luz (noite) é maior do que o tempo de presença de luz (dia). Ao passo que o contrário, isto é, dias mais longos que noites, podem atrasar ou inibir o florescimento e o início do ciclo reprodutivo. Dessa forma, nota-se que a extensão do ciclo da cultura 202a, o número de nós, vagens e sementes por vagem e a distribuição de vagens nas partes aéreas da soja são positivamente afetados por fotoperíodos estendidos por meio de suplementação luminosa artificial, uma vez que se aumenta o período de atividade fotossintética da cultura 202a e o acúmulo de biomassa devido ao ciclo estendido.

[039] É importante mencionar também, que para realização da fotossíntese com saldo positivo geralmente o fluxo luminoso fica entre 200 e 600 $\mu mol\ m^{-2}\ s^{-1}$. Contudo, a suplementação luminosa artificial atua em outros aspectos fisiológicos que afetam direta e indiretamente a fotossíntese na planta, e não necessariamente a suplementação luminosa artificial é aplicada para ser a fonte luminosa para causar a fotossíntese.

[040] Em geral, fontes de iluminação artificial (10a, 10b, 10c, 10d, 10e) com fluxo luminoso inferior a 200 $\mu mol\ m^{-2}\ s^{-1}$ não são capazes de causar quantidades consideráveis de fotossíntese positiva. Contudo, mesmo fluxos luminosos menores podem causar estímulos nas culturas 202a que podem direta ou indiretamente afetar positivamente a fotossíntese a ser realizada no dia seguinte. Portanto, tanto uma luminosidade baixa, capaz apenas de causar reações, mas incapaz de causar quantidades consideráveis de fotossíntese positiva, quanto uma luminosidade maior, terão aplicações distintas e úteis de acordo com a presente invenção.

202a sob cultivo, do atual estágio fenológico da cultura 202a, bem como do local de desenvolvimento e do manejo aplicado à cultura 202a.

[036] Em outras palavras, o fluxo luminoso, bem como o balanço entre as bandas espectrais emitidas pela pluralidade de diodos emissores de luz *(LED)* são variáveis por meio do dimerizador ou polarizador e controláveis pela interação entre as células fotovoltaicas e o processador, bem como de acordo com dada rotina de suplementação luminosa artificial, que por sua vez leva em consideração os fatores mencionados anteriormente. Por exemplo, para as culturas 202a de modo geral, os estágios fenológicos básicos são o vegetativo (V) (onde ocorre o pré florescimento) e o reprodutivo (R) (que se inicia com a primeira flor ou estrutura reprodutiva), em que cada estágio fenológico além dos estágios básicos recebe um balanço de bandas espectrais específicos para cada estágio e para cada cultura 202a. Além disso, em aplicações noturnas, o fluxo luminoso pode ser ajustado para ser menor, por exemplo, do que o fluxo luminoso em aplicações diurnas, intendendo apenas causar estímulos na cultura 202a, que serão comentados adiante. Especialmente em aplicações diurnas, o fluxo luminoso pode ser ajustado para ser maior em períodos nublados, intendendo mitigar os efeitos da redução fotossintética.

[037] Isto é especialmente vantajoso, visto que a nebulosidade pode reduzir a capacidade fotossintética de culturas 202a em mais de 50% em situações críticas muito nebulosas, fazendo com que a cultura 202a produza menos açúcares, o que resulta em menores quantidades de exsudatos radiculares liberados ao solo e aos microrganismos simbiontes, que por sua vez têm a função de obter nutrientes à cultura 202a, tornando-as mais resistentes à patógenos e pragas agrícolas. Desta forma, fica evidente que a compensação pela baixa incidência de luz solar é fator decisivo para o combate à patógenos e pragas agrícolas.

artificial 10a, 10b, 10c, 10d, 10e, bem como um processador em comunicação com o dispositivo de aspersão, o dispositivo de acionamento e um dimerizador ou polarizador da pluralidade de fontes de iluminação artificial (10a, 10b, 10c, 10d, 10e), em que o processador é configurado para ajustar, em intervalos do espectro eletromagnético, o balanço entre as bandas espectrais emitidas pela pluralidade de diodos emissores de luz *(LED)* do tipo espectro total *(full-spectrum)*; e determinar e inicializar uma rotina de irrigação; e uma rotina de suplementação luminosa artificial, em que as rotinas de irrigação e de suplementação luminosa artificial são independentes entre si. Em outras palavras, o processador pode comandar a atuação do dispositivo de acionamento, do dispositivo de aspersão e do dimerizador ou polarizador de forma individual, de acordo com a rotina estabelecida, as quais são determinadas pelo processador considerando pelo menos um dentre: o tipo de cultura 202a sob cultivo; o estágio fenológico da cultura 202a sob cultivo; o fotoperíodo e as condições meteorológicas sob as quais o campo agrícola 200 está submetido; e um ou mais objetivos de desenvolvimento da cultura 202a sob cultivo a serem alcançados.

[034] Em uma realização, o processador pode adicionalmente estar em comunicação com a pluralidade de células fotovoltaicas, a fim de determinar um limiar de incidência de luz solar nas referidas placas fotovoltaicas, para o qual abaixo deste, e a depender de uma determinada rotina de suplementação luminosa artificial, o processador comanda a atuação da pluralidade de diodos emissores de luz *(LED)* do tipo espectro total *(full-spectrum)*, compensando por adversidades meteorológicas sob as quais o campo agrícola 200 está submetido, tais como dias nublados com baixa incidência de luz solar.

[035] Destaca-se ainda, que o limiar de incidência de luz pode adicionalmente ser dependente de demais fatores, tais como o tipo de cultura

[030] O dispositivo modular 101 compreende também um dispositivo de aspersão dotado de uma linha hidráulica de pressão em comunicação hídrica com um reservatório que pode estar disposto, por exemplo, no pivô central, a linha hidráulica se estendendo ao longo do primeiro e do pelo menos um segundo braço de irrigação 102a; 102b, os quais são dotados de uma pluralidade de aspersores a fim de promover a irrigação do campo agrícola 200.

[031] O sistema de suplementação luminosa artificial 100 incorpora uma pluralidade de fontes de iluminação artificial 10a, 10b, 10c, 10d, 10e dispostas, por exemplo, ao longo dos braços de irrigação 102a; 102b do dispositivo modular de irrigação agrícola 101 podendo estar localizadas em pontos equidistantes e a uma distância predeterminada acima das partes aéreas da cultura 202a, a distância em relação ao solo e às demais fontes de iluminação artificial 10a, 10b, 10c, 10d, 10e pode ainda ser ajustada conforme necessário, a depender do tipo de dispositivo modular 101 que receberá as referidas fontes, e do tipo de cultura 202a sob cultivo.

[032] Além disso, a pluralidade de fontes de iluminação artificial 10a, 10b, 10c, 10d, 10e compreendem uma pluralidade de diodos emissores de luz *(LED)* do tipo espectro total *(full-spectrum)* capazes de emitir radiação fotossinteticamente ativa, com comprimentos de ondas que variam de 280nm, no limite do espectro UV-C com o UV-B, até 1200nm, no espectro infravermelho próximo, os quais estão diretamente associados à produção de biomassa, à morfologia vegetal e ao desenvolvimento de culturas 202a de maneira geral. Em uma realização, o intervalo de comprimento de ondas aplicado podem ser os mesmos no período diurno ou noturno, mas com intensidades de fluxo luminoso variáveis.

[033] O sistema 100 compreende ainda, uma pluralidade de células fotovoltaicas que alimentam a pluralidade de fontes de iluminação

existente em um campo agrícola 200, tal como um pivô de irrigação central, seja ele rebocável ou não rebocável ou mesmo um pivô de irrigação linear. No presente relatório descritivo o pivô é descrito de uma maneira geral como "dispositivo modular de irrigação agrícola 101".

[028] Este dispositivo modular de irrigação agrícola 101 é posicionado sobre o campo agrícola 200 sobre o qual ocorre o cultivo de uma cultura 202a, sendo que o dispositivo modular 101 compreende um primeiro módulo, tendo um primeiro braço de irrigação 102a que possui um formato substancialmente oblongo, tendo uma extremidade distal do primeiro braço de irrigação 102a suportada por, e mecanicamente associada a, uma primeira torre de deslocamento 103a dotada de um primeiro dispositivo de acionamento, tal como um motor ou equivalente, e de primeiras rodas 104a; 105a, sendo que uma extremidade proximal do primeiro braço de irrigação 102a é mecanicamente associada de forma rotativa, ao pivô central, de maneira a permitir o movimento circular do primeiro módulo em relação ao pivô central, quando a primeira torre de deslocamento 103a é acionada pelo primeiro dispositivo de acionamento.

[029] O dispositivo modular 101 pode adicionalmente compreender pelo menos um segundo módulo dotado de um segundo braço de irrigação 102b que possui um formato substancialmente oblongo, em que uma extremidade distal do segundo braço de irrigação 102b é suportada por, e mecanicamente associada a, uma segunda torre de deslocamento 103b dotada de um segundo dispositivo de acionamento, tal como um motor ou equivalente, e de segundas rodas 104b; 105b, sendo que uma extremidade proximal do segundo braço de irrigação 102b é mecanicamente associada de forma rotativa, à primeira torre de deslocamento 103a, de maneira a permitir o movimento circular do primeiro módulo e do pelo menos um segundo módulo em relação ao pivô central.

executadas de diferentes formas e variações e conforme a aplicação desejada pelo técnico no assunto.

[024] Em uma realização, a presente invenção revela um sistema de suplementação luminosa artificial 100 para o cultivo de uma cultura 202a em um campo agrícola 200.

[025] Em uma outra realização, a presente invenção revela um método de suplementação luminosa artificial 500 para o cultivo de uma cultura 202a em um campo agrícola 200.

[026] Cumpre notar que as expressões “planta” ou “cultura” devem ser entendidas como quaisquer cultivares, sejam de dias longos, tais como aveia *(Avena sativa)* ou batata *(Solanum tuberosum)* ou dias curtos, como soja *(Glycine max)* ou café *(Coffea sp.)*, que se beneficiem da suplementação luminosa artificial de acordo com a presente invenção. Exemplos não exaustivos de tais cultivares são soja *(Glycine max)*, feijão *(Phaseolus vulgaris)*, milho *(Zea mays)*, tomate *(Solanum lycopersicum)*, cenoura *(Daucus carota)* algodão *(Gossypium L)*, cana-de-açúcar *(Saccharum officinarum)*, tabaco *(Nicotiana tabacum)*, alho *(Allium sativum)*, cebola *(Allium cepa)*, ervilha *(Pisum sativum)*, girassol *(Helianthus annuus)*, batata-inglesa *(Solanum tuberosum), lúpulo (Humulus lupulus), morango (Fragaria × ananassa)*, pitaya *(Hylocereus undatus)* entre outros, cabendo ajustes na suplementação luminosa artificial para cada cultura 202a e região de cultivo, bem como outros fatores tais como o estágio fenológico da cultura 202a sob cultivo, o fotoperíodo e as condições meteorológicas sob as quais o campo agrícola 200 está submetido e um ou mais objetivos de desenvolvimento da cultura 202a a serem alcançados.

[027] Conforme pode ser visto através das figuras 1 e 2, o sistema de suplementação luminosa artificial 100 de acordo com uma realização da presente invenção, pode ser adaptado a um pivô de irrigação já

- a Figura 3 ilustra as etapas da lógica de funcionamento do método de suplementação luminosa artificial 500, conforme uma realização da presente invenção;

- a Figura 4 ilustra uma vista superior de uma esquematização de um pivô de irrigação no qual o sistema de suplementação luminosa artificial 100 foi instalado, de acordo com um exemplo da presente invenção;

- a Figura 5 ilustra um primeiro gráfico de uma análise de uma primeira variável da cultura 202a ao longo do tempo, sob a atuação do sistema de suplementação luminosa artificial 100, de acordo com o exemplo da presente invenção;

- a Figura 6 ilustra um segundo gráfico de uma análise de uma segunda variável da cultura 202a ao longo do tempo, sob a atuação do sistema de suplementação luminosa artificial 100, de acordo com o exemplo presente invenção;

- a Figura 7 ilustra um terceiro gráfico de uma análise de uma terceira variável da cultura 202a ao longo do tempo, sob a atuação do sistema de suplementação luminosa artificial 100, de acordo com o exemplo da presente invenção;

- a Figura 8 mostra uma comparação entre uma primeira amostra da cultura 202a sob a atuação do sistema de suplementação luminosa artificial 100, e uma segunda amostra da cultura 202b fora da atuação do sistema de suplementação luminosa artificial 100, de acordo com o exemplo da presente invenção.

DESCRIÇÃO DE REALIZAÇÕES DA INVENÇÃO

[023] Inicialmente, cumpre destacar que o sistema e método da presente invenção serão descritos a seguir de acordo com realizações particulares, mas não limitativas, uma vez que suas realizações poderão ser

de iluminação artificial; e

b) determinar e inicializar:

- uma rotina de irrigação de um dispositivo modular de irrigação agrícola; e

- uma rotina de suplementação luminosa artificial da pluralidade de fontes de iluminação artificial,

em que as rotinas de irrigação e de suplementação luminosa artificial são independentes entre si, sendo que as etapas a) e b) são determinadas considerando pelo menos um dentre:

- o tipo de cultura sob cultivo;

- o estágio fenológico da cultura sob cultivo;

- o fotoperíodo e as condições meteorológicas sob as quais o campo agrícola está submetido; e

- um ou mais objetivos de desenvolvimento da cultura sob cultivo a serem alcançados.

BREVE DESCRIÇÃO DOS DESENHOS

[022] Os objetivos, efeitos técnicos e vantagens da presente invenção serão aparentes aos técnicos no assunto a partir da descrição detalhada a seguir que faz referência às figuras anexas, que ilustram realizações exemplificadoras, mas não limitadoras, dos objetos reivindicados:

- a Figura 1 ilustra um sistema de suplementação luminosa artificial 100 operando junto a um dispositivo modular de irrigação agrícola 101 sobre um campo agrícola 200, de acordo com a presente invenção;

- a Figura 2 mostra uma ampliação de uma cultura 202a no campo agrícola 200 sob a atuação do sistema de suplementação luminosa artificial 100, de acordo com a presente invenção;

[020] O sistema de suplementação luminosa artificial compreende ainda:

- um processador em comunicação com o dispositivo de aspersão, o dispositivo de acionamento, um dimerizador ou polarizador da pluralidade de fontes de iluminação artificial, e com a pluralidade de células fotovoltaicas, em que o processador é configurado para:

a) ajustar, nos intervalos do espectro eletromagnético, o balanço entre as bandas espectrais emitidas pela pluralidade de diodos emissores de luz *(LED)* do tipo espectro total *(full-spectrum)*; e

b) determinar e inicializar:

- uma rotina de irrigação; e

- uma rotina de suplementação luminosa artificial,

em que as rotinas de irrigação e de suplementação luminosa artificial são independentes entre si, sendo que as etapas a) e b) são determinadas pelo processador considerando pelo menos um dentre:

- o tipo de cultura sob cultivo;

- o estágio fenológico da cultura sob cultivo;

- o fotoperíodo e as condições meteorológicas sob as quais o campo agrícola está submetido; e

- um ou mais objetivos de desenvolvimento da cultura sob cultivo a serem alcançados.

[021] Um ou mais objetivos da presente invenção acima mencionado(s), dentre outros, é(são) também alcançado(s) por meio de um método de suplementação luminosa artificial para o cultivo de uma cultura em um campo agrícola, compreendendo as etapas de:

a) ajustar, nos intervalos do espectro eletromagnético, o balanço entre as bandas espectrais emitidas por uma pluralidade de diodos emissores de luz *(LED)* do tipo espectro total *(full-spectrum)* de uma pluralidade de fontes fenológicos durante todas as etapas de desenvolvimento de uma cultura, promovendo uma produção agrícola em quantidade e qualidade.

[017] A presente invenção também tem por objetivo proteger a cultura sob cultivo ao repelir pragas agrícolas por meio da modulação da luz impedindo a inoculação de doenças na cultura, o que reduz a necessidade da aplicação de produtos fitossanitários e por consequência mitiga os danos a longo prazo que tal aplicação poderia causar ao solo.

[018] Por fim, a presente invenção objetiva o aumento da eficiência da irrigação e do uso de fertilizantes e agroquímicos (inseticidas, fungicidas, bactericidas,...), em virtude dos efeitos causados pela suplementação luminosa artificial, tal como o desenvolvimento do sistema radicular da cultura.

[019] Um ou mais objetivos da presente invenção acima mencionado(s), dentre outros, é(são) alcançado(s) por meio de um sistema de suplementação luminosa artificial, que compreende:

- um dispositivo modular de irrigação agrícola posicionado sobre um campo agrícola no cultivo de uma cultura e compreendendo:

- um dispositivo de acionamento para o deslocamento do dispositivo modular de irrigação agrícola sobre o campo agrícola;

- um dispositivo de aspersão compreendendo uma pluralidade de aspersores;

- uma pluralidade de fontes de iluminação artificial dispostas ao longo do dispositivo modular de irrigação agrícola em pontos equidistantes e a uma distância predeterminada acima das partes aéreas da cultura, compreendendo uma pluralidade de diodos emissores de luz *(LED)* do tipo espectro total (*full-spectrum*); e

- uma pluralidade de células fotovoltaicas que alimentam a pluralidade de fontes de iluminação artificial.

e implementado em qualquer pivô de irrigação pré-existente em uma plantação agrícola no cultivo de uma cultura, em que uma rotina de suplementação luminosa independa de uma rotina de irrigação.

[013] Ainda, a presente invenção tem por objetivo prover um sistema de suplementação luminosa artificial que seja capaz de estimular uma ou mais características de uma determinada cultura, por exemplo, a germinação ou floração de plantas de dias longos por meio do estabelecimento de uma rotina de suplementação luminosa artificial, por exemplo, após o fim do período matutino e vespertino, estabelecendo um fotoperiodismo da referida cultura superior ou pelo menos igual ao seu fotoperíodo crítico.

[014] Outro objetivo da presente invenção é prover um sistema de suplementação luminosa artificial que seja capaz de estimular uma ou mais características de uma determinada cultura, por exemplo, a germinação ou floração de plantas de dias curtos por meio do estabelecimento de uma rotina de suplementação luminosa artificial, por exemplo, em consideração de condições meteorológicas adversas à fotossíntese por meio da luz natural durante o período matutino e vespertino, compensando pela baixa luminosidade durante o dia, estabelecendo um fotoperiodismo da referida cultura inferior ao seu fotoperíodo crítico.

[015] É ainda um objetivo da presente invenção prover meios para automaticamente dimerizar ou polarizar bandas do espectro eletromagnético total emitidas em virtude da rotina de suplementação luminosa artificial conforme as diferentes demandas e condições ideais de desenvolvimento de uma ou mais culturas, em considerações de um ou mais fatores tais como o tipo de cultura, a região do cultivo e o tipo de sistema produtivo agrícola em uso.

[016] A presente invenção adicionalmente objetiva manter e adaptar a rotina de irrigação e suplementação luminosa em diferentes períodos

[007] Desta forma, foram feitos avanços recentes em estudos sobre suplementação luminosa artificial destacando-se efeitos benéficos do uso de diodos emissores de luz *(LEDs)* no metabolismo de cultivares, na eficiência de absorção de luz em suas partes aéreas (ou seja, as partes das plantas que estão acima do nível do solo), bem como a mitigação de estresses bióticos como o controle de pragas e patógenos na produção agrícola, ao passo que se aplica um manejo consciente de recursos energéticos para tal.

[008] O documento US 2016/0198640 A1 revela um pivô de irrigação móvel dotado de aspersores e uma pluralidade de diodos emissores de luz *(LEDs)* configurados para emitir diferentes frequências de luz polarizada em bandas espectrais desde o violeta, o vermelho e o vermelho extremo, sobre plantas de dias curtos ou dias longos em um campo agrícola durante a operação móvel do pivô, conforme ilustrado pela figura 1 do referido documento.

[009] O pivô de irrigação descrito pode compreender também, um circuito de controle configurado para controlar a operação dos diodos emissores de luz *(LEDs)*, dos aspersores ou de rodas do pivô de irrigação.

[010] No entanto, fica claro que o estado da técnica carece de melhorias tecnológicas em relação ao gerenciamento consciente de recursos energéticos e hídricos em conjunto com um sistema de suplementação luminosa artificial que leve em consideração as condições meteorológicas sob as quais um campo agrícola está submetido.

OBJETIVOS E DESCRIÇÃO DA INVENÇÃO

[011] Portanto, um objetivo da presente invenção é prover um sistema de suplementação luminosa artificial capaz de eliminar ou ao menos reduzir as limitações das técnicas conhecidas atualmente.

[012] Além disso, é um objetivo da presente invenção prover um sistema de suplementação luminosa artificial versátil e que possa ser adaptado

risco climático (ZARC) para uma dada cultivar, diversos têm sidos os esforços de novas tecnologias a fim de modelar e monitorar variáveis como a pedologia do solo e condições edafoclimáticas a fim de entender as consequências e interações que estas causam a uma determinada cultura. Como exemplo, cita-se o uso de tecnologias e estratégias de manejo do solo e recursos hídricos, o uso inteligente de agroquímicos, a aplicação eficiente de fertilizantes, a integração de *Internet of Things (IoT)* às práticas de monitoramento agrícola e climático.

[005] Além do monitoramento e controle de fatores externos, também é desejado pelos produtores agrícolas a implementação de tecnologias biológicas, tais como cultivares geneticamente modificadas *(GMOs)*, que sejam benéficas aos produtores, consumidores e à economia de modo geral, bem como o uso de compostos bioativos, como fito-hormônios reguladores de crescimento da cultivar, resultando na alteração de aspectos desde a germinação até processos metabólicos como a senescência plantar, podendo também estimular o desenvolvimento e a relação fonte-dreno de fotoassimiados de uma cultivar. Tais tecnologias trazem benefícios ao produto, que pode melhor suportar condições adversas ao seu desenvolvimento, bem como a incrementação do valor nutricional ao consumidor final.

[006] Ao longo das últimas décadas, o uso de tais tecnologias tornou-se constante a fim de intensificar produções agrícolas ao redor do globo, visto que a frequência de uso de tais tecnologias como na Ásia e América do Sul quase se equiparou à frequência de uso na Europa e América do Norte. No entanto, o uso de tais tecnologias em larga escala em adição às crescentes mudanças climáticas recentemente causaram uma nova demanda pela intensificação da produção agrícola, desta vez por meio de abordagens tecnológicas mais sustentáveis.

"SISTEMA E MÉTODO DE SUPLEMENTAÇÃO LUMINOSA ARTIFICIAL"

CAMPO DA INVENÇÃO

[001] A presente invenção refere-se, de uma maneira geral, a um sistema de suplementação luminosa artificial. A presente invenção refere-se também a um método de suplementação luminosa artificial. Particularmente, o sistema e método de suplementação luminosa artificial de acordo com a presente invenção são direcionados para o cultivo de uma cultura em um campo agrícola.

ANTECEDENTES DA INVENÇÃO

[002] A produção agrícola em larga escala sempre esteve intimamente interligada a e dependente de variáveis múltiplas tais como fatores nutricionais e microbiológicos do solo de plantio, características intrínsecas a uma determinada região, tal como o clima e o fotoperíodo, bem como uma pluralidade de estresses bióticos e abióticos que pairam sobre as cultivares, tais como inoculações de organismos nocivos às cultivares como patógenos de solo, infestações de pragas agrícolas, plantas invasoras, bem como a deficiência hídrica, irradiação, entre outros.

[003] No contexto do atual cenário agroindustrial, o Brasil notadamente se destaca como um dos maiores produtores e exportadores de *commodities* agrícolas, tais como a soja *(Glycine max)* e o milho *(Zea mays)* com uma produção anual de grãos de 124,8 milhões de toneladas. Neste sentido, é evidente que o desenvolvimento de novas técnicas e tecnologias de manejo agrícola têm grande impacto econômico e industrial. Além disso, a intensificação da produção agrícola é pressionada pela crescente população mundial e por consequência pelo aumento da demanda internacional por tais *commodities*.

[004] Neste sentido, além de ferramentas dinâmicas e macroscópicas como a determinação de zoneamentos agroecológicos e de

Documentos anexados

Tipo Anexo	Nome
Procuração	3610-0013_Depósito_POA.PDF
Relatório Descritivo	3610-0013_Depósito_Relatório Descritivo.PDF
Reivindicação	3610-0013_Depósito_Reivindicações.PDF
Desenho	3610-0013_Depósito_Desenhos.PDF
Resumo	3610-0013_Depósito_Resumo.PDF
Comprovante de pagamento de GRU 200	3610-0013_Depósito_GRU.pdf

Acesso ao Patrimônio Genético

☑ Declaração Negativa de Acesso - Declaro que o objeto do presente pedido de patente de invenção não foi obtido em decorrência de acesso à amostra de componente do Patrimônio Genético Brasileiro, o acesso foi realizado antes de 30 de junho de 2000, ou não se aplica.

Declaração de veracidade

☑ Declaro, sob as penas da lei, que todas as informações acima prestadas são completas e verdadeiras.

Dados do Procurador

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Numero OAB:

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Dados do Pedido

Natureza Patente: 10 - Patente de Invenção (PI)

Título da Invenção ou Modelo de Utilidade (54): SISTEMA E MÉTODO DE SUPLEMENTAÇÃO LUMINOSA ARTIFICIAL

Resumo: O sistema (100) compreende: um dispositivo modular de irrigação (101) posicionado sobre um campo (200) no cultivo de uma cultura (202a) e compreendendo um dispositivo de acionamento para o deslocamento do dispositivo modular (101) sobre o campo (200); um dispositivo de aspersão compreendendo uma pluralidade de aspersores; uma pluralidade de fontes de iluminação artificial (10a, 10b, 10c, 10d, 10e) dispostas ao longo do dispositivo modular (101) a uma distância predeterminada acima da parte aérea da cultura (202a), compreendendo uma pluralidade de diodos emissores de luz (LED) do tipo espectro total (full-spectrum); e uma pluralidade de células fotovoltaicas que alimentam a pluralidade de fontes de iluminação (10a, 10b, 10c, 10d, 10e), o sistema (100) compreendendo ainda: um processador em comunicação com o dispositivo de aspersão, o dispositivo de acionamento um dimerizador ou polarizador das fontes de iluminação (10a, 10b, 10c, 10d, 10e), e com a pluralidade de células fotovoltaicas em que o processador é configurado para: a) ajustar (501), no intervalo do espectro eletromagnético, o balanço entre as bandas espectrais emitidas pela pluralidade de diodos; e b) determinar e inicializar: uma rotina de irrigação (502); e uma rotina de suplementação luminosa artificial (503), independentes entre si, sendo que as etapas a) e b) são determinadas pelo processador considerando pelo menos um dentre: o tipo de cultura (202a) sob cultivo; o estágio fenológico da cultura (202a); o fotoperíodo e as condições meteorológicas sob as quais o campo (200) está submetido; e um ou mais objetivos de desenvolvimento da cultura (202a).

Figura a publicar: 01

Pedido nacional de Invenção, Modelo de Utilidade, Certificado de Adição de Invenção e entrada na fase nacional do PCT

Número do Processo: BR 10 2022 007272 8

Dados do Depositante (71)

Depositante 1 de 1

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MINISTÉRIO DA ECONOMIA

INSTITUTO NACIONAL DA PROPRIEDADE INDUSTRIAL

CÓPIA OFICIAL

PARA EFEITO DE REIVINDICAÇÃO DE PRIORIDADE

O documento anexo é cópia fiel de um Pedido de Depósito de Patente regularmente depositado no Instituto Nacional da Propriedade Industrial, sob número BR 102022007272-8 de data 14/04/2022

Rio de Janeiro, 29 de Agosto de 2022

Assinado eletronicamente por:
Instituto Nacional da Propriedade Industrial

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DOCUMENT MADE AVAILABLE UNDER THE PATENT COOPERATION TREATY (PCT)

International application number:		**PCT/BR2022/050461**
International filing date:		**24 November 2022 (24.11.2022)**
Document type:		**Certified copy of priority document**
Document details:	Country/Office:	**BR**
	Number:	**1020220072728**
	Filing date:	**14 April 2022 (14.04.2022)**
Date of receipt at the International Bureau:		**25 November 2022 (25.11.2022)**

Remark: Priority document submitted or transmitted to the International Bureau in compliance with Rule 17.1(a),(b) or (b-*bis*)

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1211 Geneva 20, Switzerland
www.wipo.int

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) **World Intellectual Property Organization**
International Bureau

(43) **International Publication Date**
19 October 2023 (19.10.2023)

WIPO | PCT

(10) **International Publication Number**
WO 2023/197049 A1

(51) **International Patent Classification:**
A01G 7/04 (2006.01) ***H05B 47/10*** (2020.01)
A01G 9/20 (2006.01) *A01G 25/09* (2006.01)

(21) **International Application Number:**
PCT/BR2022/050461

(22) **International Filing Date:**
24 November 2022 (24.11.2022)

(25) **Filing Language:** English

(26) **Publication Language:** English

(30) **Priority Data:**
1020220072728 14 April 2022 (14.04.2022) BR

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(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH,

(54) **Title:** SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT

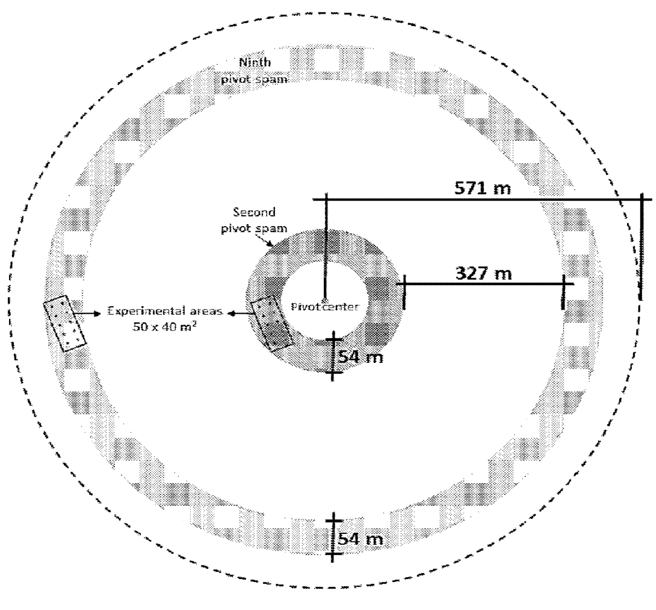

Figure 4

(57) **Abstract:** SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT The system (100) comprises a modular agricultural irrigation pivot-like device (101) positioned on an agricultural field (200) in the cultivation of a crop (202a), the device (101) comprising artificial lighting sources (10a, 10b, 10c, 10d, 10e) arranged along the irrigation pivot device (101) at a predetermined distance above the aerial parts of the crop, comprising LEDs, and a plurality of energy sources that feed a plurality of artificial lighting sources, a processor in communication with a dimerizer and/or polarizer of artificial lighting sources and with power sources, wherein a processor a) adjusts (501), in the intervals of the electromagnetic spectrum, the balance between the spectral bands emitted by the light-emitting diodes; and b) determines and implements - an irrigation routine (502); and/or - light(s) supplementation routine (503); in which stages a) and b) are determined by a processor different parameters.

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[Continued on next page]

TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

— *in black and white; the international application as filed contained color or greyscale and is available for download from PATENTSCOPE*

SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT

FIELD OF THE INVENTION

The present invention refers, in general, to an agricultural management system. The present invention also refers to an agricultural management method. In particular, according to the present invention, the system and method of agricultural management include artificial light(s) supplementation and are directed to the cultivation of a crop in an agricultural field.

BACKGROUND OF THE INVENTION

Large-scale agricultural production has always been closely linked to and dependent on multiple variables. Such variables include the nutritional and microbiological factors of the soil, intrinsic characteristics of a given region (e.g., climate, photoperiod, and rainfall distribution), as well as a plurality of stresses that affect crops, such as pathogens (plant diseases), insect infestations (plant predations), invasive plants (weeds), extreme (deficit or excess) of climatic, light irradiation, nutritional and water factors, among others.

In the context of the current agro-industrial scenario, Brazil notably stands out as one of the largest producers and exporters of agricultural commodities, such as soybeans (*Glycine max*) and corn (*Zea mays*), with an annual grain production of over 270 million tons according to CONAB (*Companhia Nacional de Abastecimento*, Brazilian agricultural ministry department) 2022 estimations. Thus, it is evident that developing new techniques and technologies for crop management has a tremendous economic and industrial impact. In addition, agricultural production is pressured by the growing world population and, consequently, by the increased international demand for agricultural commodities.

In this sense, there have been several efforts of new technologies to model and monitor variables such as edaphoclimatic conditions to understand the consequences and interactions between soil and crop. For example, the use of technologies and strategies for soil management and water resources, intelligent use of agrochemicals, efficient application of fertilizers, integration of the Internet of Things (IoT) into agriculture, and climate monitoring practices are essential for high crop performance and yield.

In addition to monitoring and controlling external factors, other technologies can improve agricultural activity. For example, biological technologies, such as genetically modified cultivars, benefit farmers, consumers, the environment,

and the economy; bioactive compounds, such as growth-regulating phytohormones, result in plant changes from germination to senescence and the source-drain relationship of photoassimilates in the plant during its cycle. Such technologies also improve the plant's resistance to adverse conditions during the crop cycle and increase the human nutritional value of crop production.

Over the past few decades, the use of such technologies has become constant to intensify agricultural production around the globe. The frequency of use of such technologies in South America and Asia farms has almost equated to the frequency of use in Europe and North America. However, climate change has recently caused a new demand for intensified agricultural production with more sustainable technological approaches. Additionally, the intensification of agricultural output to meet global demand is driven by the use of costly non-renewable fertilizers.

In this way, recent advances have been made in studies on artificial light(s) supplementation for crop production *outdoor* (large scales), defined as the process of applying artificial light(s) to plants grown in the open field, emphasizing the beneficial effects of the use of light-emitting diodes (LEDs) on plant's metabolism, on the efficiency of light absorption by the leaves, as well as the mitigation of abiotic (e.g., extreme temperatures and drought) and biotic (e.g., insect pests, plant diseases, weeds) stresses, while applying a sustainable management of the available resources.

Document *US 2016/0198640 A1* reveals a mobile irrigation pivot equipped with sprinklers and a plurality of light-emitting diodes configured to emit different frequencies of polarized light in spectral bands from violet to far red spectrum over plants of short, long, or neutral photoperiod response in an agricultural field. The light-emitting diodes are fixed on the irrigation pivot structure, illustrated in Figure 1 of the referred document.

The described irrigation pivot can also comprise a control circuit configured to control the operation of light-emitting diodes, irrigation parameters, and pivot moving.

Light(s) supplementation applied to crops can alter plant responses significantly. However, these responses are affected by several factors, such as plant species, crop management, soil fertility, water availability, and the prevailing climate. Document *US 2016/0198640 A1* fails to reveal artificial light(s) supplementation combined with crop management factors. Instead, when artificial light(s) supplementation is used alone, as indicated in document *US 2016/0198640 A1*, this

may not have the desired effect or may even impair plant development (empirical observation). Artificial light(s) supplementation may, for example, not achieve high yields if the applied fertilization does not adequately meet the desired level of crop production, or artificial light(s) supplementation may favor a condition of intense weeds competition in the crop field if an adequate positioning of herbicides is not made.

Noticeably, the *state of the art* lacks technological improvements regarding integrated crop management strategies. Actions in crop fields are still evaluated independently and not integrally. The sustainable use of energy, fertilizers, water, and adequate artificial light(s) supplementation are essential for sustainable large-scale improved cropping activities. These large-scale cropping activities have a great responsibility in human impact on Earth's environments. Improving the sustainability of large-scale cropping activities is possible with the present invention.

OBJECTIVES AND DESCRIPTION OF THE INVENTION

Therefore, an objective of the present invention is to provide an agricultural management system combined with artificial light(s) supplementation capable of raising agricultural production in a cropping area, increasing its productivity, reducing the negative effects of stresses present in the *outdoor* environment, increasing the efficiency of the applied inputs for crop production and, in this way, reduce the limitations of the currently known cropping techniques.

Another objective of the present invention is to provide an agricultural management system via consultancy combined with adequate artificial light(s) supplementation routine. The light-emitting diodes can be implemented in any new or preexisting irrigation pivot in an agricultural cropping area. The routine of light(s) supplementation is usually independent of the irrigation routine.

Another objective of the present invention is to provide an agricultural management system combined with artificial light(s) supplementation capable of stimulating plant characteristics of any species at a given phenological stage. These responses are regulated by the moment of artificial light(s) supplementation, the predominant color in the artificial light(s) applied, and the interaction among these factors and the environment, crop genetics, crop response to photoperiod, and crop management.

Another objective of the present invention is to provide an agricultural management system combined with artificial light(s) supplementation capable of stimulating plant characteristics of a given species at a given phenological stage.

These stimulated characteristics can improve plant performance against adverse stressful conditions that impair photosynthesis using natural light (sunlight) and reduce the negative effects of low natural luminosity during cloudy days.

Another objective of the present invention is to provide dimerization and/or polarization of the spectral bands in the artificial light(s) supplementation according to the crop species, region, soil physical and chemical conditions, climate, predominant agronomic management and type of agricultural production system in use (e.g., no-tillage cropping system).

Another objective of the present invention is to maintain and adapt the routine of water irrigation and light(s) supplementation at different phenological stages during all crop development stages, improving agricultural production in quantity, quality, and sustainability.

Another objective of the present invention is to protect crops against plant diseases and insect pests by modulating artificial light(s) supplementation. Artificial light(s) can be used to affect plant diseases and insect pest development, cycle, and pressure on crop performance. The improved crop protection advantageously has the potential to reduce the need for the application of phytosanitary products. This potential reduction in use of phytosanitary products (e.g., insecticides and fungicides) consequently reduces the damage caused to the environment by the excessive use of such products.

Another objective of the present invention is to act beyond the mere application of light(s) supplementation, as it must consider soil factors, plant nutrition levels, climate, photoperiod responses, agronomic management, and crop variety selection, among others, to achieve the balance between the demand of the plant stimulated by light(s) supplementation and the technical use of production resources. In other words, according to the present invention, artificial light(s) supplementation is a tool that must be inserted in a set of appropriate technical actions to achieve the best production results and sustainability of large-scale agriculture.

Finally, the present invention aims to increase the efficiency of production resources, such as irrigation, fertilizers, and agrochemicals (insecticides, fungicides, bactericides, fertilizers, stimulants, ...), due to the effects caused by artificial light(s) supplementation, such as a great development of the plant root system, allowing improved exploration of the soil profile and reduce the water, nutrients and agrochemicals losses.

One or more objectives of the above-mentioned invention(s), among others, are achieved by means of an agricultural management system combined with artificial light(s) supplementation, comprising:

- a modular agricultural irrigation device positioned on an agricultural field using a plurality of artificial lighting sources arranged along the modular agricultural irrigation device, optionally at equidistant points and at a predetermined distance above the aerial crop parts.

- a plurality of light-emitting diodes capable of emitting a plurality of electromagnetic spectrum bands applied alone or in combinations of different proportions of spectral bands from the limit of ultraviolet C and B (wavelength of 280 nm) to infrared (wavelength > 700 nm); and

a plurality of energy sources that feed a plurality of artificial lighting sources.

The agricultural management system also comprises

- a processor in communication with a dimerizer and/or polarizer of a plurality of artificial lighting sources and a plurality of energy sources, in which a processor is configured to

a) adjust, in the intervals of the electromagnetic spectrum, the balance between the spectral bands emitted by a plurality of light-emitting diodes; and

b) determine and implement - an irrigation routine; and/or - an artificial light(s) supplementation routine; in which stages a) and b) are determined by a processor considering at least one among

- the crop species 202a under cultivation;

- the phenological stage of the crop 202a under cultivation;

- the photoperiod, station and current weather conditions under which the agricultural field 200 is subjected; and

- one or more objective(s) intended for the crop 202a development under light(s) supplementation.

Understand "*objective(s) intended for the crop*" as the main purpose of the cropping of such plant specie; if, for example, the crop is for grain production, then a crop and artificial light(s) management, or protocol, is applied; however, if the crop is only intended for cattle grazing, then another crop and artificial light(s) management, or protocol, is applied.

The objective(s) of the above-mentioned invention, among others, is also achieved by means of adequate agricultural management methods combined with artificial light(s) supplementation for crop cultivation in an agricultural field, comprising the stages

a) adjusting the balance between the spectral bands emitted by a plurality of light-emitting diodes of a plurality of lighting sources artificially capable of emitting a plurality of electromagnetic spectrum bands applied alone, or in combinations of spectral bands from the limit of ultraviolet C and B (wavelength of 280 nm) to infrared (wavelength > 700 nm); and

b) determine and implement - an irrigation routine of a modular agricultural irrigation device; and/or

- a routine of artificial light(s) supplementation of a plurality of artificial lighting sources; in which stages a) and b) are determined considering at least one among

- the crop species under cultivation;

- the phenological stage of the crop under cultivation;

- the crop photoperiod response, crop cropping season and current weather conditions under which the agricultural field is subjected; and

- the objective(s) intended for the crop 202a development under light(s) supplementation.

BRIEF DESCRIPTION OF THE DRAWINGS

The objectives, technical effects and advantages of the present invention will be apparent with the following detailed description that refers to the attached figures, which illustrate, but not limited, embodiments of the objects claimed

- Figure 1 illustrates a 100 agricultural management system combined with light(s) supplementation operating on a modular agricultural irrigation device 101 on an agricultural field 200, according to the present invention;

- Figure 2 shows an expansion of a crop 202a in the agricultural field 200 under the action of the agricultural management system 100 combined with artificial light(s) supplementation, according to the present invention;

- Figure 3 illustrates the stages of the logic operation of the agricultural management method 500 combined with artificial light(s) supplementation, according to an embodiment of the present invention;

- Figure 4 illustrates a superior view of a schematization of an irrigation pivot in which the agricultural management system 100 combined with artificial light(s) supplementation was installed, according to an embodiment of the present invention;

- Figure 5 illustrates a first graph of an analysis of a sovbean plant internode variable of the crop 202a over time, under the performance of the agricultural management system 100 allied to artificial light(s) supplementation, according to the embodiment of the present invention;

- Figure 6 illustrates a second graph of an analysis of soybean plant height variable of the crop 202a over time, under the action of the agricultural management system 100 allied to artificial light(s) supplementation, according to the present invention embodiment;

- Figure 7 illustrates a third graph of an analysis of third plant variable of the crop 202a over time, under the action of the agricultural management system 100 combined with artificial light(s) supplementation, according to the embodiment of the present invention;

- Figure 8 illustrates a comparison between crop 202a plants under the intervention of the agricultural management system 100 combined with artificial light(s) supplementation, and crop 202b plants with no artificial light(s) supplementation and corresponding crop management, according to the embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS OF THE INVENTION

Initially, it should be noted that the system and method of the present invention will be described below according to particular but non-limiting embodiments since it may be executed in different ways and variations and according to the objective(s) intended for the crop 202a development under light(s) supplementation.

In one embodiment, the present invention reveals a 100 agricultural management system combined with artificial light(s) supplementation for the cultivation of a crop 202a in an agricultural field 200.

In another embodiment, the present invention reveals a 500 agricultural management method combined with artificial light(s) supplementation for the cultivation of a crop 202a in an agricultural field 200.

It is emphasized that adjustments in agricultural management and artificial light(s) supplementation should be implemented for each crop 202a and cropping region due to latitude, the height of the area compared to sea level, soil

characteristics, and climate variations. The crop 202a phenological stage, photoperiod, the weather conditions under which the agricultural field 200 is submitted, and the objective with the plant development should also be considered to define the wavelength range applied and its combinations of electromagnetic spectrum bands to meet the specified objective. The luminous flux and the balance between the spectral bands emitted by a plurality of light-emitting diodes are, therefore, variable by means of digital dimerization and/or polarization and controllable by an electronic processor, according to the routine of artificial light(s) supplementation, which in turn takes into account the factors mentioned above.

It should be noted that the expressions “plant”, “cultivate”, or “culture” should be understood as any plant varieties, whether from long-day, such as oats (*Avena sativa*) or potato (*Solanum tuberosum*) or short-day plants, such as soy (*Glycine max*) or coffee (*Coffea* sp.), or neutral plants, which benefit from artificial light(s) supplementation in accordance with the present invention. Crop species evaluated with adequate crop corrections and management combined with artificial light(s) supplementation include soybean (*Glycine max*), bean (*Phaseolus vulgaris*), corn (*Zea mays*), tomato (*Solanum lycopersicum*), carrot (*Daucus carota*), sugarcane (*Saccharum officinarum*), tobacco (*Nicotiana tabacum*), garlic (*Allium sativum*), onion (*Allium cepa*), pea (*Pisum sativum*), sunflower (*Helianthus annuus*), sorghum (*Sorghum bicolor*), cotton (*Gossypium hirsutum*), potato (*Solanum tuberosum*), hops (*Humulus lupulus*), strawberry (*Fragaria × ananassa*), pitaya (*Hylocereus undatus*), lettuce (*Lactuca sativa*), arugula (*Eruca vesicaria* ssp. *sativa*) and agricultural soil cover crops. Each crop species received adjusted in artificial light(s) supplementation for each crop 202a and region of cultivation, as well as other factors such as the phenological stage of the crop 202a under cultivation, the photoperiod, and the meteorological conditions under which the agricultural field 200 is submitted and the objective(s) intended for the crop 202a development. All these crop species 202a showed positive results with adequate agricultural management and artificial light(s) supplementation, according to the present invention, compared to control (no artificial light(s) supplementation). The positive results are discussed below.

Furthermore, this descriptive report means “corrections” as any practice carried out by the producer in the agricultural area to improve the conditions available for plant development. In this sense, all practices that affect soil management (chemical and physical structure) and plant nutrition management (fertilizers) can be

considered “corrections”. Examples of corrections are the application of limestone (soil acidity correcting, calcium and magnesium source), the application of gypsum (reducing potential acidity in depth in the soil, source of calcium and sulfur), and the cultivation of cover crops (soil compaction management, nutrient recycling, pest control such as phytonematodes).

As can be seen in figures 1 and 2, the agricultural management system 100 combined with artificial light(s) supplementation, according to the application of the present invention, can be adapted to an irrigation new pivot or already existing in an agricultural field 200, such as a central irrigation pivot, whether towed or non-towable, or even a linear irrigation pivot. In this descriptive report, the pivot is generally described as “agricultural irrigation modular device 101”.

This modular agricultural irrigation device 101 is positioned on the agricultural field 200 on which the cultivation of a crop 202a occurs, and the modular device 101 comprises an irrigation line 102a with wheeled towers and many spans (irrigation space between towers presenting oblong arms). The distal end of the first irrigation span 102a is supported by a wheeled tower 103a, and mechanically associated with a drive device, such as an engine or equivalent, and wheels 104a; 105a; the proximal end of the first irrigation span 102a is mechanically connected in a circular rotating way to the center of the pivot. The drive device triggers the tower 103a displacement.

The modular agricultural irrigation device 101 may have one or many wheeled towers and spans.

The span(s) of the modular device 101 presents a plurality of water sprinklers connected to a hydraulic pressure line in water communication with a reservoir which may be arranged, for example, at a central pivot, in the hydraulic line extending along the pivot spans 102a; 102b, which are equipped with water sprinklers in order to promote the irrigation of the agricultural field 200.

The agricultural management system 100, combined with artificial light(s) supplementation, incorporates a plurality of artificial lighting sources 10a, 10b, 10c, 10d, 10e arranged, for example, along the irrigation spans 102a; 102b of the agricultural irrigation modular device 101 and may be located at specific points and at a predetermined distance above the aerial part (canopy, plant shoot) of the crops 202a, the distance from the ground and other sources of artificial lighting 10a, 10b, 10c, 10d, 10e can also be adjusted as necessary, depending on the type of modular device 101

that will receive the artificial lighting sources and the crop 202a species under cultivation.

In addition, a plurality of artificial lighting sources 10a, 10b, 10c, 10d, 10e comprise a plurality of light-emitting diodes. In a preferred embodiment, light-emitting diodes are full-spectrum with wavelengths ranging from 280 nm, at the limit of the UV-C spectrum with UV-B, up to 1200 nm, in the near-infrared spectrum, over agricultural crop 202as (whether short, long or neutral-day plants) which are directly associated with biomass production, plant morphology, plant resistance to stresses, and crop development 202a. In one embodiment, the wavelength interval applied may be the same during the day or night but with variable luminous flux intensities.

The system 100 also comprises a plurality of energy sources, feed a plurality of artificial lighting sources 10a, 10b, 10c, 10d, 10e, as well as a processor in communication with the water sprinkles, the pivot drive device, and a dimerizer or polarizer of a plurality of artificial lighting sources 10a, 10b, 10c, 10d, 10e The referred processor is configured to adjust 501 the light spectral bands, the balance between these spectral bands emitted by a plurality of light-emitting diodes, and determine an irrigation routine 502 and an artificial light(s) supplementation 503 routine. The irrigation routines and artificial light(s) supplementation are independent. In other words, according to the established routine, a processor can command the action of the drive device, water sprinkle device, and the light dimerizer or polarizer. A processor determines this routine, preferably using an artificial intelligence model, considering the crop 202a species under cultivation; the phenological stage of the crop 202a under cultivation; the photoperiod and weather conditions under which the agricultural field 200 is/was subjected; the objectives intended for the crop 202a development, and information provided by users (farmers) through a user interface, which will be commented on below.

In an embodiment of the artificial light(s) supplementation routine, the crop 202a plant development can be stimulated or inhibit the production of leaves, branches, flowers, and roots; stimulate or inhibit the production of grains, fibers, fruits, and essences; stimulate or inhibit vegetative and reproductive growth, and stimulate plant photosynthesis.

In an embodiment of the artificial light(s) supplementation routine, a processor may be in communication with a plurality of photoresponsive sensors to determine a threshold of sunlight incidence, which controls the performance of a

plurality of light-emitting diodes and routines of application, reducing the negative effects of weather adversities under which the agricultural field 200 is subjected, such as cloudy days with a low sunlight incidence.

It is also noteworthy that the threshold of light incidence may additionally depend on other factors, such as the crop 202 species under cultivation, current crop 202a phenological stage, the region (e.g., information regarding soil, climate, history of the cropping area), and crop 202a management applied.

A light dimerizer or polarizer adjusts the luminous flux and the balance between the spectral bands emitted by a plurality of light-emitting diodes. The light dimerization or polarization is controllable by the interaction between photoresponsive cells and a processor to define a routine of light artificial supplementation. The definition of such routine takes into account the factors mentioned above. For example, for crops 202a in general, the basic phenological stages are vegetative (V) (crop cycle period before flowering and where pre-flowering occurs) and reproductive (R) (begins with the first reproductive structure, usually flowers), in which specific artificial light(s) supplementation with specific spectral band composition is applied. This balance of spectral bands can be the same applied during the day or night or may diverge between these periods, varying the intensity of the luminous flux and spectral band composition. In nocturnal applications, the luminous flux can be adjusted to be lower, for example, than the luminous flux in daytime applications, intending only to cause stimuli in crop 202a plants, which will be commented on below. Especially in daytime applications, the luminous flux can be adjusted to be higher in cloudy periods, intending to mitigate the effects of photosynthetic reduction due to low natural light availability.

This is especially advantageous, as cloudiness can reduce the photosynthetic capacity of the crop 202a plants by more than 50%, causing the crop 202a to produce fewer sugars (assimilated organic carbon via photosynthesis) and consequently grow less and produce less biomass (e.g., grains, fruits, fibers). This reduction in photosynthetic activity also results in smaller amounts of root exudates released to the soil (decreasing the soil aggregating effect) and lower symbiont microorganisms (due to decreased root exudate supply), which in turn have the function of obtaining nutrients from the environment to the crop 202a, making them more resistant to pathogens and agricultural pests. Thus, it is evident that compensation for the low incidence of natural sunlight is a decisive factor for soil structuring and plant protection against pathogens and agricultural pests.

In another embodiment, a plurality of energy sources can be generated by wind, sunlight, thermal, or combustion generators in order to feed a plurality of artificial lighting sources 10a, 10b, 10c, 10d, 10e. In any of these embodiments, a processor may be in communication with a machine-readable memory, which stores database information comprising real-time updates on the geolocation of agricultural field 200 and climate indicators to suggest to the user, through a user interface, the crop 202a variety to be cultivated.

The user interface is in communication with a processor, and in turn, the user feeds other information to a processor, through the interface, such as

- the history of cultivation of the agricultural field 200 in order to identify successful plants species and crop varieties previously cultivated in the agricultural field 200;

- the history of agricultural inputs used in the agricultural field 200, such as fertilizations and corrections made;

- the occurrence of stresses in plants, such as the emergence of plant diseases and insect pest infestation, nutritional deficiencies, extreme of temperatures and rainfall distribution;

- the occurrence, intensity and determination of the principal weeds;

- results of productivity from previous harvests;

- the characteristics of the irrigation pivot 101, such as irrigated area, irrigation flow, working speeds and the height of the structure wherein a plurality of artificial lighting sources 10a, 10b, 10c, 10d, 10e are fixed in order to adjust the illumination of the light-emitting diodes as a function of the distance of a plurality of artificial lighting sources 10a, 10b, 10c, 10d, 10e

- the current crop season weather conditions and weather indicators of the crop field area.

The user interfaces in an embodiment implemented on a panel, mobile phone, tablet, or similar mobile devices with a direct connection to a center of information where the reported data will be processed, and the artificial intelligence will be fed.

In another embodiment, a plurality of energy sources uses information such as the sunlight duration, cloudiness, sunlight brightness as well as the insolation index (ratio between the actual number and the maximum possible number of hours of sunlight brightness) to determine the threshold of sunlight incidence in the agricultural

field 200. Below the calculated threshold and depending on a certain routine of artificial light(s) supplementation, a processor interacts with the dimerizer or polarizer to command the performance of a plurality of light-emitting diodes and project artificial light(s) with specific spectral band composition, reducing the negative impact of meteorological adversities (e.g., cloudy days) under which the agricultural field 200 is subjected.

In one embodiment, data on the crop 202a species, crop 202a phenological stage, photoperiod, meteorological conditions under which the agricultural field 200 is submitted, objective(s) intended for the crop 202a development, as well as the technologies implemented in the agricultural field (fertilizers, agrochemicals, and soil management techniques) are stored in a machine-readable memory and accessed by a processor, in order to properly apply light(s) supplementation, according to parameters provided by the machine-readable memory.

Such previous information on the agricultural field 200 and the routine of artificial light(s) supplementation is important because they help

- in understanding and predict the consequences and interactions potentially present in the agricultural field 200;

- indicate improvements and corrections to be implemented in the agricultural field 200 for the optimization of the results of artificial light(s) supplementation;

- assist in the use of technologies and strategies for soil and water resources management;

- assist in the intelligent use of agrochemicals and in the efficient application of fertilizers; - assist in the integration of internet of things (IOT) to monitor crop (satellite), climate and agricultural practices; and

- help to improve the application format of the routine of artificial light(s) supplementation, such as the type of artificial lighting source 10a, 10b, 10C, 10D, 10e to be used, such as light-emitting diode panels (LEDs), led strips (LED), lamps in general, and their respective power, frequency and wavelength.

In addition, pedological, edaphological, mineralogical, textural, phytopathological, and nutritional analyses are essential before the agricultural field 200 receives adequate agricultural management and artificial light(s) supplementation routine. It is impossible to define the best inputs management for crop production without knowing such mentioned information. How many, how much, and when to

apply fertilizers for high crop performance under artificial light supplementation? Soil, irrigation, and phytosanitary management, what is the best routine? It is necessary to know the soil conditions before implementing adequate agricultural and artificial light(s) supplementation management to understand how soil will behave after the referred implementation.

The 100 system of the present invention comprises a plurality of soil sensors under the agricultural field 200 to capture nutritional data from the soil of the agricultural field 200. A processor uses the data to determine and suggest routines for soil treatment/corrections of the agricultural field 200. The respective recommendation made by a processor, using an artificial intelligence model fed with specific parameters and users information, considering the crop parameters, adjusts the balance between the spectral bands 501, and determines the irrigation routine 502 and artificial light(s) supplementation 503.

Short-day crops, such as soybean (*Glycine max*), are largely influenced by abiotic factors such as photoperiod and temperature. Soybean flowering and reproductive cycle occur under short photoperiodisms, that is, on days when the absence of light (night period) is longer than the presence of light (day period). While the opposite, extended day periods can delay or inhibit flowering and the beginning of the reproductive cycle. This condition of dependence on the photoperiod allows light(s) supplementation to influence the extension of the crop 202a cycle. Consequently, plant height, number of internodes, pods, seeds per pod, and distribution of pods in the aerial parts of soybean are affected by extended photoperiods through adequate agricultural and artificial light(s) supplementation management.

It is also important to mention that for a positive balance for photosynthesis, the luminous flux is usually between 200 and 600 μmol m^{-2} s^{-1}. However, artificial light(s) supplementation acts on other physiological aspects that directly and indirectly affect photosynthesis in the plant, and not necessarily artificial light(s) supplementation is applied to be the light source that momentarily causes photosynthesis. This light source may have a luminous flux of less than 200 μmol m^{-2} s^{-1}.

In general, artificial lighting sources 10a, 10b, 10c, 10d, 10e with luminous flux less than 200 μmol m^{-2} s^{-1} are not able to cause considerable amounts of positive photosynthesis on most plants. However, even smaller luminous fluxes can cause stimuli in crop 202a that can directly or indirectly positively affect photosynthesis

to be performed the following day after the night of application of artificial light(s) supplementation. Therefore, a low luminosity, capable only of causing other responses but unable to directly cause considerable amounts of positive photosynthesis; a higher luminosity, will consequently have specific and useful applications according to the present invention.

Artificial light(s) supplementation, according to the present invention, is, therefore, a tool within a broad technical project that interacts both with the agricultural management of soil aspects, such as soil fertility and texture, and plant nutrition, as well as with the pathological and beneficial microbiological aspects, environmental aspects, such as temperature and rain in the agricultural region, and economic aspects, such as the cost of production and marketing of agricultural commodities that receive agricultural management combined with artificial light(s) supplementation according to the present invention.

The increase in agricultural production, according to the present invention, is the result of the interaction among stimulated crop 202a physiological processes by light(s) supplementation, the time defined for sowing, irrigation volume, time of application, formulation, frequency, and dosage of fertilizers, climate variation, management of insect pests and plant diseases and their impacts on the relationships with the environment. Agricultural cultivation with this integration of adequate technical knowledge (agricultural management) and artificial light(s) supplementation, according to the present invention, increases the resilience and stability of crop production, which increases regional and global food security.

It is noteworthy here that artificial light(s) supplementation improves the result of good management but does not correct poor management. In other words, according to the present invention, artificial light(s) supplementation enhances the development of plants that are well nourished, with good water distribution throughout the crop cycle, and that present soil physical and chemical structure suitable for high yields. Under these conditions, supplement artificial light(s) will generate the best results. However, if light(s) supplementation is not combined with adequate agricultural management, then light(s) supplementation alone cannot fix preexisting limitations for the full development of plants, such as nutritional deficiencies, lack of water, insect infestations, or the presence of agricultural pathogens.

The application of agricultural management and artificial light(s) supplementation, according to the present invention, does not present

contraindications regarding - crop 202a species (any cultivated plant specie would benefit from adequate agricultural management and artificial light(s) supplementation); - phenological stage during crop 202a cycle (vegetative or flowering/reproductive); - joint application, or not, with water irrigation.

In addition, the application of agricultural management and artificial light(s) supplementation, according to the present invention - can be handled to raise the levels of specific substances in the final product (e.g., grains, fruits, and fibers); - recommend the dimerization/polarization of the light spectrum to be applied with the development of the crop 202a (e.g., modification of the bluish spectrum in the vegetative to the reddish spectrum in the reproductive stage); and - recommend the application of artificial light(s) supplementation at specific periods of the crop 202a cycle, and not applied throughout the crop cycle, from sowing to harvest.

Without getting in the light of any specific theory, it was observed that light dimerization/polarization effects are beneficial, including changes in plant morphology, crop cycle extension, physiological responses, and plant productivity.

For example, it was observed that the bluish spectrum (spectral band of approximately 400 to 500 nm) is a stimulant of vegetative growth, which is appropriate for plants before flowering. After flowering, plants paralyze growth investments and start investing in grain, fiber, fruit, or essence production.

In turn, it was observed that the reddish spectrum (spectral band of approximately 600 to 750 nm) is a stimulant of reproductive growth, with beneficial effects for flowering, the rate of photosynthesis, and fruit formation. In this post-flowering period, the photosynthetic activity for biomass accumulation and the translocation of these reserves produced to “fill” production is essential. Therefore, avoiding the blue spectrum, or having less blue, is important in the reproductive phenological stage because blue is a stimulant of the vegetative stage, which would cause nutrient reserves to be consumed and not destined to fill the production. On the other hand, having the red spectrum, or having redder to stimulate photosynthesis and the distribution of reserves, is essential for the best results in the reproductive stage.

In a preferred embodiment, the balance between red-green-blue spectral bands presents at least 40% blue color for vegetative phenological stages and about 60% or at least 40% red color for the reproductive phenological stage of the crop 202a under cultivation. More than 40% red color in the artificial light(s) supplementation is recommended for any plant phenological stage.

Figure 3 illustrates the agricultural management method 500 combined with artificial light(s) supplementation for the cultivation of a crop 202a in an agricultural field 200, which comprises the stages a) adjusting 501, in the intervals of the electromagnetic spectrum, the balance between the spectral bands emitted by a plurality of light-emitting diodes of a plurality of artificial lighting sources 10a, 10b, 10c, 10d, 10e; and b) determine and implement an irrigation routine 502 of a modular agricultural irrigation device 101; and/or a routine of artificial light(s) supplementation 503 of a plurality of artificial lighting sources 10a, 10b, 10c, 10d, 10e in which the irrigation routine 502 and the supplementation routine are independent of each other, and in which stages a) and b) are determined through an artificial intelligence model considering at least one of the type of crop 202a under cultivation; the phenological stage of the crop 202a under cultivation; the photoperiod, station and current weather conditions under which the agricultural field 200 is subjected; and the objective(s) intended for the crop 202a development.

Method 500 also comprises stage c) determining and suggesting a soil treatment routine based on soil nutritional data from the agricultural field 200, stage c) being defined through the artificial intelligence model considering at least one of the same parameters considered for stages a) and b), in addition to considering the irrigation routine 502 and/or the routine of artificial light(s) supplementation 503.

In a preferred embodiment, the objective(s) with crop 202a development is to stimulate or inhibit the production of leaves, branches, roots, grains, fibers, fruits, and essences and, also, to stimulate or inhibit vegetative and reproductive growth and photosynthesis.

In a preferred embodiment, the routine of artificial light(s) supplementation 503 occurs, preferably, between the phenological stages V3-V4 to R5-R6 of the crop 202a under cultivation, and the balance between the spectral bands is adjusted 501, the balance between red-green-blue spectral bands presents at least 40% blue color for vegetative phenological stages and about 60% or at least 40% red color for the reproductive phenological stage of the crop 202a under cultivation. More than 40% red color in the artificial light(s) supplementation is recommended for any plant phenological stage.

EXAMPLE 1

Reference is made to an example (technically adequate and representative study) in which the present invention was carefully implemented in order

to verify its effectiveness. According to the present invention, this example evaluated the soybean 202a plant responses related to plant development and crop productivity in an open commercial area 200 (field scale) cultivated under agricultural management conditions and artificial light(s) supplementation. An irrigation pivot 101, irrigating a commercial cropping area 200, received an artificial lighting source 10a, 10b, 10c, 10d, 10e, according to the present invention, in internal pivot 101 spans for artificial light(s) supplementation of the soybean plants 202a.

According to the example, about 40 hours of artificial light(s) supplementation was applied to soybean plants 202a during the soybean crop 202a cycle. The number of plant internodes, soybean plant height, and the number of pods per soybean plant were evaluated weekly to calculate the area below the variable progression curve. Grain yield at harvest was also evaluated. Later, the area below the progression curve of the number of internodes, soybean plants height, and pods per soybean plant was positively affected by the system and method of adequate agricultural management combined with artificial light(s) supplementation 100, 500, according to the present invention.

The regular soybean 202a cycle, without artificial light(s) supplementation, is about 15 to 17 weeks; however, soybean harvesting occurred two weeks later when no artificial light(s) supplementation was applied. The artificial light(s) supplementation increased soybean grain yield by 57.3% and profitability by 180% when compared to soybean cropping without artificial light(s) supplementation.

METHODOLOGY EXPERIMENTAL AREA AND SOYBEAN CULTIVATION

The experiment with light(s) supplementation on soybean was carried out in an irrigation pivot 101, on a commercial farm in Monte Carmelo, Minas Gerais state, Brazil. Located at a latitude and longitude of 18º 57” South, 47° 25” West, at 980 m above sea level. The most common and representative biome of the region is the Cerrado (savannah-like biome). The climate of the region is humid tropical, with rainy summers and dry winters.

Physical analyses of the soil in the agricultural area 200, from 0 to 0.4 m deep, indicated 450, 100, and 450 g kg^{-1} of sand, silt, and clay, respectively. The chemical analyses of the soil up to the depth of 0.4 m did not indicate the acute deficiency of any nutrient necessary for the crops to complete their cultivation cycle fully. The soil analyses are presented in Table 1.

TABLE 1

pH H_2O	Ca	Mg	Al	H+Al	CEC	V	P	K	S.O.M
1-2.5	----cmol$_c$ dm^{-3}----					%	---mg dm^{-3}---		g kg^{-1}
---0-0.2 m soil depth---									
6.9	6.03	2.87	0	1.26	10.44	88	188	96	2.9
---0.2-0.4 m soil depth---									
6.8	5.70	2.78	0	1.08	9.77	89	158	82	2.3

B	Co	Cu	Fe	Mn	Mo	Si	Zn
---mg dm^{-3}---							
---0-0.2 m soil depth---							
0.19	1.7	9.0	14.0	1.9	2.9	12.4	12.8
---0.2-0.4 m soil depth---							
0.14	1.3	7.7	17.0	3.5	2.3	11.4	11.1

Despite the large soil clay proportion and high soil fertility, 3,000 kg ha^{-1} of soil remineralizer (rock powder) (FMX® Tratto. Aparecida from Goiânia, Brazil) was applied throughout the experimental area 200, 30 days before the soybean sowing 202a; 400 kg ha^{-1} of organomineral 6-30-05 (% of N, P_2O_5, K_2O) (Valoriza Agro Ltda. Patos de Minas, Brazil) and 150 kg ha^{-1} of KCl was applied at the time of sowing, and 2 L ha^{-1} of Mn was sprayed on the aerial parts of the soybean plants 202a, 40 days after the crop 202a seed germination.

The soybean cultivar 202a evaluated in this example was Desafio 8473 RSF (Brasmax® GDM. Cambé, Brazil), which is a soybean variety with indeterminate growth and 7.4 maturity group. Fourteen seeds per linear meter (280,000 plants per hectare) were sowed in lines spaced by 0.5 m; plants 202a were harvested approximately 4 months later. The soybean plants cultivated with no artificial light(s) supplementation were harvested first. The average daily air temperature during the experimental period ranged from 24 to 34 °C.

In the experimental area, insects, pests, plant diseases, and weeds were controlled with products registered for soybeans as indicated by the manufacturer. All areas were monitored before and after the first application, and the products were reapplied as needed. The management of crop plants 202a and water irrigation were similar between the areas that received the artificial light(s) supplementation and the control [area with no without artificial light(s) supplementation].

EXPERIMENTAL TREATMENTS AND RESEARCH

The central irrigation pivot 101 that was implemented with the artificial light(s) supplementation light source had ten spans and an irrigation radius of about 571 m. In the four internal spans of the referred irrigation pivot 101, which corresponds to an area of 33.5 ha, the artificial light source 10a, 10b, 10c, 10d, 10e was installed, but the six external spans of irrigation pivot 101, corresponding to an area of 69.5 ha, did not receive artificial light(s) supplementation (control). The main composition of the red-green-blue (RGB) light delivered to the soybean plants presented about 59% red, 33% green, and 8% blue. A continuous light band of approximately 40 m wide by 230 m long was projected below the arm extension of the four internal spans of the irrigation pivot 101.

Each light-emitting diode has a power ranging from 50 to 200 W. About 600 W h^{-1} ha^{-1} were consumed during the artificial light(s) supplementation process. The light-emitting diode module were positioned about 3 meters above the aerial parts of the crop 202a plants and distributed to ensure an equally distributed light power in each span of the circular pivot. The luminous flux per unit area at the level of the aerial parts of soybean 202a plants was about 30 lx.

The artificial light(s) supplementation system 100, according to the present invention, was turned on every night after the full sunset and on very cloudy days. Approximately 480 hours of artificial light(s) supplementation was applied throughout the area during the soybean crop 202a cycle. As irrigation pivot 101 completes a turnover the cultivation area 200 in 12.8 hours in a circular routine, each crop 202a plant received about 40 hours of artificial light(s) supplementation during its cycle. During the soybean cycle, foliar fertilizers containing micronutrients, such as boron and manganese, were applied throughout the area [with and without artificial light(s) supplementation] to compensate for the intense development of plants stimulated by artificial light(s) supplementation.

Artificial light(s) supplementation began in V3-V4 (third to fourth fully expanded trifoliated leaf) soybean phenological stage and ended in the R5-R6 soybean phenological stage (full grain stage). The choice of vegetative phenological stage V3-V4 for the beginning of artificial light(s) supplementation allows crop 202a to close the space between lines in the agricultural field 200 and begin cultivation area covering (a situation where the plant’s growth is enough to shelter all exposed soil from an up-sight perspective). If artificial light(s) supplementation is applied before soybean plants cover the cropping area, weed plants start to compete for resources with crop

202a. The plant competition for resources such as water, nutrients, and light, impairs crop performance and yield and increases herbicide costs. In turn, the choice of the end of artificial light(s) supplementation in the reproductive phenological stage R5-R6 is due to the fact that at this stage, the soybean crop 202a reached its final development. However, it should be noted that artificial light(s) supplementation could continue after R5-R6 stage, favoring some extra crop 202a production; however, the benefits would not be higher than the energy costs related to artificial light(s) supplementation beyond this plant stage.

Between the first and second pivot span towers 103a; 103b, a homogeneous area of 50 by 40 m was delimited, corresponding to an area of 2,000 m^2 to be evaluated as the treatment "supplemented by artificial light(s)". The schematization of irrigation pivot 101 according to the experiment can be seen in figure 4, in which the crop 202as under the green span of irrigation pivot 101 received artificial light(s) supplementation, while the rectangles indicate the position of both treatments, with and without artificial light(s) supplementation, and the dots in each rectangle indicate the sampling points.

SOYBEAN EVALUATIONS

The evaluations of plant internode number, plant height from the soil level to the highest node, and pods per plant 202a were assessed weekly from the R3 soybean phenological stage (beginning of the pod formation) to R7 (beginning of soybean maturity). During nine weeks, evaluations were performed weekly; no further evaluation was possible after R7 because the plants in the treatment without artificial light(s) supplementation reached physiological maturity earlier than the plants in the treatment of artificial light(s) supplementation.

In this sense, it is important to highlight the delay of physiological maturity induced by the treatment with artificial light(s) supplementation. This extension of the crop 202a cycle stimulated by artificial light supplementation depends on factors such as the crop 202a species, the geographic region of the cropping area, prevailing climate, crop phenological stage, period of suspension of artificial light(s) supplementation, and the crop management.

The soybean crop 202a, for example, extended its cycle between 5 and 20 days, depending on the cultivar, light management, and cropping region. However, this extension was not prominent in grass crops tested, such as corn, sorghum, and wheat, being only a few days longer than where artificial light(s) supplementation was

not applied. Avoiding any specific theory, this crop cycle extension as affected by artificial light(s) supplementation may be a consequence of a series of metabolic and morphological reactions, such as photomorphogenesis (morphological modification of the 202a culture stimulated by light, which could favor photosynthesis during the day), alteration of the crop 202a predominant photoperiod and crop 202a circadian cycle (modification of the crop 202a routine compared to the period of natural light), regulation of crop 202a secondary metabolism (regulation of natural defenses of crop 202a to stresses), and crop 202a phytochrome activities (photoresponsive substances and response modulators in culture 202a).

Amazingly, it was concluded that through these reactions or stimuli (and other possible causes or joint action of these responses) caused by artificial light(s) supplementation, as well as the correct management of soil and water resources, the crop 202a ends up producing more biomass through a more efficient photosynthesis process. Even after the study, it was observed that the plant stand (quantity of plants per area) could be reduced by about 20%, considering this greater amount of biomass produced (larger canopy and larger root systems). Overall, good productive results were observed, even with smaller stands, which reduces investment in seeds and their agrochemical treatment for sowing, in addition to increasing the sustainability of agricultural activity by producing more food using precise resources and technologies.

The mean measurement of each evaluated variable was estimated from a representative evaluation of the plants 202a in 10 sampling points in each area (2,000 m^2). Each sample point evaluated was considered a replication.

The influence of artificial light(s) supplementation or no artificial light(s) supplementation in each variable was evaluated using the area below the progression curve of each specific variable to interpret the results of the evaluations in various times. The area below the progression curve was calculated by trapezoidal integration area below the progression curve= (dti × ((Yi + Yi+d)/ 2))

Where *dti* is the time interval between every two observations, *Yi* and *Yi + d*. The area below the variable progression curve was calculated based on nine evaluations. Correlations between the area below the progression curve of the evaluated variables were computed to determine whether there was, or not, a linear relationship between them.

The agricultural areas used for each treatment (2,000 m^2) were harvested at 115 and 136 days after sowing without and with artificial light(s) supplementation,

respectively. Grain yield in each area was expressed in kilograms per hectare (kg ha^{-1}).

STATISTICAL ANALYSIS

Extreme values (outliers) in the area below the progression curve of each variable were identified using boxplot graphs of the data residuals. When outliers' values were identified, these were replaced by an average dataset value that does not include the outlier(s). The boxplots were generated in the Software SPSS Statistics®, which was also used to calculate Pearson's correlation coefficients and the basic premises for analysis of variance (ANOVA), normality of residue distribution by Shapiro-Wilk, and homogeneity of variances by Levene, both at $p > 0.01$.

Variance analysis (ANOVA, F test) was performed after confirmation of its assumptions and considering a completely randomized experimental design. When significant differences were observed ($p < 0.05$) in ANOVA, the area below the progression curve of the variables was compared using the Tukey test of averages ($p < 0.05$) to distinguish treatments with artificial light(s) supplementation and without artificial light(s) supplementation. The ANOVA and Tukey test were performed using SISVAR® statistical program. Sigma Plot® v.12 software was used to generate the graphics.

RESULTS

The weekly evaluation data of all variables (number of soybean internodes, plant height, and number of pods per soybean plant) for both treatments with artificial light(s) supplementation and without artificial light(s) supplementation did not include extreme values. This observation indicates that the responses were grouped around an average with low standard error. The soybean variables and their respective standard errors during the nine weeks are presented in Figures 5, 6, and 7, where the lines on the bars indicate the data standard error.

The number of internodes per soybean plant, plant height, and the number of pods per plant treated with artificial light(s) supplementation 202a were higher when compared to the sample without artificial light(s) supplementation 202b. These superior responses can also be observed in Figure 8, where on the left side are represented soybean plants treated with artificial light(s) supplementation 202a at 80 days after sowing, while on the right are represented soybean plants without artificial light(s) supplementation 202b. Each segment on the measuring tape illustrates 0.1 m.

The ANOVA of the area below the progression curve and the assumptions (normality and homogeneity) are presented in Table 2.

TABLE 2

SV	DF	Internodes	Height	Pods per plant
Light supplementation	1	375**	1,590**	2,649**
Error	18			
CV (%)		1.67	1.17	0.98
KS	20	0.935^{+}	0.985^{+}	0.964^{+}
L	1+18	1.139^{+}	0.106^{+}	0.262^{+}

Table 2. Analysis of variance (F test) and statistics of the ANOVA presumptions of the area below the progression curve of the variables number of soybean internodes, plant height, and the number of pods per soybean plant. ** significant differences at 0.01. CV (%) coefficient of variation. KS Kolmogorov-Smirnov statistics for normality of waste distribution ($p > 0.01$). L Levene statistics for homogeneity of data variances ($p > 0.01$). + normality of the residues (KS) or homogeneity of the variances (L) fulfilled.

All the area data below the progression curve of the soybean variables (number of internodes, plant height, and pods per plant) met the assumptions of ANOVA (normality of residue distribution and homogeneity of variances). In addition, the coefficients of variation, CV (%), were very low (< 2%). Thus, it was appropriate to proceed with ANOVA, which indicated significant differences ($p < 0.01$) between treatments [with artificial light(s) supplementation and without artificial light(s) supplementation].

The area below the progression curve of the number of internodes per soybean plant, plant height, and the number of pods per plant in the treatment with light(s) supplementation were 15.6, 23.3, and 25.3% higher than the treatment without artificial light(s) supplementation.

Pearson's calculation and interpretation of correlation require that data be normally distributed and without outliers. These requirements were met, as presented in Table 1. All correlations observed in Table 3 were strong ($r > 0.9$) and obtained statistical significance ($p < 0.01$).

TABLE 3

	Internodes	Plant height	Pods per plant
Internodes	1	0.962**	0.970**
Plant height		1	0.990**
Pods per plant			1

Table 3. Pearson correlation (r) between the area below the progression curve of the variables studied. Internodes number of soybean internodes; Plant height soybean plant height; Pods per plant number of pods per soybean plant. ** significant differences at 0.01.

The evaluated soybean cultivar has a cycle of approximately 17 weeks. On day 115 after sowing, soybean plants from the area without artificial light(s) supplementation 202b (2,000 m^2) were harvested; however, the harvest of soybean plants in the area with artificial light(s) supplementation occurred three weeks later, representing a 17.6% longer crop 202a cycle.

The estimated productivity of the area without artificial light(s) supplementation was about 4,500 kg ha^{-1} (75 bags ha^{-1}; 1 bag = 60 kg), while treatment with artificial light(s) supplementation was about 7,080 kg ha^{-1} (118 bags ha^{-1}). Grain yield under artificial light(s) supplementation was 57.3% higher and 109.5% above the average Brazilian soybean yield (3,379 kg ha^{-1}).

The average cost to produce soybean from soil management to harvesting is about 55 bags of soybean per hectare. The average cost required by artificial light(s) supplementation was about 7 bags ha^{-1}. Thus, the profitability of soybean traditionally produced (without artificial light(s) supplementation) and soybean produced with artificial light(s) supplementation was about 20 and 56 bags ha^{-1}, respectively.

The extension of the soybean crop 202a cycle by three weeks due to artificial light(s) supplementation also increased the period of plant 202a photosynthetic activity. This prolonged cycle also contributes to increasing biomass accumulation via natural daily photosynthesis, an absent process in the regular soybean cultivar cycle (17 weeks) where no artificial light(s) supplementation 202b was applied. This combination of factors resulted in taller soybean plants, with more internodes, more pods, and, consequently, more than 57% extra grain yield.

In the exposed example, the extra yield generated by the application of adequate crop management and artificial light(s) supplementation cannot be attributed only to the hours of artificial light(s) supplementation provided to each soybean crop

202a (about 40 hours). As mentioned above, in addition to the extension of the soybean cycle through artificial light(s) supplementation, other factors should be taken into account, such as photomorphogenesis, alteration of the plant photoperiod and circadian cycle of culture 202a, upper or lower regulation of phytohormones and phytochromes, as well as changes in secondary metabolism of the crop 202a plant, which are factors responsive to artificial light(s) supplementation.

Agricultural inputs such as fertilizers, plant inoculants, and plant protection products, applied during crop 202a cycle 202b, are intended to maximize agricultural production and economic returns. Although such agricultural inputs have adverse effects on soil dynamics and these effects are often overlooked. However, according to the present invention, artificial light(s) supplementation 200 to field crops can potentially reduce the proportional need for such inputs, mainly fertilizers.

The efficiency of fertilization in this exemplified study probably resulted from a significant increase in shoot biomass followed by artificial light(s) supplementation. The increase in the biomass of the shoots, in turn, causes a proportional increase in the biomass of the roots. This improved root development increases the efficiency of absorption of nutrients by the roots, thus increasing fertilizer efficiency.

The present invention is used as a response model to reproducibly understand and apply the consequences and interactions of nutritional, microbiological, environmental, and economic aspects around agricultural production by integrating valuable information on physiological processes, sowing time, irrigation frequency, and time, fertilizer doses, management of insects and plant diseases, and soil relations with the environment. The inclusion of climate information may clarify the relationship between agricultural production and weather fluctuations. This integrated approach increases the resilience of the global food production system and food security against unexpected climate shocks.

Currently, there is a rapid continuous increase in the integration of technologies and digitization in agriculture. This movement is also aligned with the sustainability of the ecosystems explored for agricultural activities. In this sense, before starting cropping, other factors must be considered for a productive and sustainable agricultural activity. Such other factors include crop management strategies and their consequences, the level of technologies implemented, and soil water and nutrient

availability. Although the use of artificial light(s) supplementation on a field scale 200 is a challenge to control, the present invention makes it possible.

The present invention also has great potential to reduce deforestation of new native areas for agricultural production purposes since more food can be produced in the same agricultural area. Although crop 202a productivity can be increased with adequate implementation of artificial light(s) supplementation throughout the crop 202a cycle, the *state of the art* does not reveal the interactions between the different factors. For example, soil, plant, climate, agronomic management, crop 202a performance, yield formation, and cost-benefit ratio indicate its inherent complexity. In addition, the present invention has the potential to reduce the use of agrochemicals, fertilizers, and water since the plant becomes more efficient in soil exploration through an improved root system stimulated by artificial light(s) supplementation and other technologies implemented.

According to the present invention, the production costs of crops 202a cultivated by the artificial light(s) supplementation system 100 depend on several factors. These factors include the efficiency of the available cropping structure, for example, machinery and farm administration; the technology implemented, for example, genetic materials and fertilizers; and the use of precise agricultural systems. Other factors include the characteristics of the irrigation system, for example, the irrigated area and the height of the irrigation pivot 101 that affects light dissipation, artificial light(s) supplementation in areas of static irrigation, soil structuring, for example without physical or chemical limitation, and with healthy microbiota; electricity supply, for example, source, spinning, constancy, and stability, in addition to the internet of things and agronomic management of agricultural crops 202a. Thus, the cost and profitability in this example reflect a specific scenario of soybean production that may vary on a case-by-case basis. Despite this observation, according to the present invention, artificial light(s) supplementation presents an opportunity to improve crop 202a production.

In conclusion, in the exemplified study, the present invention was implemented and delivered approximately 40 hours of artificial light(s) supplementation to each soybean plant were required during the crop 202a cycle to positively affect the number of internodes, pods, plant height, and crop 202a cycle.

Artificial light(s) supplementation, according to the present invention, increased soybean yield by 57.3% and its profitability by 180% in relation to cultivation

processes without artificial light(s) supplementation and proved to be a viable and promising technique to improve sustainably of crop production in the same agricultural field.

Due to the youth of *outdoor* artificial light(s) supplementation technology and due to its success being associated with its application integrated with technically adequate and balanced agriculture, preliminary studies were conducted for other crops besides soybeans (*Glycine max*). However, the results obtained have been positive for biomass production by plants were light(s) supplementation was(were) present. The responses observed for other crops and perceptions of the application of artificial light(s) supplementation integrated with appropriate agronomic technologies and management will be briefly discussed below.

BEANS (*PHASEOLUS VULGARIS*)

The common bean was cultivated in the winter crop season and received artificial light(s) supplementation from post-sowing until pre-harvest. Soil remineralizers and biological products were applied before sowing. The plant stand was reduced by 15% compared to the regular stand recommendation for traditional crop cultivation without artificial light(s) supplementation.

A lower number of fungicide applications and 36% more grain yield were observed in the area that received artificial light(s) supplementation. Other studies with beans were conducted in different regions and confirmed the positive response of this crop when artificial light(s) supplementation is applied according to the present invention.

CORN (*ZEA MAYS*)

Corn was grown in spring/summer and received artificial light(s) supplementation from post-sowing until pre-harvest, as well as soil remineralizers, organominerals, and biological products that were applied to the soil before sowing. In this study, the plant stand (plant number per hectare) was 60% higher than the stand regularly used in traditional cultivation without artificial light(s) supplementation.

Differences were observed among the studied varieties (hybrids), such as plants generally higher (> 4 m), higher average ear number per plant, and greater crop health. Healthier plants in the area that received artificial light(s) supplementation allowed crop cultivation with fewer fungicide applications. Grain yield was 183% higher than the regional grain yield average for the same year.

TOMATO (*SOLANUM LYCOPERSICUM*)

Different varieties of tomato for pulp were evaluated, and the area that received artificial light(s) supplementation presented plants with superior development of the aerial plant part compared to the area without artificial light(s) supplementation. This further development of the aerial part allowed the early plant cover of the space between planting lines and doubled the production of tomato fruits.

Only the area that did not receive artificial light(s) supplementation had problems with calcium deficiency, causing the "*blossom end rot*" symptom in the fruits. In the area that received artificial light(s) supplementation, no such stress was observed that would impair the development of the plants and their respective productions.

Both areas received soil remineralizers and foliar nutrients. Artificial light(s) supplementation occurred throughout the crop cycle in the respective area, and the light color combination used in soybean (59% red, 33% green, and 8% blue) showed excellent results in tomato plant development.

COTTON (*GOSSYPIUM HIRSUTUM*)

Cotton was tested in different regions and different varieties. As observed for the other crops, the aerial part of the cotton plants that received the artificial light(s) supplementation project was significantly higher than the plants that did not receive artificial light(s) supplementation.

The cotton tree that received the artificial light(s) supplementation project produced 20 to 40% more "apples" (structure containing the plume, the cotton fiber) per plant and about 12% more final fiber production. The artificial light(s) supplementation positively impacted the final production and quality of the cotton fiber. The presence of insects in the area that received artificial light(s) supplementation was reduced compared to traditional cotton cultivation without artificial light(s) supplementation.

SUGARCANE (*SACCHARUM OFFICINARUM*)

Artificial light(s) supplementation in sugarcane has brought many beneficial effects. The area received the application of soil remineralizer and was cultivated without any fungicide application. Initially, sugarcane with artificial light(s) supplementation showed a higher number of tillers (seedlings) per clump, which increased the production of crop biomass.

Stem height, total soluble solids content, apparent sucrose, and recovered total sugars were higher in sugarcanes grown with artificial light(s)

supplementation. The "*brown spot*" was a foliar fungal disease that occurred only in the area that did not receive artificial light(s) supplementation, indicating how the present invention promotes not only increases in yield, but also increases the plant resistance to stresses and reduces the cost and environmental impacts with lower frequencies of fungicide application.

TOBACCO (*NICOTIANA TABACUM*)

More vigorous tobacco plants, larger leaves, and higher leaf production were commonly observed in the area that received artificial light(s) supplementation. The tobacco cropping area received the application of soil remineralizer and was cultivated without any application of insecticide or fungicide. Light supplementation with the predominance of blue collors favored the development of tobacco plants.

GARLIC (*ALLIUM SATIVUM*) AND ONION (*ALLIUM CEPA*)

Areas that received the application of soil remineralizer and organominerals were cultivated without any insecticide application and with a reduced amount of fungicide applications. The yields were higher than 80% in the areas that received artificial light(s) supplementation all night during specific periods, both for garlic and onion.

The application of foliar fertilizers was similar between the areas [with or without light(s) supplementation]; however, the excellent plant development caused by artificial light(s) supplementation turned the plant more sensitive to the lack of essential nutrients, especially those required in smaller amounts (micronutrients).

PEA (*PISUM SATIVUM*)

Pea is a crop that responds satisfactorily well to artificial light(s) supplementation. Depending on its application (grain production or cover crop), it should be changed the color composition of artificial light(s) supplementation.

The high pea biomass production, which increased the crop residues added to the soil surface, was produced with a predominance of blue coloration in the artificial light(s) supplementation; however, for exclusive grain production, the composition of artificial light(s) supplementation in soybean (59% red, 33% green and 8% blue) was more adequate.

SUNFLOWER (*HELIANTHUS ANNUUS*)

Artificial light(s) supplementation increased the size of the sunflowers, increasing the production of larger seeds with improved quality parameters such as

size and integrity. Sunflower areas cultivated with artificial light(s) supplementation showed high vegetative-productive development and plant sanity.

In areas where artificial light(s) supplementation was applied, insecticides or fungicides were not applied to the crop plants. The production of sunflower seeds was 44% higher in the area that received the artificial light(s) supplementation compared to the traditional cultivation area without artificial light(s) supplementation.

POTATO (*SOLANUM TUBEROSUM*)

Different varieties and planting stands were studied for potatoes that received artificial light(s) supplementation. Artificial light(s) supplementation in this crop can be used from emergence until about ten days before harvest desiccation. The production occurred with lower use of fungicides compared to the area without artificial light(s) supplementation and the commercial cropping area adjacent to the experimental area 200.

There was a large production of root tubers, and production was about 38% higher than in traditional cultivation without artificial light(s) supplementation. Soil and organomineral remineralizers were used in both areas to complement the basic fertilization and support higher root tuber productions.

HOPS (*HUMULUS LUPULUS*)

The artificial light(s) supplementation applied to hop plants generated promising results. It was possible to develop and harvest the second crop of hops in the same agricultural year, which was not observed in the area without artificial light(s) supplementation. The number of floral cones (structures used as raw material for beer) was much higher, and their dimensions were larger in plants that received artificial light(s) supplementation.

The beer produced using the hops produced with artificial light(s) supplementation did not present any harm in relation to traditional cultivation. Therefore, artificial light(s) supplementation allowed more than doubling the productive capacity of hops in an area, besides not negatively affecting beer production and quality.

STRAWBERRY (*FRAGARIA × ANANASSA*)

Production, fruit sanity, and shelf time were superior for strawberries produced with artificial light(s) supplementation applied throughout the crop cycle. Some strawberry varieties respond better to artificial light(s) supplementation. In

general, reddish artificial light(s) supplementation provides better results in fruit production and seedlings of plant development.

PITAYA (*HYLOCEREUS UNDATUS*)

The number of crops and fruits was positively affected by artificial light(s) supplementation. The harvests became continuous with adequate crop management and artificial light(s) supplementation. About 4 to 6 hours of artificial light(s) supplementation per night were enough to maintain this fruit harvest constancy and increase the number of fruits per plant. With increased harvests per year and fruits per plant, the required amounts of fertilizers, soil pH correctors and conditioners, soil remineralizers, and organominerals were necessary to support the production.

This situation of great fertilizer need to compensate for a higher total production is further indication that the full functioning of artificial light(s) supplementation, according to the present invention, is dependent on other factors that need to be available so that plant responses are not limited by factors whose deficiency may compromise crop full development and yield.

LETTUCE (*LACTUCA SATIVA*) AND ARUGULA (*ERUCA VESICARIA SSP. SATIVA*)

All experiments with horticultural crops with artificial light(s) supplementation showed more accelerated plant development from seedlings to adult plants, allowing for more year-round harvests. In addition, they presented more intense colors and more pleasant flavors.

The use of more bluish artificial light(s) supplementation allowed better results; however, there are significant differences in responses between the varieties studied in each plant species. This observation indicates that each region should be studied for adequate crop varieties to select those with better responses to artificial light(s) supplementation.

COVER CROPS

Different cover crops were responsive to artificial light(s) supplementation, and all responses were positive. The higher the plant biomass (e.g., leaves, stems, and roots) growth, the faster the covering of the cropping area, which improves soil protection and reduces crop competition with invasive plants (weeds). The cropping of solitary crop species (only one predominant species) or mixtures of different species presented improved results under artificial light(s) supplementation.

The use of more bluish artificial light(s) supplementation also allowed better results. However, it was clear how each cover crop (such as Sudan grass, fodder

turnip, millet, crotalaria, wheat, and buckwheat) in different regions presented differentiated responses to the same spectral signature of artificial light(s) supplementation, indicating that different crop species would have distinct and unique spectral band composition for each plant species and edaphoclimatic condition.

The achievements exposed above indicated that the present invention accomplishes significant advances in the application and development of artificial light(s) supplementation, highlighting the beneficial effects of the use of artificial lighting sources 10a, 10b, 10c, 10d, 10e in the metabolism and agronomic management of plants, in the efficiency of light absorption and photosynthesis in their respective aerial parts, as well as in the mitigation of stresses such as insect pests and plant pathogens that can be repelled or controlled in the areas that receive a light(s) supplementation. These effects benefit the agricultural production process by extending the plant resistance to adverse conditions during crop development, improving qualitative and nutritional aspects of the final crop product, and elevating the sustainability of the agricultural activity.

Despite the description of crop yield achievements to specific accomplishments, the present invention may present modifications in its implementation so that the scope of protection of the invention is limited to the content of the attached claims, including possible equivalent variations.

SET OFCLAIMS

1. AGRICULTURAL MANAGEMENT SYSTEM (100) is characterized by comprising:

- a modular agricultural irrigation pivot-like device (101) positioned on an agricultural field (200) in the cultivation of a crop (202a) species, the modular agricultural irrigation pivot-like device (101) comprising:

- a plurality of artificial lighting sources (10a, 10b, 10c, 10d, 10e) arranged along the modular agricultural irrigation pivot-like device (101) at a predetermined distance above the aerial parts of the crop (202a), comprising a plurality of light-emitting diodes; and

- a plurality of energy sources that feed the plurality of artificial lighting sources (10a, 10b, 10c, 10d, 10e),

the agricultural management system (100) further comprising:

a processor in communication with a dimerizer and/or a polarizer of the plurality of artificial lighting sources (10a, 10b, 10c, 10d, 10e) and with the plurality of energy sources, wherein the processor is configured to:

a) adjust (501), in the intervals of the electromagnetic spectrum, the balance between the spectral bands emitted by the plurality of light-emitting diodes; and

b) determine and implement:

- an irrigation routine (502); and/or

- an artificial light(s) supplementation routine (503);

wherein stages a) and b) are determined by the processor considering at least one among:

- a crop (202a) species under cultivation;

- a phenological stage of the crop (202a) under cultivation;

- a photoperiod, a season and current weather conditions under which the agricultural field (200) is subjected; and

- one or more objective(s) intended for the crop (202a) development.

2. SYSTEM (100), according to claim 1, characterized in that stages a) and b) determined by the processor using an artificial intelligence model.

3. SYSTEM (100), according to any of claims 1 and 2, characterized in that the modular agricultural irrigation pivot-like device (101) comprises:

- a drive device for the displacement of the modular agricultural irrigation device (101) over the agricultural field (200); and

- sprinkler devices comprising a plurality of sprinklers,

wherein the processor is in communication with the drive device and with the sprinkler device for the execution of stage b).

4. SYSTEM (100), according to any of claims 1 to 3, characterized by in that a plurality of soil sensors under the agricultural field (200) captures nutritional data of the soil of the agricultural field (200).

5. SYSTEM (100), according to claim 4, characterized in that the processor using all data available from the agricultural field (200):

c) determines and suggests the routines for crop and artificial light(s) supplementation management.

6. SYSTEM (100), according to claim 5, characterized in that stage c) determined by the processor using the artificial intelligence model, considers one of the following:

- the irrigation routine (502);

- the routine of artificial light(s) supplementation (503);

- the crop (202a) species under cultivation;

- the phenological stage of the crop (202a) under cultivation;

- the photoperiod responses, the season and the current weather conditions under which the agricultural field (200) is subjected; and

- the one or more objective(s) intended for the crop (202a) development.

7. SYSTEM (100), according to any of claims 1 to 6, characterized in that the one or more objectives intended for the crop (202a) development under cultivation is/are:

- stimulating or inhibiting a production of leaves, branches, and roots;

- stimulating or inhibiting a production of grains, fibers, fruits, and essences

- stimulating or inhibiting vegetative growth; and

- stimulating photosynthesis.

8. SYSTEM (100), according to any of the claims 1 to 7, characterized in that the routine of artificial light(s) supplementation (503), majorly occurs, but not exclusively, between phenological stages V3-V4 to R5-R6 of the crop (202a) under cultivation.

9. SYSTEM (100), according to any of claims 7 to 8, characterized in that the balance between spectral bands being adjusted (501) to understand compositions of red-green-blue spectral bands presenting at least 40% blue color for vegetative phenological stages and about 60% or at least 40% red color for the reproductive phenological stage of the crop 202a under cultivation, more than 40% red color in the artificial light(s) supplementation is recommended for any plant phenological stage.

10. SYSTEM (100), according to any of the claims 1 to 9, characterized in that the processor further considers:

- the geolocation of the agricultural field (200) and climatic indicators for the determination of agricultural zoning of climatic risk (ZARC) to suggest a crop (202a) to be cultivated, if regional information regarding the most adapted crop varieties is unavailable.

11. SYSTEM (100), according to any of claims 5 to 10, characterized in that an user interface is in communication with the processor, wherein an user feeds the following information to the processor:

- history of crops previously cultivated in the agricultural field (200);

- history of agricultural inputs used in the agricultural field (200);

- occurrence of stresses during the crop (202a) cycle, such as at least one of the following: the occurrence of phytopathology; the occurrence of pests and the occurrence of weeds;

- productivity results from previous harvests; and

- characteristics of the modular agricultural irrigation device (101), among irrigated area, irrigation flow, pivot working speed and height of the agricultural irrigation modular device (101);

wherein stages a), b) and c) are determined by the processor using the artificial intelligence model, considering at least one of the following:

- the crop (202a) species under cultivation;

- the phenological stage of the crop (202a) under cultivation;

- the photoperiod, the season and the current weather conditions under which the agricultural field (200) is subjected;

- the one or more objective(s) for crop (202a) development and responses; and

- the user-fed information through the user interface.

12. SYSTEM (100), according to claim 11, characterized in that the processor using information on the height of the modular agricultural irrigation device (101) to adjust (501) the illumination emitted by the LEDs as a function of the distance of the plurality of artificial lighting sources (10a, 10b, 10c, 10d, 10e) for the crop (202a) under cultivation.

13. SYSTEM (100), according to claims 1 to 12, characterized in that the plurality of energy sources being a plurality of photovoltaic and wind cells for energy production to support the energy needed for the artificial light(s) supplementation working during nights (majorly).

14. SYSTEM (100), according to claim 13, characterized in that the processor, in communication with a plurality of photosensor cells, determines a threshold of incidence of sunlight in the photovoltaic cells, for which below this, and depending on a certain routine of artificial light(s) supplementation (503), a processor commands the performance of the plurality of light-emitting diodes.

15. SYSTEM (100), according to any of claims 1 to 12, characterized in that the plurality of energy sources being at least one of the following: wind, thermal, or combustion generators.

16. SYSTEM (100), according to claim 15, characterized in that the processor using information of insolation index and cloudiness to determine a threshold of incidence of sunlight in the agricultural field (200) for which below this, and depending on a certain routine of artificial light(s) supplementation (503), the processor commands the performance of the plurality of light-emitting diodes.

17. SYSTEM (100), according to any of claims 1 to 16, characterized in that the crop under cultivation being at least one of: soybean, beans, corn, tomato, carrot, cotton, sugar cane, tobacco, garlic, onion, pea, sunflower, sorghum, potato, hops, strawberry, pitaya, lettuce, arugula, oats, coffee, and soil cover crops and grasses.

18. AGRICULTURAL MANAGEMENT METHOD (500), for the cultivation of a crop (202a) in an agricultural field (200), characterized by comprising the steps of:

a) adjusting (501), in intervals of the electromagnetic spectrum, the balance between the spectral bands emitted by a plurality of light-emitting diodes of a plurality of artificial lighting sources (10a, 10b, 10c, 10d, 10e); and

b) determining and implementing:

- an irrigation routine (502) of a modular agricultural irrigation device (101); and/or

- a routine of artificial light(s) supplementation (503) of the plurality of artificial lighting sources (10a, 10b, 10c, 10d, 10e);

wherein stages a) and b) are determined considering at least one among:

- a crop (202a) species under cultivation;

- a phenological stage of the crop (202a) under cultivation;

- a season, a photoperiod, and current weather conditions under which the agricultural field (200) is subjected; and

- one or more objective(s) intended for the crop (202) development.

19. METHOD (500), according to claim 18, characterized in that stages a) and b) are determined by the processor using an artificial intelligence model.

20. METHOD (500), according to any of the claims 18 to 19, is characterized by further comprising a stage c) of determining a routine of soil management in the agricultural field (200) based on soil analyses from the agricultural field (200).

21. METHOD (500), according to claim 20, characterized in that stage c) of determining through the artificial intelligence model considers at least one of the following:

- the irrigation routine (502);

- the routine of artificial light(s) supplementation (503);

- the crop (202a) species under cultivation;

- the phenological stage of the crop (202a) under cultivation;

- the photoperiod, the season and the current weather conditions under which the agricultural field (200) is subjected; and

- the one or more objective(s) intended for the crop (202a) development.

22. METHOD (500), according to any of the claims 18 to 21, characterized in that the one or more objectives intended for the crop (202a) development to:

- stimulate or inhibit the production of leaves, branches, and roots;

- stimulate or inhibit the production of grains, fibers, fruits, and essences - stimulate or inhibit vegetative growth; and - stimulate photosynthesis.

23. METHOD (500), according to any of the claims 18 to 22, characterized in that the routine of artificial light(s) supplementation (503) that majorly,

but not always, occurs between phenological stages V3-V4 to R5-R6 of the crop (202a) under cultivation.

24. METHOD (500), according to any of the claims 22 to 23, characterized in that the balance between the spectral bands being adjusted (501) to understand compositions of red-green-blue spectral bands that should present at least 40% blue color for vegetative phenological stages and about 60% or at least 40% red color for the reproductive phenological stage of the crop 202a under cultivation, more than 40% red color in the artificial light(s) supplementation is recommended for any plant phenological stage.

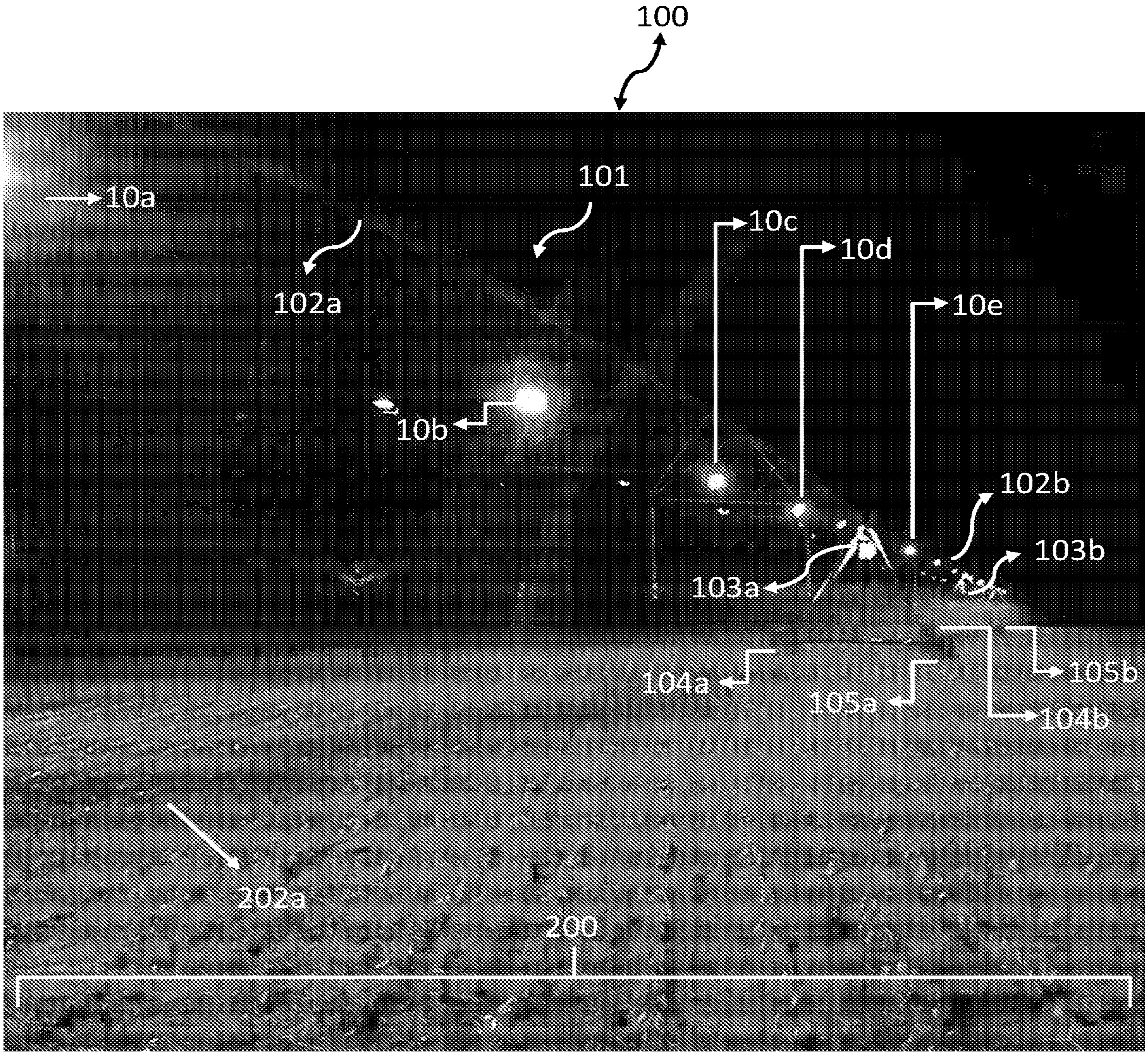
100
10a
101
102a
10c
10d
10e
10b
102b
103b
103a
104a
105a
105b
104b
202a
200

Figure 1

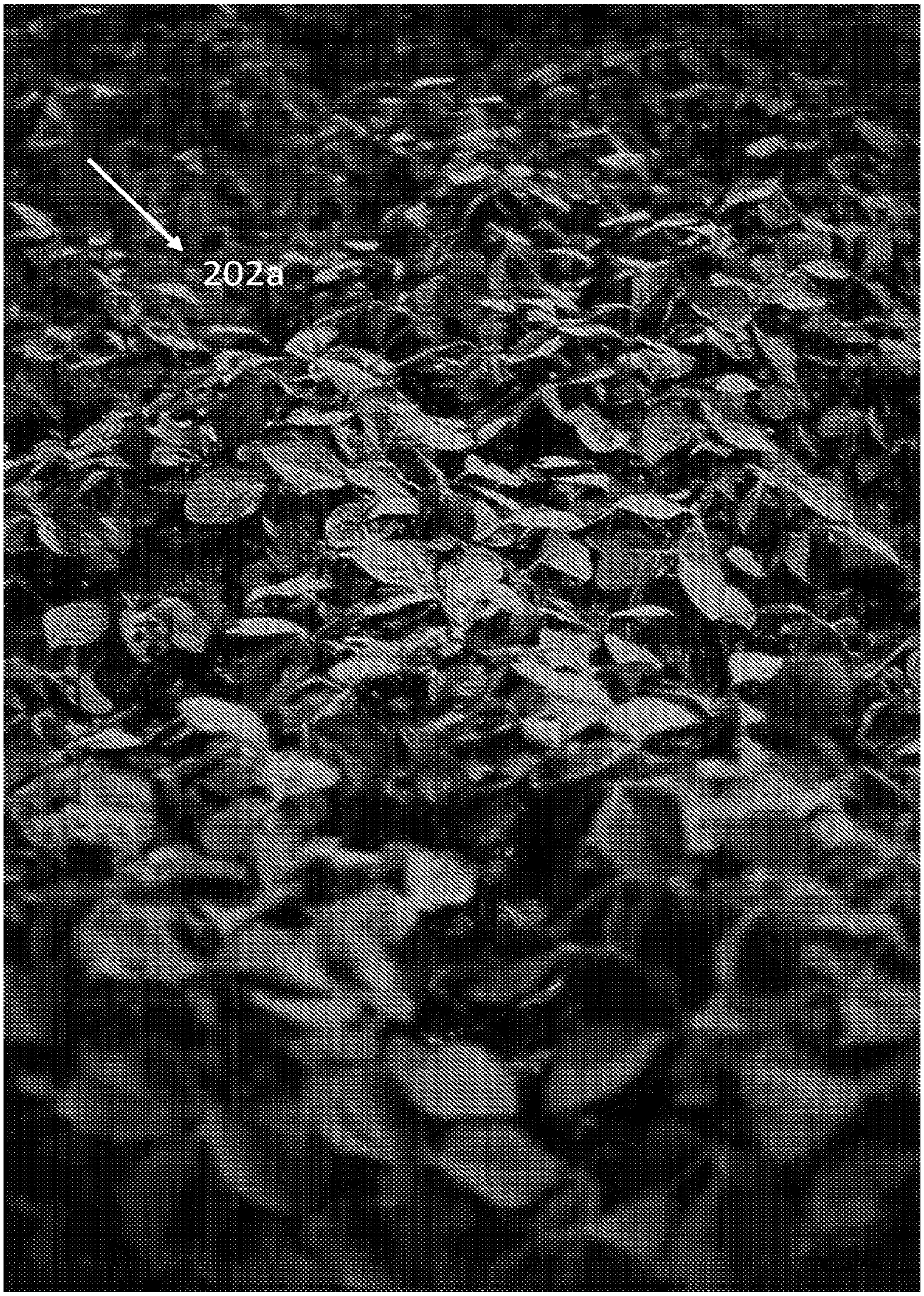

Figure 2

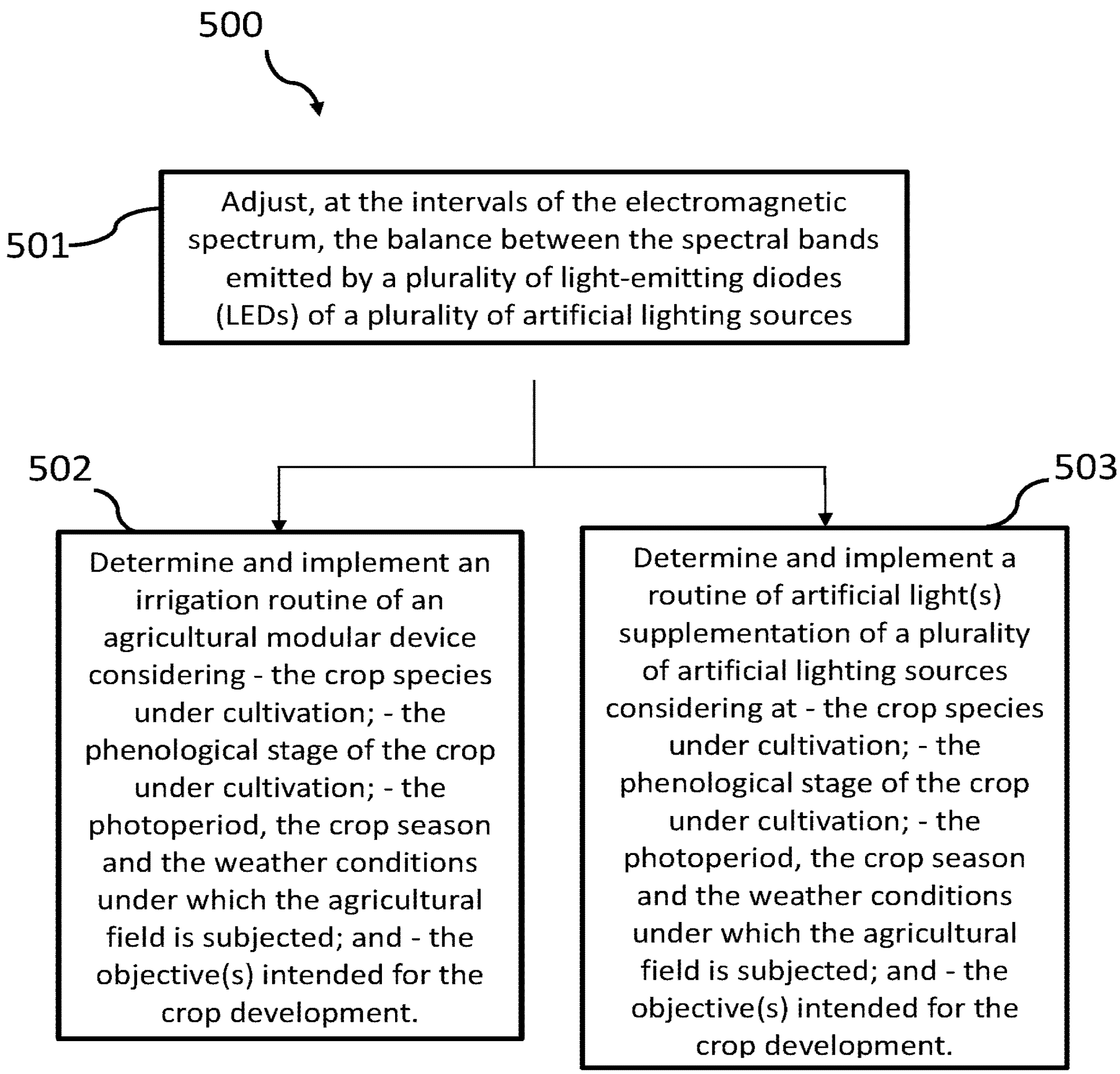
500
501
Adjust, at the intervals of the electromagnetic spectrum, the balance between the spectral bands emitted by a plurality of light-emitting diodes (LEDs) of a plurality of artificial lighting sources
502
Determine and implement an irrigation routine of an agricultural modular device considering - the crop species under cultivation; - the phenological stage of the crop under cultivation; - the photoperiod, the crop season and the weather conditions under which the agricultural field is subjected; and - the objective(s) intended for the crop development.
503
Determine and implement a routine of artificial light(s) supplementation of a plurality of artificial lighting sources considering at - the crop species under cultivation; - the phenological stage of the crop under cultivation; - the photoperiod, the crop season and the weather conditions under which the agricultural field is subjected; and - the objective(s) intended for the crop development.

Figure 3

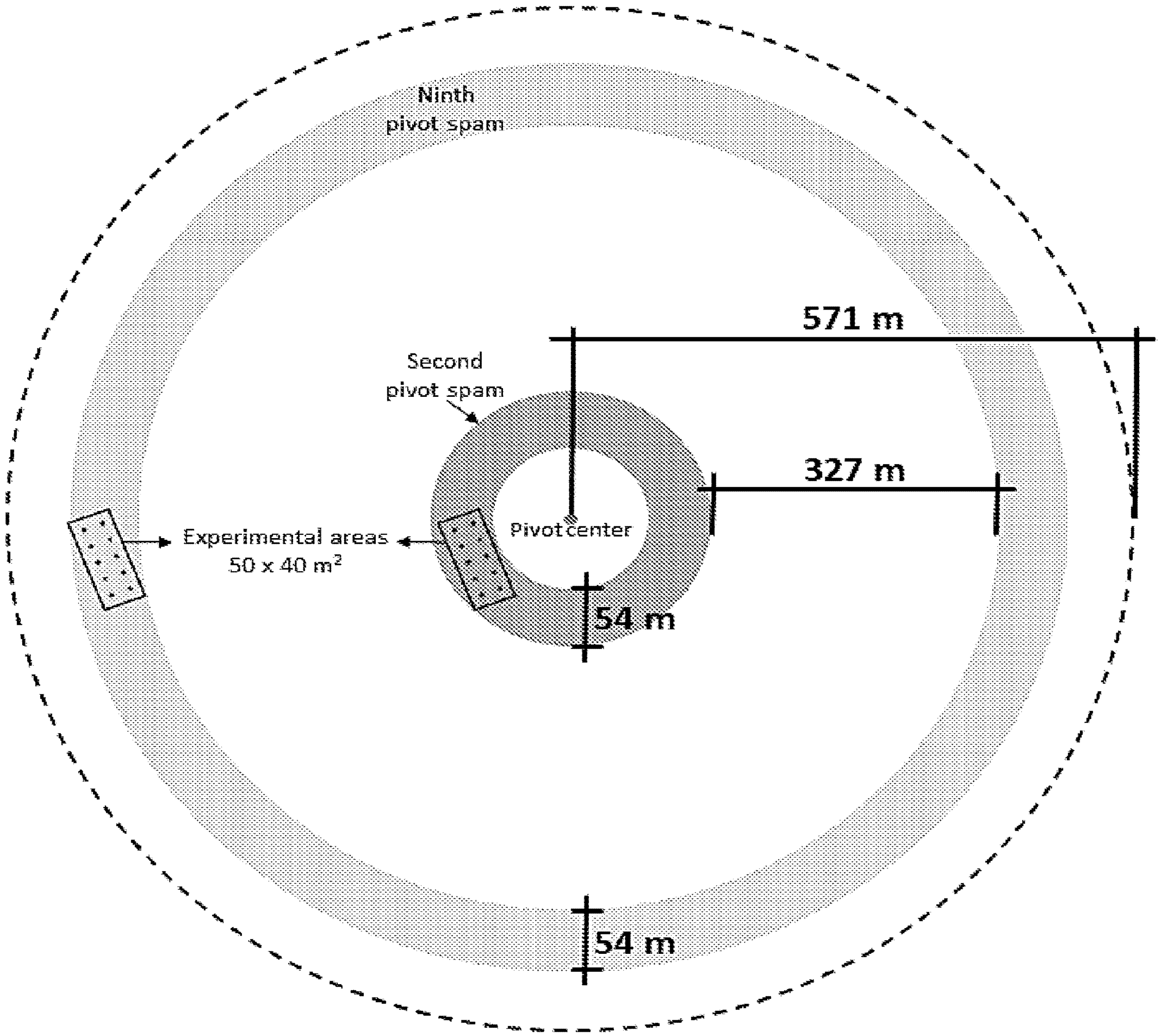
Ninth
pivot spam
571 m
Second
pivot spam
327 m
Pivot center
Experimental areas
50 x 40 m²
54 m
54 m

Figure 4

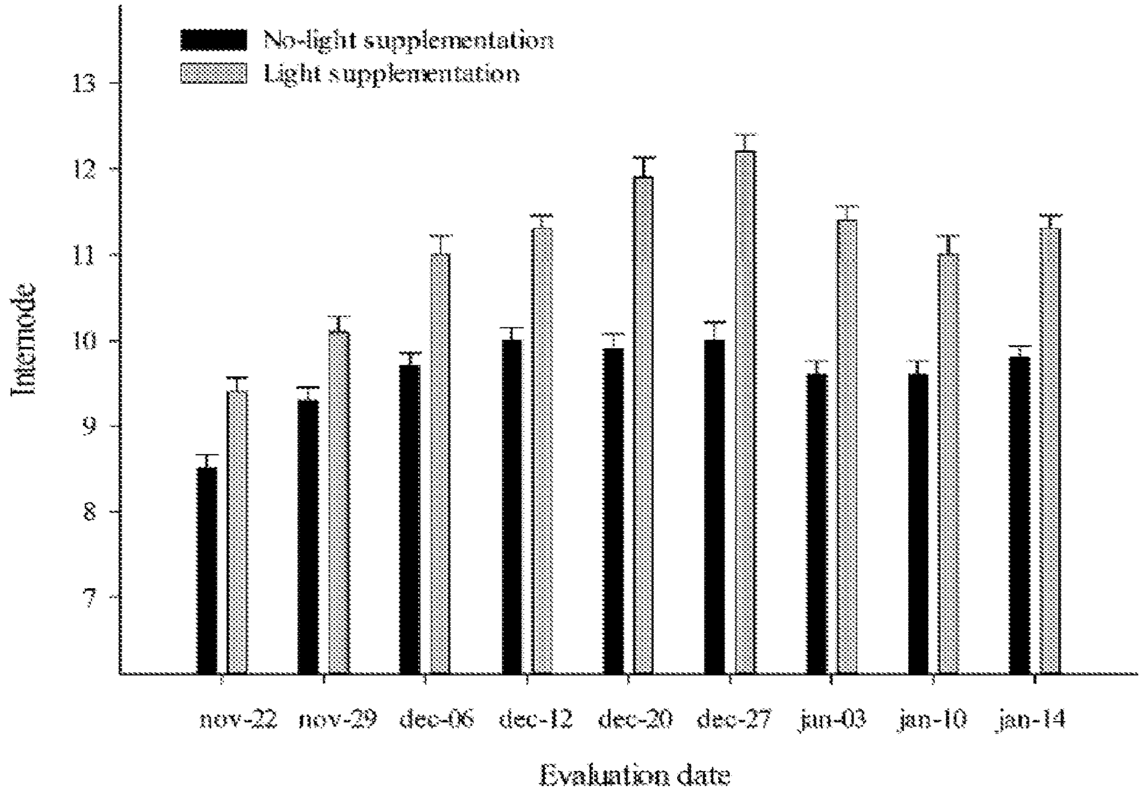
No-light supplementation
Light supplementation
13
12
11
10
9
8
7
Internode
nov-22
nov-29
dec-06
dec-12
dec-20
dec-27
jan-03
jan-10
jan-14
Evaluation date

Figure 5

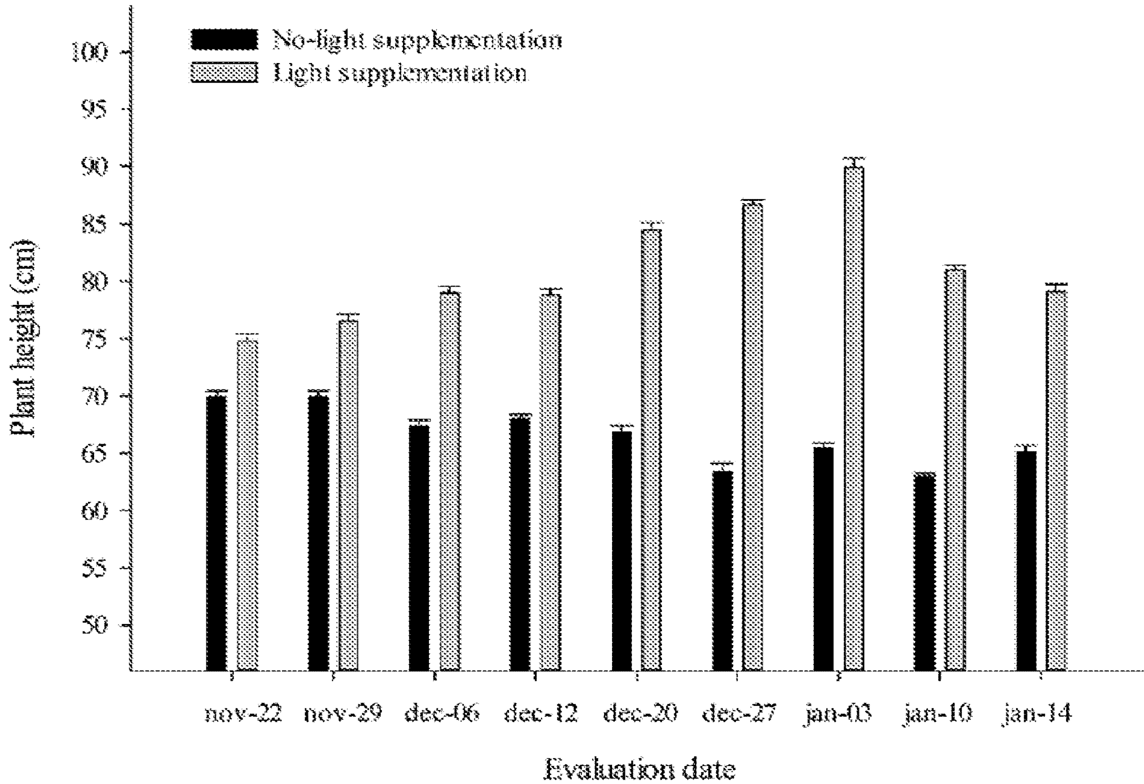
No-light supplementation
Light supplementation
Plant height (cm)
100
95
90
85
80
75
70
65
60
55
50
nov-22
nov-29
dec-06
dec-12
dec-20
dec-27
jan-03
jan-10
jan-14
Evaluation date

Figure 6

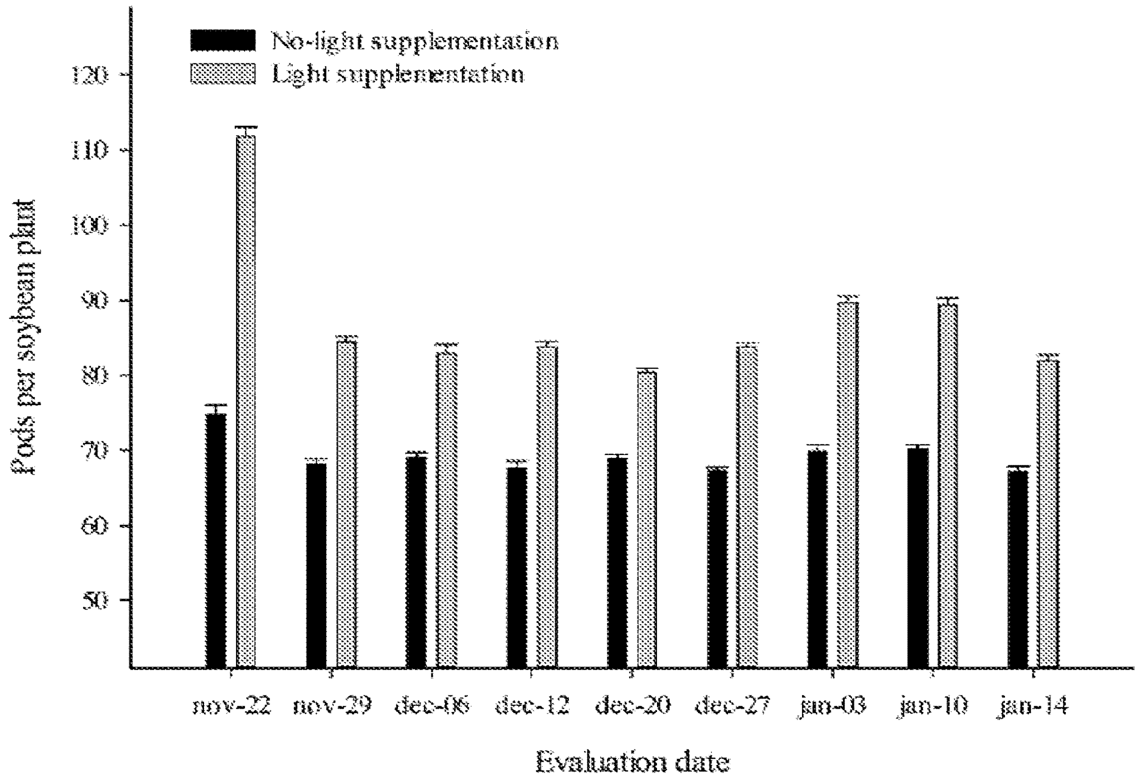
No-light supplementation
Light supplementation
Pods per soybean plant
120
110
100
90
80
70
60
50
nov-22
nov-29
dec-06
dec-12
dec-20
dec-27
jan-03
jan-10
jan-14
Evaluation date

Figure 7

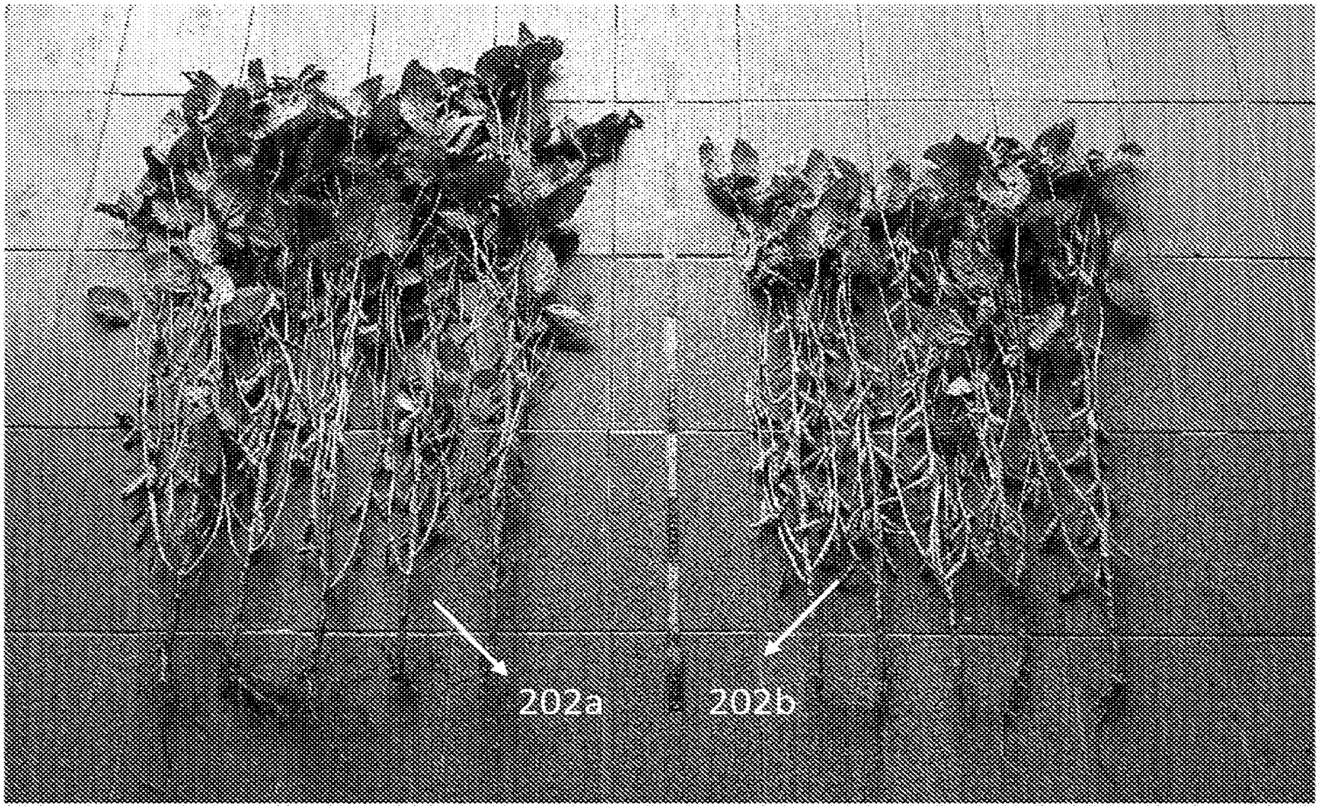

Figure 8

SCORE Placeholder Sheet for IFW Content

Application Number: 18292837 Document Date: 01/26/2024

The presence of this form in the IFW record indicates that the following document type was received in electronic format on the date identified above. This content is stored in the SCORE database.

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- Drawing

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Form Revision Date: March 1, 2019

PTO/SB/20GLBL (04-15)
Approved for use through 04/30/2018. OMB 0651-0058
U.S. Patent and Trademark Office; U.S DEPARTMENT OF COMMERCE

REQUEST FOR PARTICIPATION IN THE GLOBAL/IP5 PATENT PROSECUTION HIGHWAY (PPH) PILOT PROGRAM IN THE USPTO

Application No.:	Not Yet Assigned	First Named Inventor:	Gustavo Alexandre GROSSI
Filing Date:	January 26, 2024	Attorney Docket No.:	092210-786599
Title of the Invention:	SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT		

THIS REQUEST FOR PARTICIPATION IN THE PPH PILOT PROGRAM ALONG WITH THE REQUIRED DOCUMENTS MUST BE SUBMITTED VIA EFS-WEB. INFORMATION REGARDING EFS-WEB IS AVAILABLE AT HTTP://WWW.USPTO.GOV/PATENTS-APPLICATION-PROCESS/FILING-ONLINE/ABOUT-EFS-WEB.

APPLICANT HEREBY REQUESTS PARTICIPATION IN THE PATENT PROSECUTION HIGHWAY (PPH) PILOT PROGRAM AND PETITIONS TO MAKE THE ABOVE-IDENTIFIED APPLICATION SPECIAL UNDER THE PPH PILOT PROGRAM.

Office of earlier examination (OEE): United States (United States Patent and Trademark Office)

OEE application number: PCT/BR2022/050461

Both the OEE application and the above-identified U.S. application have the following earliest date (filing or priority date): April 14, 2022

Type of OEE work product relied upon: Written Opinion of the International Searching Authority (WO/ISA)

Mailing date of OEE work product: April 24, 2023

Supporting Documents

One or more of the required documents below may be available electronically from the Dossier Access System or PATENTSCOPE (see https://www.jpo.go.jp/ppph-portal/filewrapper.htm). If the applicant requests the USPTO to attempt to obtain a document electronically and such attempt is unsuccessful, the applicant will be required to supply the document. Accordingly, to avoid dismissal of the initial PPH request and potential denial of participation in the PPH program, the applicant should verify that the document is actually available via the Dossier Access System or PATENTSCOPE before requesting retrieval. If the applicant is unable to verify availability, then the applicant should submit the document with the PPH request.

1. OEE Work Product and Translation
A copy of the OEE work product and translation if not already in English:

- [x] Attached
- [ ] Previously submitted
- [ ] Not required because the decision to grant a patent was the first office action
- [ ] Applicant requests the USPTO to attempt to obtain the document(s) from the Dossier Access System or PATENTSCOPE

2. References Cited in OEE Work Product
A listing of references cited in the OEE work product and document copies (except U.S. patents and U.S. published patent applications):

- [x] Attached
- [ ] Previously Submitted
- [ ] Not required because no references were cited in the OEE work product
- [ ] Applicant requests the USPTO to attempt to obtain the document(s) from the Dossier Access System or PATENTSCOPE

REQUEST FOR PARTICIPATION IN THE GLOBAL/IP5 PPH PILOT PROGRAM IN THE USPTO
(continued)

Application No.:	Not Yet Assigned	First Named Inventor:	Gustavo Alexandre GROSSI

3. Claims Correspondence Certification Statement

All of the claims in this application sufficiently correspond to the patentable/allowable claims in the OEE application.

4. Claims Correspondence Table

Claims in US Application	Patentable Claims in OEE Application	Explanation regarding the correspondence
1		Identical
2	2	Identical
3	3	Substantially Identical (multiple dependencies removed)
4-17	4-17	Cancelled
18	18	Identical
19	19	Identical
20	20	Substantially Identical (multiple dependencies removed)
21	21	Identical
22-24	22-24	Cancelled

Signature /R. James Balls/	Date January 26, 2024
Name (Print/Typed) R. James Balls	Registration Number 57703

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The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To: CAROLINA NAKATA
AV. BRIGADEIRO FARIA LIMA, 1485 - 11O
ANDAR- TORRE NORTE
01452-002 SAO PAULO-SP
BRASIL

PCT

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing (*day/month/year*) APR 24 2023

Applicant's or agent's file reference	FOR FURTHER ACTION
3610-0016	See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/BR 22/50461	24 November 2022 (24.11.2022)	14 April 2022 (14.04.2022)

International Patent Classification (IPC) or both national classification and IPC
IPC - INV. A01G 7/04, A01G 9/20, H05B 47/10 (2023.01)
ADD. A01G 25/09 (2023.01)
CPC - INV. A01G 7/045, A01G 9/20, A01G 9/249, H05B 47/10
ADD. A01G 25/09

Applicant FIENILE AGRONEGOCIOS LTDA

1. This opinion contains indications relating to the following items:

- [X] Box No. I Basis of the opinion
- [ ] Box No. II Priority
- [X] Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- [ ] Box No. IV Lack of unity of invention
- [X] Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- [ ] Box No. VI Certain documents cited
- [ ] Box No. VII Certain defects in the international application
- [X] Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/US	Date of completion of this opinion	Authorized officer
Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	3 April 2023 (03.04.2023)	Kari Rodriquez PCT Help Desk Telephone No. 571-272-4300

Form PCT/ISA/237 (cover sheet) (revised July 2022)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/BR 22/50461

Box No. I **Basis of this opinion**

1. With regard to the **language**, this opinion has been established on the basis of:

[X] the international application in the language in which it was filed.

[ ] a translation of the international application into ______________ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. [ ] This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(b)).

3. [ ] With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:

   a. [ ] forming part of the international application as filed.

   b. [ ] furnished subsequent to the international filing date for the purposes of international search (Rule 13ter.1(a)),

      [ ] accompanied by a statement to the effect that the sequence listing does not go beyond the disclosure in the international application as filed.

4. [ ] With regard to any nucleotide and/or amino acid sequence disclosed in the international application, this opinion has been established to the extent that a meaningful opinion could be formed without a WIPO Standard ST.26 compliant sequence listing.

5. Additional comments:

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.

PCT/BR 22/50461

Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non obvious), or to be industrially applicable have not been examined in respect of:

☐ the entire international application.

☒ claims Nos. 4-17, 22-24

because:

☐ the said international application, or the said claims Nos. ______ relate to the following subject matter which does not require an international search *(specify)*:

☒ the description, claims or drawings *(indicate particular elements below)* or said claims Nos. 4-17, 22-24 are so unclear that no meaningful opinion could be formed *(specify)*:

because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

☐ the claims, or said claims Nos. ______ are so inadequately supported by the description that no meaningful opinion could be formed *(specify)*:

☒ no international search report has been established for said claims Nos. 4-17, 22-24

☐ a meaningful opinion could not be formed without the sequence listing; the applicant did not, within the prescribed time limit:

- ☐ furnish a sequence listing in the form of an Annex C/ST.25 text file, and such listing was not available to the International Searching Authority in the form and manner acceptable to it; or the sequence listing furnished did not comply with the standard provided for in Annex C of the Administrative Instructions.
- ☐ furnish a sequence listing on paper or in the form of an image file complying with the standard provided for in Annex C of the Administrative Instructions, and such listing was not available to the International Searching Authority in the form and manner acceptable to it; or the sequence listing furnished did not comply with the standard provided for in Annex C of the Administrative Instructions.
- ☐ pay the required late furnishing fee for the furnishing of a sequence listing in response to an invitation under Rule 13*ter*.1(a) or (b).

☐ See Supplemental Box for further details.

Form PCT/ISA/237 (Box No. III) (revised July 2022)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No. PCT/BR 22/50461

Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-3, 18-21	YES
	Claims	NONE	NO
Inventive step (IS)	Claims	1-3, 18-21	YES
	Claims	NONE	NO
Industrial applicability (IA)	Claims	1-3, 18-21	YES
	Claims	NONE	NO

2. Citations and explanations:

Claims 1-3 and 18-21 meet the criteria of PCT Article 33(2) - 33(3) because, as will be shown, the prior art does not teach, nor does it fairly suggest, the claimed limitations.

Regarding claims 1-3 and 18-21, the most similar prior art is exemplified by 1) US 2020/0359550 A1 to Tran; and 2) US 2013/0263503 A1 to Firefly-One, LLC (hereinafter 'Firefly').

1) Tran teaches an agricultural method (Fig. 1A-6), the method comprising:
selecting a seed with predetermined end product properties (para [0233]-[0236]);
selecting microbes to assist seed growth and providing the microbes to help the seed during early stage growth (Fig. 4C, 4D; para [0244], [0245]);
planting the seed on a farm and periodically capturing growth data with one or more sensors (Fig. 1A-6; para [0270], [0271]);
storing the growth data on a blockchain (para [0305]-[0312]);
viewing the growth data by an interested party [0004]); and
controlling an irrigation system in response to the growth data (para [0158]).
2) Firefly teaches a system for encouraging maturation and growth of a plant (the system 2 – Fig. 1-6; para [0025], [0026]), comprising:
at least one stroboscopic lamp adapted to be disposed adjacent the plant (the stroboscopic lamp 14 – Fig. 1-6; para [0026], [0027]);
a controller in communication with and controlling the at least one stroboscopic lamp, the controller configured to cycle the stroboscopic lamp through at least one on-period and at least one off-period for a predetermined cycling time (the controller 8 – Fig. 1-6; para [0028]-[0030]).

Regarding claim 1 (NOTE: See Box VIII), Tran teaches an agricultural method (Fig. 1A-6), the method comprising:
selecting a seed with predetermined end product properties (para [0233]-[0236]);
selecting microbes to assist seed growth and providing the microbes to help the seed during early stage growth (Fig. 4C, 4D; para [0244], [0245]);
planting the seed on a farm and periodically capturing growth data with one or more sensors (Fig. 1A-6; para [0270], [0271]);
storing the growth data on a blockchain (para [0305]-[0312]);
viewing the growth data by an interested party [0004]); and
controlling an irrigation system in response to the growth data (para [0158]), and
Firefly teaches a system for encouraging maturation and growth of a plant (the system 2 – Fig. 1-6; para [0025], [0026]), comprising:
at least one stroboscopic lamp adapted to be disposed adjacent the plant (the stroboscopic lamp 14 – Fig. 1-6; para [0026], [0027]);
a controller in communication with and controlling the at least one stroboscopic lamp, the controller configured to cycle the stroboscopic lamp through at least one on-period and at least one off-period for a predetermined cycling time (the controller 8 – Fig. 1-6; para [0028]-[0030]),
but the prior art does not teach nor fairly suggest the combination of a modular agricultural irrigation pivot-like device positioned on an agricultural field in the cultivation of a crop species, the modular agricultural irrigation pivot-like device including a plurality of artificial lighting sources arranged along the modular agricultural irrigation pivot-like device at a predetermined distance above the aerial parts of the crop, comprising a plurality of light-emitting diodes, and a plurality of energy sources that feed the plurality of artificial lighting sources, the agricultural management system further including a processor in communication with a dimerizer and/or a polarizer of the plurality of artificial lighting sources and with the plurality of energy sources, wherein the processor is configured to: a) adjust, in the intervals of the electromagnetic spectrum, the balance between the spectral bands emitted by the plurality of light-emitting diodes; and b) determine and implement: an irrigation routine; and/or an artificial light(s) supplementation routine, and wherein stages a) and b) are determined by the processor considering at least one among: a crop species under cultivation; a phenological stage of the crop under cultivation; a photoperiod, a season and current weather conditions under which the agricultural field is subjected; and one or more objective(s) intended for the crop development.

Regarding claims 2 and 3 (NOTE: See Box VIII), the prior art does not teach or fairly suggest the system as claimed since they are dependent on claim 1.

Please See Supplemental Box

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

Regarding claim 1, the recitation 'Agricultural Management System' lacks proper antecedent basis. Accordingly, claim 1 is interpreted to recite 'An agricultural management system'.

Regarding claims 2 and 3, the recitation 'System, according to claim' lacks proper antecedent basis. Accordingly, claims 2 and 3 are interpreted to recite 'The system according to claim'.

Regarding claim 18, the recitation 'Agricultural Management Method' lacks proper antecedent basis. Accordingly, claim 18 is interpreted to recite 'An agricultural management method'.

Regarding claims 19-21, the recitation 'Method, according to claim' lacks proper antecedent basis. Accordingly, claims 19-21 are interpreted to recite 'The method according to claim'.

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of:
Box No. V.2. Citations and Explanations:

Regarding claim 18 (NOTE: See Box VIII), Tran teaches an agricultural method (Fig. 1A-6), the method comprising:
selecting a seed with predetermined end product properties (para [0233]-[0236]);
selecting microbes to assist seed growth and providing the microbes to help the seed during early stage growth (Fig. 4C, 4D; para [0244], [0245]);
planting the seed on a farm and periodically capturing growth data with one or more sensors (Fig. 1A-6; para [0270], [0271]);
storing the growth data on a blockchain (para [0305]-[0312]);
viewing the growth data by an interested party [0004]); and
controlling an irrigation system in response to the growth data (para [0158]), and
Firefly teaches a system for encouraging maturation and growth of a plant (the system 2 – Fig. 1-6; para [0025], [0026]), comprising:
at least one stroboscopic lamp adapted to be disposed adjacent the plant (the stroboscopic lamp 14 – Fig. 1-6; para [0026], [0027]);
a controller in communication with and controlling the at least one stroboscopic lamp, the controller configured to cycle the stroboscopic lamp through at least one on-period and at least one off-period for a predetermined cycling time (the controller 8 – Fig. 1-6; para [0028]-[0030]),
but the prior art does not teach nor fairly suggest the combination of an agricultural management method, for the cultivation of a crop in an agricultural field, including a) adjusting, in intervals of the electromagnetic spectrum, the balance between the spectral bands emitted by a plurality of light-emitting diodes of a plurality of artificial lighting sources; and b) determining and implementing: an irrigation routine of a modular agricultural irrigation device; and/or a routine of artificial light(s) supplementation of the plurality of artificial lighting sources; wherein stages a) and b) are determined considering at least one among: a crop species under cultivation; a phenological stage of the crop under cultivation; a season, a photoperiod, and current weather conditions under which the agricultural field is subjected; and one or more objective(s) intended for the crop (202) development.

Regarding claims 19-21 (NOTE: See Box VIII), the prior art does not teach or fairly suggest the method as claimed since they are dependent on claim 18.

Claims 1-3 and 18-21 have industrial applicability as defined by PCT Article 33(4) because the subject matter can be made or used by industry.

ABSTRACT

SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT

The system (100) comprises a modular agricultural irrigation pivot-like device (101) positioned on an agricultural field (200) in the cultivation of a crop (202a), the device (101) comprising artificial lighting sources (10a, 10b, 10c, 10d, 10e) arranged along the irrigation pivot device (101) at a predetermined distance above the aerial parts of the crop, comprising LEDs, and a plurality of energy sources that feed a plurality of artificial lighting sources, a processor in communication with a dimerizer and/or polarizer of artificial lighting sources and with power sources, wherein a processor a) adjusts (501), in the intervals of the electromagnetic spectrum, the balance between the spectral bands emitted by the light-emitting diodes; and b) determines and implements - an irrigation routine (502); and/or - light(s) supplementation routine (503); in which stages a) and b) are determined by a processor different parameters.

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING
AVAILABILITY OF THE PUBLICATION
OF THE INTERNATIONAL APPLICATION

To:

NAKATA, Carolina
AV. BRIGADEIRO FARIA LIMA, 1485 - 11o ANDAR -
TORRE NORTE
01452-002 São Paulo-SP
BRÉSIL

Date of mailing *(day/month/year)* 19 October 2023 (19.10.2023)		
Applicant's or agent's file reference 3610-0016	**IMPORTANT NOTICE**	
International application No. PCT/BR2022/050461	International filing date *(day/month/year)* 24 November 2022 (24.11.2022)	Priority date *(day/month/year)* 14 April 2022 (14.04.2022)
Applicant FIENILE AGRONEGÓCIOS LTDA		

The applicant is hereby **notified** that the International Bureau:

☒ has **published** the above-indicated international application on 19 October 2023 (19.10.2023) under No. WO 2023/197049

☐ has **republished** the above-indicated international application on ____________________ under No. WO ____________________
For an explanation as to the reason for this republication of the international application, reference is made to INID codes (15), (48) or (88) *(as the case may be)* on the front page of the published international application.

- A copy of the international application is available for viewing and downloading on WIPO's website at the following address: https://patentscope.wipo.int/ (in the appropriate field of the structured search, enter the PCT or WO number).

- The applicant may also obtain a paper copy of the published international application from the International Bureau by sending an e-mail to patentscope@wipo.int or by submitting a written request to the contact details provided below.

Warning: Following publication of the international application, applicants, agents and inventors may receive misleading requests for payment of fees that appear to come from the International Bureau of WIPO or other patent Offices which are unrelated to the processing of international applications under the PCT.

Agents are particularly encouraged to be vigilant and alert their clients about this practice. Examples of such requests for payment which have been received by the International Bureau can be found at: http://www.wipo.int/pct/en/warning/pct_warning.html.

Please forward copies of any such requests to pct.legal@wipo.int.

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer Simin Baharlou e-mail pct.team9@wipo.int Telephone No. +41 22 338 74 09

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference		FOR FURTHER ACTION
3610-0016		see Form PCT/ISA/220 as well as, where applicable, item 5 below.
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/BR 22/50461	24 November 2022 (24.11.2022)	14 April 2022 (14.04.2022)
Applicant FIENILE AGRONEGOCIOS LTDA		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 7 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language**, the international search was carried out on the basis of:
      ☒ the international application in the language in which it was filed.
      ☐ a translation of the international application into ______________ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).
   b. ☐ This international search report has been established taking into account **the rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).
   c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.
2. ☒ **Certain claims were found unsearchable** (see Box No. II).
3. ☐ **Unity of invention is lacking** (see Box No. III).
4. With regard to the **title**,
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established by this Authority to read as follows:
5. With regard to the **abstract**,
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.
6. With regard to the **drawings**,
   a. the figure of the **drawings** to be published with the abstract is Figure No. 4
      ☒ as suggested by the applicant.
      ☐ as selected by this Authority, because the applicant failed to suggest a figure.
      ☐ as selected by this Authority, because this figure better characterizes the invention.
   b. ☐ none of the figures is to be published with the abstract.

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 4-17, 22-24
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/BR 22/50461

A. CLASSIFICATION OF SUBJECT MATTER

IPC - INV. A01G 7/04, A01G 9/20, H05B 47/10 (2023.01)

ADD. A01G 25/09 (2023.01)

CPC - INV. A01G 7/045, A01G 9/20, A01G 9/249, H05B 47/10

ADD. A01G 25/09

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
See Search History document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2020/0359550 A1 (Tran), 19 November 2020 (19.11.2020), entire document, especially Fig. 1A-6; para [0233]-[0236], [0244], [0245], [0270], [0271], [0305]-[0312].	1-3, 18-21
A	US 2013/0263503 A1 (Firefly-One, LLC), 10 October 2013 (10.10.2013), entire document, especially Fig. 1-6; para [0025]-[0030].	1-3, 18-21
A	US 2016/0262313 A1 (LED Living Technology), 15 September 2016 (15.09.2016), entire document.	1-3, 18-21
A	US 2012/0038281 A1 (Verfuerth), 16 February 2012 (16.02.2012), entire document.	1-3, 18-21
A	US 2002/0154504 A1 (Fang et al.), 24 October 2002 (24.10.2002), entire document.	1-3, 18-21

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"D" document cited by the applicant in the international application

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 March 2023 (30.03.2023)	APR 24 2023

Name and mailing address of the ISA/US	Authorized officer
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Kari Rodriquez Telephone No. PCT Helpdesk: 571-272-4300

Form PCT/ISA/210 (second sheet) (July 2022)

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To: CAROLINA NAKATA
AV. BRIGADEIRO FARIA LIMA, 1485 - 11O
ANDAR- TORRE NORTE
01452-002 SAO PAULO-SP
BRASIL

PCT

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing *(day/month/year)*	APR 24 2023
Applicant's or agent's file reference 3610-0016	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/BR 22/50461	24 November 2022 (24.11.2022)	14 April 2022 (14.04.2022)

International Patent Classification (IPC) or both national classification and IPC

IPC - INV. A01G 7/04, A01G 9/20, H05B 47/10 (2023.01)
ADD. A01G 25/09 (2023.01)

CPC - INV. A01G 7/045, A01G 9/20, A01G 9/249, H05B 47/10
ADD. A01G 25/09

Applicant FIENILE AGRONEGOCIOS LTDA

1. This opinion contains indications relating to the following items:

- [x] Box No. I Basis of the opinion
- [ ] Box No. II Priority
- [x] Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- [ ] Box No. IV Lack of unity of invention
- [x] Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- [ ] Box No. VI Certain documents cited
- [ ] Box No. VII Certain defects in the international application
- [x] Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/US	Date of completion of this opinion	Authorized officer
Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	3 April 2023 (03.04.2023)	Kari Rodriquez PCT Help Desk Telephone No. 571-272-4300

Form PCT/ISA/237 (cover sheet) (revised July 2022)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.

PCT/BR 22/50461

Box No. I **Basis of this opinion**

1. With regard to the **language**, this opinion has been established on the basis of:

☒ the international application in the language in which it was filed.

☐ a translation of the international application into ______________ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(b)).

3. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:

   a. ☐ forming part of the international application as filed.

   b. ☐ furnished subsequent to the international filing date for the purposes of international search (Rule 13ter.1(a)),

      ☐ accompanied by a statement to the effect that the sequence listing does not go beyond the disclosure in the international application as filed.

4. ☐ With regard to any nucleotide and/or amino acid sequence disclosed in the international application, this opinion has been established to the extent that a meaningful opinion could be formed without a WIPO Standard ST.26 compliant sequence listing.

5. Additional comments:

Form PCT/ISA/237 (Box No. I) (revised July 2022)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.

PCT/BR 22/50461

Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non obvious), or to be industrially applicable have not been examined in respect of:

☐ the entire international application.

☒ claims Nos. 4-17, 22-24

because:

☐ the said international application, or the said claims Nos. ______ relate to the following subject matter which does not require an international search *(specify)*:

☒ the description, claims or drawings *(indicate particular elements below)* or said claims Nos. 4-17, 22-24 are so unclear that no meaningful opinion could be formed *(specify)*:

because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

☐ the claims, or said claims Nos. ______ are so inadequately supported by the description that no meaningful opinion could be formed *(specify)*:

☒ no international search report has been established for said claims Nos. 4-17, 22-24

☐ a meaningful opinion could not be formed without the sequence listing; the applicant did not, within the prescribed time limit:

- ☐ furnish a sequence listing in the form of an Annex C/ST.25 text file, and such listing was not available to the International Searching Authority in the form and manner acceptable to it; or the sequence listing furnished did not comply with the standard provided for in Annex C of the Administrative Instructions.
- ☐ furnish a sequence listing on paper or in the form of an image file complying with the standard provided for in Annex C of the Administrative Instructions, and such listing was not available to the International Searching Authority in the form and manner acceptable to it; or the sequence listing furnished did not comply with the standard provided for in Annex C of the Administrative Instructions.
- ☐ pay the required late furnishing fee for the furnishing of a sequence listing in response to an invitation under Rule 13*ter*.1(a) or (b).

☐ See Supplemental Box for further details.

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No. PCT/BR 22/50461

Box No. V **Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims	1-3, 18-21	YES
	Claims	NONE	NO
Inventive step (IS)	Claims	1-3, 18-21	YES
	Claims	NONE	NO
Industrial applicability (IA)	Claims	1-3, 18-21	YES
	Claims	NONE	NO

2. Citations and explanations:

Claims 1-3 and 18-21 meet the criteria of PCT Article 33(2) - 33(3) because, as will be shown, the prior art does not teach, nor does it fairly suggest, the claimed limitations.

Regarding claims 1-3 and 18-21, the most similar prior art is exemplified by 1) US 2020/0359550 A1 to Tran; and 2) US 2013/0263503 A1 to Firefly-One, LLC (hereinafter 'Firefly').

1) Tran teaches an agricultural method (Fig. 1A-6), the method comprising:
selecting a seed with predetermined end product properties (para [0233]-[0236]);
selecting microbes to assist seed growth and providing the microbes to help the seed during early stage growth (Fig. 4C, 4D; para [0244], [0245]);
planting the seed on a farm and periodically capturing growth data with one or more sensors (Fig. 1A-6; para [0270], [0271]);
storing the growth data on a blockchain (para [0305]-[0312]);
viewing the growth data by an interested party [0004]); and
controlling an irrigation system in response to the growth data (para [0158]).
2) Firefly teaches a system for encouraging maturation and growth of a plant (the system 2 – Fig. 1-6; para [0025], [0026]), comprising:
at least one stroboscopic lamp adapted to be disposed adjacent the plant (the stroboscopic lamp 14 – Fig. 1-6; para [0026], [0027]);
a controller in communication with and controlling the at least one stroboscopic lamp, the controller configured to cycle the stroboscopic lamp through at least one on-period and at least one off-period for a predetermined cycling time (the controller 8 – Fig. 1-6; para [0028]-[0030]).

Regarding claim 1 (NOTE: See Box VIII), Tran teaches an agricultural method (Fig. 1A-6), the method comprising:
selecting a seed with predetermined end product properties (para [0233]-[0236]);
selecting microbes to assist seed growth and providing the microbes to help the seed during early stage growth (Fig. 4C, 4D; para [0244], [0245]);
planting the seed on a farm and periodically capturing growth data with one or more sensors (Fig. 1A-6; para [0270], [0271]);
storing the growth data on a blockchain (para [0305]-[0312]);
viewing the growth data by an interested party [0004]); and
controlling an irrigation system in response to the growth data (para [0158]), and
Firefly teaches a system for encouraging maturation and growth of a plant (the system 2 – Fig. 1-6; para [0025], [0026]), comprising:
at least one stroboscopic lamp adapted to be disposed adjacent the plant (the stroboscopic lamp 14 – Fig. 1-6; para [0026], [0027]);
a controller in communication with and controlling the at least one stroboscopic lamp, the controller configured to cycle the stroboscopic lamp through at least one on-period and at least one off-period for a predetermined cycling time (the controller 8 – Fig. 1-6; para [0028]-[0030]),
but the prior art does not teach nor fairly suggest the combination of a modular agricultural irrigation pivot-like device positioned on an agricultural field in the cultivation of a crop species, the modular agricultural irrigation pivot-like device including a plurality of artificial lighting sources arranged along the modular agricultural irrigation pivot-like device at a predetermined distance above the aerial parts of the crop, comprising a plurality of light-emitting diodes, and a plurality of energy sources that feed the plurality of artificial lighting sources, the agricultural management system further including a processor in communication with a dimerizer and/or a polarizer of the plurality of artificial lighting sources and with the plurality of energy sources, wherein the processor is configured to: a) adjust, in the intervals of the electromagnetic spectrum, the balance between the spectral bands emitted by the plurality of light-emitting diodes; and b) determine and implement: an irrigation routine; and/or an artificial light(s) supplementation routine, and wherein stages a) and b) are determined by the processor considering at least one among: a crop species under cultivation; a phenological stage of the crop under cultivation; a photoperiod, a season and current weather conditions under which the agricultural field is subjected; and one or more objective(s) intended for the crop development.

Regarding claims 2 and 3 (NOTE: See Box VIII), the prior art does not teach or fairly suggest the system as claimed since they are dependent on claim 1.

Please See Supplemental Box

Form PCT/ISA/237 (Box No. V) (revised July 2022)

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

Regarding claim 1, the recitation 'Agricultural Management System' lacks proper antecedent basis.
Accordingly, claim 1 is interpreted to recite 'An agricultural management system'.

Regarding claims 2 and 3, the recitation 'System, according to claim' lacks proper antecedent basis.
Accordingly, claims 2 and 3 are interpreted to recite 'The system according to claim'.

Regarding claim 18, the recitation 'Agricultural Management Method' lacks proper antecedent basis.
Accordingly, claim 18 is interpreted to recite 'An agricultural management method'.

Regarding claims 19-21, the recitation 'Method, according to claim' lacks proper antecedent basis.
Accordingly, claims 19-21 are interpreted to recite 'The method according to claim'.

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of:
Box No. V.2. Citations and Explanations:

Regarding claim 18 (NOTE: See Box VIII), Tran teaches an agricultural method (Fig. 1A-6), the method comprising:
selecting a seed with predetermined end product properties (para [0233]-[0236]);
selecting microbes to assist seed growth and providing the microbes to help the seed during early stage growth (Fig. 4C, 4D; para [0244], [0245]);
planting the seed on a farm and periodically capturing growth data with one or more sensors (Fig. 1A-6; para [0270], [0271]);
storing the growth data on a blockchain (para [0305]-[0312]);
viewing the growth data by an interested party [0004]); and
controlling an irrigation system in response to the growth data (para [0158]), and
Firefly teaches a system for encouraging maturation and growth of a plant (the system 2 – Fig. 1-6; para [0025], [0026]), comprising:
at least one stroboscopic lamp adapted to be disposed adjacent the plant (the stroboscopic lamp 14 – Fig. 1-6; para [0026], [0027]);
a controller in communication with and controlling the at least one stroboscopic lamp, the controller configured to cycle the stroboscopic lamp through at least one on-period and at least one off-period for a predetermined cycling time (the controller 8 – Fig. 1-6; para [0028]-[0030]),
but the prior art does not teach nor fairly suggest the combination of an agricultural management method, for the cultivation of a crop in an agricultural field, including a) adjusting, in intervals of the electromagnetic spectrum, the balance between the spectral bands emitted by a plurality of light-emitting diodes of a plurality of artificial lighting sources; and b) determining and implementing: an irrigation routine of a modular agricultural irrigation device; and/or a routine of artificial light(s) supplementation of the plurality of artificial lighting sources; wherein stages a) and b) are determined considering at least one among: a crop species under cultivation; a phenological stage of the crop under cultivation; a season, a photoperiod, and current weather conditions under which the agricultural field is subjected; and one or more objective(s) intended for the crop (202) development.

Regarding claims 19-21 (NOTE: See Box VIII), the prior art does not teach or fairly suggest the method as claimed since they are dependent on claim 18.

Claims 1-3 and 18-21 have industrial applicability as defined by PCT Article 33(4) because the subject matter can be made or used by industry.

Application Data Sheet 37 CFR 1.76

The Application Data Sheet is part of the provisional or non-provisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.

Inventor Information

of inventors: 1

1. **Gustavo Alexandre GROSSI**

Residence Information
Non-US Residency
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BRAZIL

Application Information

Customer number	**30678 -**
Correspondence address	---
Title of invention	**SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT**
Attorney docket number	**092210-786599**
Entity status	Small

Application type	U.S. National Stage under 35 USC 371
Subject matter	Utility
Total number of drawing sheets	8
Suggested figure for publication	---
Filing by reference	No
Publication request	Normal eighteen-month publication

Representative Information

of representatives: 1

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).

Customer number 30678

Domestic Benefit/National Stage Information

of benefit claims: 1

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c), 386(c), or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78(a)(2) or CFR 1.78(a)(4), and need not otherwise be made part of the specification.

Prior app status	Pending
Application number	---
Continuity type	**A 371 of international**
Prior app number	**PCT/BR2022/050461**
Filing Date	11/24/2022

Foreign Priority Information

of foreign priority claims: 1

This section allows for the applicant to claim benefit of foreign priority and to identify any prior foreign application for which priority is not claimed. Providing this information in the Application Data Sheet constitutes the claim for priority as required by 35 U.S.C. 119 (b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX) the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Application number	**1020220072728**
Country	Federative Republic Of Brazil
Filing Date	04/14/2022
Access code	---

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

Checking this box will cause the application to be examined under the first inventor to file provisions of the AIA.

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013. NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 2016, 2013, will be examined under the first inventor to file provisions of the AIA.

Authorization or Opt-Out of Authorization to Permit Access

When this Application Data Sheet is properly signed and filled with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE:
This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A.

Priority Document Exchange (PDX)

Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h) (1).

B.

Search Results from U.S. Application to EPO

Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with the search results from the instant application.

NOTE:
Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

Applicant Information

\# of applicants: 1

The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46.

1. **FIENILE AGRONEGÓCIOS LTDA**
Praça Dom Eduardo, nº 255 - sala 01

Applicant	Organization
Applicant type	Assignee

Centro Patos de Minas MG, ---
38700-124
BRAZIL

Phone: ---
Fax: ---
Email: ---

Assignee Information including Non-Applicant Assignee Information

of assignees: 1

An assignee-applicant identified in the "Applicant" section will appear on the patent application as an applicant.

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

FIENILE AGRONEGÓCIOS LTDA
Praça Dom Eduardo, nº 255 - sala 01
Centro Patos de Minas MG, --- 38700-124
BRAZIL

Organization

Signature

NOTE:

This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c)**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See CFR 1.4(d) for the manner of making signatures and certifications.

Signature	First name	Last name	Registration #	Date
/R. James Balls/	R. James	Balls	57703	01/26/2024

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
19 October 2023 (19.10.2023)

WIPO | PCT

(10) International Publication Number
WO 2023/197049 A1

(51) International Patent Classification:
A01G 7/04 (2006.01) *H05B 47/10* (2020.01)
A01G 9/20 (2006.01) *A01G 25/09* (2006.01)

(21) International Application Number:
PCT/BR2022/050461

(22) International Filing Date:
24 November 2022 (24.11.2022)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
1020220072728 14 April 2022 (14.04.2022) BR

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(74) Agent: NAKATA, Carolina et al.; AV. BRIGADEIRO FARIA LIMA, 1485 - 11o ANDAR - TORRE NORTE, 01452-002 São Paulo-SP (BR).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH,

(54) Title: SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT

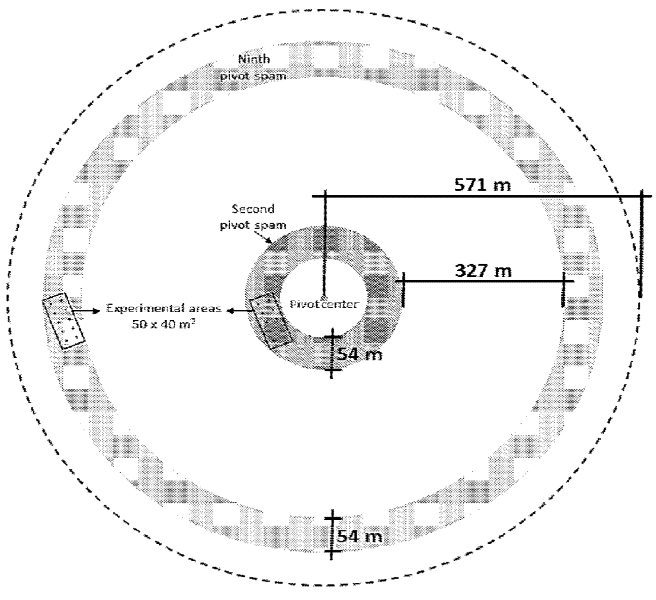

Figure 4

(57) Abstract: SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT The system (100) comprises a modular agricultural irrigation pivot-like device (101) positioned on an agricultural field (200) in the cultivation of a crop (202a), the device (101) comprising artificial lighting sources (10a, 10b, 10c, 10d, 10e) arranged along the irrigation pivot device (101) at a predetermined distance above the aerial parts of the crop, comprising LEDs, and a plurality of energy sources that feed a plurality of artificial lighting sources, a processor in communication with a dimerizer and/or polarizer of artificial lighting sources and with power sources, wherein a processor a) adjusts (501), in the intervals of the electromagnetic spectrum, the balance between the spectral bands emitted by the light-emitting diodes; and b) determines and implements - an irrigation routine (502); and/or - light(s) supplementation routine (503); in which stages a) and b) are determined by a processor different parameters.

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[Continued on next page]

TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

— *in black and white; the international application as filed contained color or greyscale and is available for download from PATENTSCOPE*

SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT

FIELD OF THE INVENTION

The present invention refers, in general, to an agricultural management system. The present invention also refers to an agricultural management method. In particular, according to the present invention, the system and method of agricultural management include artificial light(s) supplementation and are directed to the cultivation of a crop in an agricultural field.

BACKGROUND OF THE INVENTION

Large-scale agricultural production has always been closely linked to and dependent on multiple variables. Such variables include the nutritional and microbiological factors of the soil, intrinsic characteristics of a given region (e.g., climate, photoperiod, and rainfall distribution), as well as a plurality of stresses that affect crops, such as pathogens (plant diseases), insect infestations (plant predations), invasive plants (weeds), extreme (deficit or excess) of climatic, light irradiation, nutritional and water factors, among others.

In the context of the current agro-industrial scenario, Brazil notably stands out as one of the largest producers and exporters of agricultural commodities, such as soybeans (*Glycine max*) and corn (*Zea mays*), with an annual grain production of over 270 million tons according to CONAB (*Companhia Nacional de Abastecimento*, Brazilian agricultural ministry department) 2022 estimations. Thus, it is evident that developing new techniques and technologies for crop management has a tremendous economic and industrial impact. In addition, agricultural production is pressured by the growing world population and, consequently, by the increased international demand for agricultural commodities.

In this sense, there have been several efforts of new technologies to model and monitor variables such as edaphoclimatic conditions to understand the consequences and interactions between soil and crop. For example, the use of technologies and strategies for soil management and water resources, intelligent use of agrochemicals, efficient application of fertilizers, integration of the Internet of Things (IoT) into agriculture, and climate monitoring practices are essential for high crop performance and yield.

In addition to monitoring and controlling external factors, other technologies can improve agricultural activity. For example, biological technologies, such as genetically modified cultivars, benefit farmers, consumers, the environment,

and the economy; bioactive compounds, such as growth-regulating phytohormones, result in plant changes from germination to senescence and the source-drain relationship of photoassimilates in the plant during its cycle. Such technologies also improve the plant's resistance to adverse conditions during the crop cycle and increase the human nutritional value of crop production.

Over the past few decades, the use of such technologies has become constant to intensify agricultural production around the globe. The frequency of use of such technologies in South America and Asia farms has almost equated to the frequency of use in Europe and North America. However, climate change has recently caused a new demand for intensified agricultural production with more sustainable technological approaches. Additionally, the intensification of agricultural output to meet global demand is driven by the use of costly non-renewable fertilizers.

In this way, recent advances have been made in studies on artificial light(s) supplementation for crop production *outdoor* (large scales), defined as the process of applying artificial light(s) to plants grown in the open field, emphasizing the beneficial effects of the use of light-emitting diodes (LEDs) on plant's metabolism, on the efficiency of light absorption by the leaves, as well as the mitigation of abiotic (e.g., extreme temperatures and drought) and biotic (e.g., insect pests, plant diseases, weeds) stresses, while applying a sustainable management of the available resources.

Document *US 2016/0198640 A1* reveals a mobile irrigation pivot equipped with sprinklers and a plurality of light-emitting diodes configured to emit different frequencies of polarized light in spectral bands from violet to far red spectrum over plants of short, long, or neutral photoperiod response in an agricultural field. The light-emitting diodes are fixed on the irrigation pivot structure, illustrated in Figure 1 of the referred document.

The described irrigation pivot can also comprise a control circuit configured to control the operation of light-emitting diodes, irrigation parameters, and pivot moving.

Light(s) supplementation applied to crops can alter plant responses significantly. However, these responses are affected by several factors, such as plant species, crop management, soil fertility, water availability, and the prevailing climate. Document *US 2016/0198640 A1* fails to reveal artificial light(s) supplementation combined with crop management factors. Instead, when artificial light(s) supplementation is used alone, as indicated in document *US 2016/0198640 A1*, this

may not have the desired effect or may even impair plant development (empirical observation). Artificial light(s) supplementation may, for example, not achieve high yields if the applied fertilization does not adequately meet the desired level of crop production, or artificial light(s) supplementation may favor a condition of intense weeds competition in the crop field if an adequate positioning of herbicides is not made.

Noticeably, the *state of the art* lacks technological improvements regarding integrated crop management strategies. Actions in crop fields are still evaluated independently and not integrally. The sustainable use of energy, fertilizers, water, and adequate artificial light(s) supplementation are essential for sustainable large-scale improved cropping activities. These large-scale cropping activities have a great responsibility in human impact on Earth's environments. Improving the sustainability of large-scale cropping activities is possible with the present invention.

OBJECTIVES AND DESCRIPTION OF THE INVENTION

Therefore, an objective of the present invention is to provide an agricultural management system combined with artificial light(s) supplementation capable of raising agricultural production in a cropping area, increasing its productivity, reducing the negative effects of stresses present in the *outdoor* environment, increasing the efficiency of the applied inputs for crop production and, in this way, reduce the limitations of the currently known cropping techniques.

Another objective of the present invention is to provide an agricultural management system via consultancy combined with adequate artificial light(s) supplementation routine. The light-emitting diodes can be implemented in any new or preexisting irrigation pivot in an agricultural cropping area. The routine of light(s) supplementation is usually independent of the irrigation routine.

Another objective of the present invention is to provide an agricultural management system combined with artificial light(s) supplementation capable of stimulating plant characteristics of any species at a given phenological stage. These responses are regulated by the moment of artificial light(s) supplementation, the predominant color in the artificial light(s) applied, and the interaction among these factors and the environment, crop genetics, crop response to photoperiod, and crop management.

Another objective of the present invention is to provide an agricultural management system combined with artificial light(s) supplementation capable of stimulating plant characteristics of a given species at a given phenological stage.

These stimulated characteristics can improve plant performance against adverse stressful conditions that impair photosynthesis using natural light (sunlight) and reduce the negative effects of low natural luminosity during cloudy days.

Another objective of the present invention is to provide dimerization and/or polarization of the spectral bands in the artificial light(s) supplementation according to the crop species, region, soil physical and chemical conditions, climate, predominant agronomic management and type of agricultural production system in use (e.g., no-tillage cropping system).

Another objective of the present invention is to maintain and adapt the routine of water irrigation and light(s) supplementation at different phenological stages during all crop development stages, improving agricultural production in quantity, quality, and sustainability.

Another objective of the present invention is to protect crops against plant diseases and insect pests by modulating artificial light(s) supplementation. Artificial light(s) can be used to affect plant diseases and insect pest development, cycle, and pressure on crop performance. The improved crop protection advantageously has the potential to reduce the need for the application of phytosanitary products. This potential reduction in use of phytosanitary products (e.g., insecticides and fungicides) consequently reduces the damage caused to the environment by the excessive use of such products.

Another objective of the present invention is to act beyond the mere application of light(s) supplementation, as it must consider soil factors, plant nutrition levels, climate, photoperiod responses, agronomic management, and crop variety selection, among others, to achieve the balance between the demand of the plant stimulated by light(s) supplementation and the technical use of production resources. In other words, according to the present invention, artificial light(s) supplementation is a tool that must be inserted in a set of appropriate technical actions to achieve the best production results and sustainability of large-scale agriculture.

Finally, the present invention aims to increase the efficiency of production resources, such as irrigation, fertilizers, and agrochemicals (insecticides, fungicides, bactericides, fertilizers, stimulants, ...), due to the effects caused by artificial light(s) supplementation, such as a great development of the plant root system, allowing improved exploration of the soil profile and reduce the water, nutrients and agrochemicals losses.

One or more objectives of the above-mentioned invention(s), among others, are achieved by means of an agricultural management system combined with artificial light(s) supplementation, comprising:

- a modular agricultural irrigation device positioned on an agricultural field using a plurality of artificial lighting sources arranged along the modular agricultural irrigation device, optionally at equidistant points and at a predetermined distance above the aerial crop parts.

- a plurality of light-emitting diodes capable of emitting a plurality of electromagnetic spectrum bands applied alone or in combinations of different proportions of spectral bands from the limit of ultraviolet C and B (wavelength of 280 nm) to infrared (wavelength > 700 nm); and

a plurality of energy sources that feed a plurality of artificial lighting sources.

The agricultural management system also comprises

- a processor in communication with a dimerizer and/or polarizer of a plurality of artificial lighting sources and a plurality of energy sources, in which a processor is configured to

a) adjust, in the intervals of the electromagnetic spectrum, the balance between the spectral bands emitted by a plurality of light-emitting diodes; and

b) determine and implement - an irrigation routine; and/or - an artificial light(s) supplementation routine; in which stages a) and b) are determined by a processor considering at least one among

- the crop species 202a under cultivation;

- the phenological stage of the crop 202a under cultivation;

- the photoperiod, station and current weather conditions under which the agricultural field 200 is subjected; and

- one or more objective(s) intended for the crop 202a development under light(s) supplementation.

Understand "*objective(s) intended for the crop*" as the main purpose of the cropping of such plant specie; if, for example, the crop is for grain production, then a crop and artificial light(s) management, or protocol, is applied; however, if the crop is only intended for cattle grazing, then another crop and artificial light(s) management, or protocol, is applied.

The objective(s) of the above-mentioned invention, among others, is also achieved by means of adequate agricultural management methods combined with artificial light(s) supplementation for crop cultivation in an agricultural field, comprising the stages

a) adjusting the balance between the spectral bands emitted by a plurality of light-emitting diodes of a plurality of lighting sources artificially capable of emitting a plurality of electromagnetic spectrum bands applied alone, or in combinations of spectral bands from the limit of ultraviolet C and B (wavelength of 280 nm) to infrared (wavelength > 700 nm); and

b) determine and implement - an irrigation routine of a modular agricultural irrigation device; and/or

- a routine of artificial light(s) supplementation of a plurality of artificial lighting sources; in which stages a) and b) are determined considering at least one among

- the crop species under cultivation;

- the phenological stage of the crop under cultivation;

- the crop photoperiod response, crop cropping season and current weather conditions under which the agricultural field is subjected; and

- the objective(s) intended for the crop 202a development under light(s) supplementation.

BRIEF DESCRIPTION OF THE DRAWINGS

The objectives, technical effects and advantages of the present invention will be apparent with the following detailed description that refers to the attached figures, which illustrate, but not limited, embodiments of the objects claimed

- Figure 1 illustrates a 100 agricultural management system combined with light(s) supplementation operating on a modular agricultural irrigation device 101 on an agricultural field 200, according to the present invention;

- Figure 2 shows an expansion of a crop 202a in the agricultural field 200 under the action of the agricultural management system 100 combined with artificial light(s) supplementation, according to the present invention;

- Figure 3 illustrates the stages of the logic operation of the agricultural management method 500 combined with artificial light(s) supplementation, according to an embodiment of the present invention;

- Figure 4 illustrates a superior view of a schematization of an irrigation pivot in which the agricultural management system 100 combined with artificial light(s) supplementation was installed, according to an embodiment of the present invention;

- Figure 5 illustrates a first graph of an analysis of a sovbean plant internode variable of the crop 202a over time, under the performance of the agricultural management system 100 allied to artificial light(s) supplementation, according to the embodiment of the present invention;

- Figure 6 illustrates a second graph of an analysis of soybean plant height variable of the crop 202a over time, under the action of the agricultural management system 100 allied to artificial light(s) supplementation, according to the present invention embodiment;

- Figure 7 illustrates a third graph of an analysis of third plant variable of the crop 202a over time, under the action of the agricultural management system 100 combined with artificial light(s) supplementation, according to the embodiment of the present invention;

- Figure 8 illustrates a comparison between crop 202a plants under the intervention of the agricultural management system 100 combined with artificial light(s) supplementation, and crop 202b plants with no artificial light(s) supplementation and corresponding crop management, according to the embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS OF THE INVENTION

Initially, it should be noted that the system and method of the present invention will be described below according to particular but non-limiting embodiments since it may be executed in different ways and variations and according to the objective(s) intended for the crop 202a development under light(s) supplementation.

In one embodiment, the present invention reveals a 100 agricultural management system combined with artificial light(s) supplementation for the cultivation of a crop 202a in an agricultural field 200.

In another embodiment, the present invention reveals a 500 agricultural management method combined with artificial light(s) supplementation for the cultivation of a crop 202a in an agricultural field 200.

It is emphasized that adjustments in agricultural management and artificial light(s) supplementation should be implemented for each crop 202a and cropping region due to latitude, the height of the area compared to sea level, soil

characteristics, and climate variations. The crop 202a phenological stage, photoperiod, the weather conditions under which the agricultural field 200 is submitted, and the objective with the plant development should also be considered to define the wavelength range applied and its combinations of electromagnetic spectrum bands to meet the specified objective. The luminous flux and the balance between the spectral bands emitted by a plurality of light-emitting diodes are, therefore, variable by means of digital dimerization and/or polarization and controllable by an electronic processor, according to the routine of artificial light(s) supplementation, which in turn takes into account the factors mentioned above.

It should be noted that the expressions "plant", "cultivate", or "culture" should be understood as any plant varieties, whether from long-day, such as oats (*Avena sativa*) or potato (*Solanum tuberosum*) or short-day plants, such as soy (*Glycine max*) or coffee (*Coffea* sp.), or neutral plants, which benefit from artificial light(s) supplementation in accordance with the present invention. Crop species evaluated with adequate crop corrections and management combined with artificial light(s) supplementation include soybean (*Glycine max*), bean (*Phaseolus vulgaris*), corn (*Zea mays*), tomato (*Solanum lycopersicum*), carrot (*Daucus carota*), sugarcane (*Saccharum officinarum*), tobacco (*Nicotiana tabacum*), garlic (*Allium sativum*), onion (*Allium cepa*), pea (*Pisum sativum*), sunflower (*Helianthus annuus*), sorghum (*Sorghum bicolor*), cotton (*Gossypium hirsutum*), potato (*Solanum tuberosum*), hops (*Humulus lupulus*), strawberry (*Fragaria × ananassa*), pitaya (*Hylocereus undatus*), lettuce (*Lactuca sativa*), arugula (*Eruca vesicaria* ssp. *sativa*) and agricultural soil cover crops. Each crop species received adjusted in artificial light(s) supplementation for each crop 202a and region of cultivation, as well as other factors such as the phenological stage of the crop 202a under cultivation, the photoperiod, and the meteorological conditions under which the agricultural field 200 is submitted and the objective(s) intended for the crop 202a development. All these crop species 202a showed positive results with adequate agricultural management and artificial light(s) supplementation, according to the present invention, compared to control (no artificial light(s) supplementation). The positive results are discussed below.

Furthermore, this descriptive report means "corrections" as any practice carried out by the producer in the agricultural area to improve the conditions available for plant development. In this sense, all practices that affect soil management (chemical and physical structure) and plant nutrition management (fertilizers) can be

considered “corrections”. Examples of corrections are the application of limestone (soil acidity correcting, calcium and magnesium source), the application of gypsum (reducing potential acidity in depth in the soil, source of calcium and sulfur), and the cultivation of cover crops (soil compaction management, nutrient recycling, pest control such as phytonematodes).

As can be seen in figures 1 and 2, the agricultural management system 100 combined with artificial light(s) supplementation, according to the application of the present invention, can be adapted to an irrigation new pivot or already existing in an agricultural field 200, such as a central irrigation pivot, whether towed or non-towable, or even a linear irrigation pivot. In this descriptive report, the pivot is generally described as “agricultural irrigation modular device 101”.

This modular agricultural irrigation device 101 is positioned on the agricultural field 200 on which the cultivation of a crop 202a occurs, and the modular device 101 comprises an irrigation line 102a with wheeled towers and many spans (irrigation space between towers presenting oblong arms). The distal end of the first irrigation span 102a is supported by a wheeled tower 103a, and mechanically associated with a drive device, such as an engine or equivalent, and wheels 104a; 105a; the proximal end of the first irrigation span 102a is mechanically connected in a circular rotating way to the center of the pivot. The drive device triggers the tower 103a displacement.

The modular agricultural irrigation device 101 may have one or many wheeled towers and spans.

The span(s) of the modular device 101 presents a plurality of water sprinklers connected to a hydraulic pressure line in water communication with a reservoir which may be arranged, for example, at a central pivot, in the hydraulic line extending along the pivot spans 102a; 102b, which are equipped with water sprinklers in order to promote the irrigation of the agricultural field 200.

The agricultural management system 100, combined with artificial light(s) supplementation, incorporates a plurality of artificial lighting sources 10a, 10b, 10c, 10d, 10e arranged, for example, along the irrigation spans 102a; 102b of the agricultural irrigation modular device 101 and may be located at specific points and at a predetermined distance above the aerial part (canopy, plant shoot) of the crops 202a, the distance from the ground and other sources of artificial lighting 10a, 10b, 10c, 10d, 10e can also be adjusted as necessary, depending on the type of modular device 101

that will receive the artificial lighting sources and the crop 202a species under cultivation.

In addition, a plurality of artificial lighting sources 10a, 10b, 10c, 10d, 10e comprise a plurality of light-emitting diodes. In a preferred embodiment, light-emitting diodes are full-spectrum with wavelengths ranging from 280 nm, at the limit of the UV-C spectrum with UV-B, up to 1200 nm, in the near-infrared spectrum, over agricultural crop 202as (whether short, long or neutral-day plants) which are directly associated with biomass production, plant morphology, plant resistance to stresses, and crop development 202a. In one embodiment, the wavelength interval applied may be the same during the day or night but with variable luminous flux intensities.

The system 100 also comprises a plurality of energy sources, feed a plurality of artificial lighting sources 10a, 10b, 10c, 10d, 10e, as well as a processor in communication with the water sprinkles, the pivot drive device, and a dimerizer or polarizer of a plurality of artificial lighting sources 10a, 10b, 10c, 10d, 10e The referred processor is configured to adjust 501 the light spectral bands, the balance between these spectral bands emitted by a plurality of light-emitting diodes, and determine an irrigation routine 502 and an artificial light(s) supplementation 503 routine. The irrigation routines and artificial light(s) supplementation are independent. In other words, according to the established routine, a processor can command the action of the drive device, water sprinkle device, and the light dimerizer or polarizer. A processor determines this routine, preferably using an artificial intelligence model, considering the crop 202a species under cultivation; the phenological stage of the crop 202a under cultivation; the photoperiod and weather conditions under which the agricultural field 200 is/was subjected; the objectives intended for the crop 202a development, and information provided by users (farmers) through a user interface, which will be commented on below.

In an embodiment of the artificial light(s) supplementation routine, the crop 202a plant development can be stimulated or inhibit the production of leaves, branches, flowers, and roots; stimulate or inhibit the production of grains, fibers, fruits, and essences; stimulate or inhibit vegetative and reproductive growth, and stimulate plant photosynthesis.

In an embodiment of the artificial light(s) supplementation routine, a processor may be in communication with a plurality of photoresponsive sensors to determine a threshold of sunlight incidence, which controls the performance of a

plurality of light-emitting diodes and routines of application, reducing the negative effects of weather adversities under which the agricultural field 200 is subjected, such as cloudy days with a low sunlight incidence.

It is also noteworthy that the threshold of light incidence may additionally depend on other factors, such as the crop 202 species under cultivation, current crop 202a phenological stage, the region (e.g., information regarding soil, climate, history of the cropping area), and crop 202a management applied.

A light dimerizer or polarizer adjusts the luminous flux and the balance between the spectral bands emitted by a plurality of light-emitting diodes. The light dimerization or polarization is controllable by the interaction between photoresponsive cells and a processor to define a routine of light artificial supplementation. The definition of such routine takes into account the factors mentioned above. For example, for crops 202a in general, the basic phenological stages are vegetative (V) (crop cycle period before flowering and where pre-flowering occurs) and reproductive (R) (begins with the first reproductive structure, usually flowers), in which specific artificial light(s) supplementation with specific spectral band composition is applied. This balance of spectral bands can be the same applied during the day or night or may diverge between these periods, varying the intensity of the luminous flux and spectral band composition. In nocturnal applications, the luminous flux can be adjusted to be lower, for example, than the luminous flux in daytime applications, intending only to cause stimuli in crop 202a plants, which will be commented on below. Especially in daytime applications, the luminous flux can be adjusted to be higher in cloudy periods, intending to mitigate the effects of photosynthetic reduction due to low natural light availability.

This is especially advantageous, as cloudiness can reduce the photosynthetic capacity of the crop 202a plants by more than 50%, causing the crop 202a to produce fewer sugars (assimilated organic carbon via photosynthesis) and consequently grow less and produce less biomass (e.g., grains, fruits, fibers). This reduction in photosynthetic activity also results in smaller amounts of root exudates released to the soil (decreasing the soil aggregating effect) and lower symbiont microorganisms (due to decreased root exudate supply), which in turn have the function of obtaining nutrients from the environment to the crop 202a, making them more resistant to pathogens and agricultural pests. Thus, it is evident that compensation for the low incidence of natural sunlight is a decisive factor for soil structuring and plant protection against pathogens and agricultural pests.

In another embodiment, a plurality of energy sources can be generated by wind, sunlight, thermal, or combustion generators in order to feed a plurality of artificial lighting sources 10a, 10b, 10c, 10d, 10e. In any of these embodiments, a processor may be in communication with a machine-readable memory, which stores database information comprising real-time updates on the geolocation of agricultural field 200 and climate indicators to suggest to the user, through a user interface, the crop 202a variety to be cultivated.

The user interface is in communication with a processor, and in turn, the user feeds other information to a processor, through the interface, such as

- the history of cultivation of the agricultural field 200 in order to identify successful plants species and crop varieties previously cultivated in the agricultural field 200;

- the history of agricultural inputs used in the agricultural field 200, such as fertilizations and corrections made;

- the occurrence of stresses in plants, such as the emergence of plant diseases and insect pest infestation, nutritional deficiencies, extreme of temperatures and rainfall distribution;

- the occurrence, intensity and determination of the principal weeds;

- results of productivity from previous harvests;

- the characteristics of the irrigation pivot 101, such as irrigated area, irrigation flow, working speeds and the height of the structure wherein a plurality of artificial lighting sources 10a, 10b, 10c, 10d, 10e are fixed in order to adjust the illumination of the light-emitting diodes as a function of the distance of a plurality of artificial lighting sources 10a, 10b, 10c, 10d, 10e

- the current crop season weather conditions and weather indicators of the crop field area.

The user interfaces in an embodiment implemented on a panel, mobile phone, tablet, or similar mobile devices with a direct connection to a center of information where the reported data will be processed, and the artificial intelligence will be fed.

In another embodiment, a plurality of energy sources uses information such as the sunlight duration, cloudiness, sunlight brightness as well as the insolation index (ratio between the actual number and the maximum possible number of hours of sunlight brightness) to determine the threshold of sunlight incidence in the agricultural

field 200. Below the calculated threshold and depending on a certain routine of artificial light(s) supplementation, a processor interacts with the dimerizer or polarizer to command the performance of a plurality of light-emitting diodes and project artificial light(s) with specific spectral band composition, reducing the negative impact of meteorological adversities (e.g., cloudy days) under which the agricultural field 200 is subjected.

In one embodiment, data on the crop 202a species, crop 202a phenological stage, photoperiod, meteorological conditions under which the agricultural field 200 is submitted, objective(s) intended for the crop 202a development, as well as the technologies implemented in the agricultural field (fertilizers, agrochemicals, and soil management techniques) are stored in a machine-readable memory and accessed by a processor, in order to properly apply light(s) supplementation, according to parameters provided by the machine-readable memory.

Such previous information on the agricultural field 200 and the routine of artificial light(s) supplementation is important because they help

- in understanding and predict the consequences and interactions potentially present in the agricultural field 200;

- indicate improvements and corrections to be implemented in the agricultural field 200 for the optimization of the results of artificial light(s) supplementation;

- assist in the use of technologies and strategies for soil and water resources management;

- assist in the intelligent use of agrochemicals and in the efficient application of fertilizers; - assist in the integration of internet of things (IOT) to monitor crop (satellite), climate and agricultural practices; and

- help to improve the application format of the routine of artificial light(s) supplementation, such as the type of artificial lighting source 10a, 10b, 10C, 10D, 10e to be used, such as light-emitting diode panels (LEDs), led strips (LED), lamps in general, and their respective power, frequency and wavelength.

In addition, pedological, edaphological, mineralogical, textural, phytopathological, and nutritional analyses are essential before the agricultural field 200 receives adequate agricultural management and artificial light(s) supplementation routine. It is impossible to define the best inputs management for crop production without knowing such mentioned information. How many, how much, and when to

apply fertilizers for high crop performance under artificial light supplementation? Soil, irrigation, and phytosanitary management, what is the best routine? It is necessary to know the soil conditions before implementing adequate agricultural and artificial light(s) supplementation management to understand how soil will behave after the referred implementation.

The 100 system of the present invention comprises a plurality of soil sensors under the agricultural field 200 to capture nutritional data from the soil of the agricultural field 200. A processor uses the data to determine and suggest routines for soil treatment/corrections of the agricultural field 200. The respective recommendation made by a processor, using an artificial intelligence model fed with specific parameters and users information, considering the crop parameters, adjusts the balance between the spectral bands 501, and determines the irrigation routine 502 and artificial light(s) supplementation 503.

Short-day crops, such as soybean (*Glycine max*), are largely influenced by abiotic factors such as photoperiod and temperature. Soybean flowering and reproductive cycle occur under short photoperiodisms, that is, on days when the absence of light (night period) is longer than the presence of light (day period). While the opposite, extended day periods can delay or inhibit flowering and the beginning of the reproductive cycle. This condition of dependence on the photoperiod allows light(s) supplementation to influence the extension of the crop 202a cycle. Consequently, plant height, number of internodes, pods, seeds per pod, and distribution of pods in the aerial parts of soybean are affected by extended photoperiods through adequate agricultural and artificial light(s) supplementation management.

It is also important to mention that for a positive balance for photosynthesis, the luminous flux is usually between 200 and 600 $\mu mol\ m^{-2}\ s^{-1}$. However, artificial light(s) supplementation acts on other physiological aspects that directly and indirectly affect photosynthesis in the plant, and not necessarily artificial light(s) supplementation is applied to be the light source that momentarily causes photosynthesis. This light source may have a luminous flux of less than 200 $\mu mol\ m^{-2}\ s^{-1}$.

In general, artificial lighting sources 10a, 10b, 10c, 10d, 10e with luminous flux less than 200 $\mu mol\ m^{-2}\ s^{-1}$ are not able to cause considerable amounts of positive photosynthesis on most plants. However, even smaller luminous fluxes can cause stimuli in crop 202a that can directly or indirectly positively affect photosynthesis

to be performed the following day after the night of application of artificial light(s) supplementation. Therefore, a low luminosity, capable only of causing other responses but unable to directly cause considerable amounts of positive photosynthesis; a higher luminosity, will consequently have specific and useful applications according to the present invention.

Artificial light(s) supplementation, according to the present invention, is, therefore, a tool within a broad technical project that interacts both with the agricultural management of soil aspects, such as soil fertility and texture, and plant nutrition, as well as with the pathological and beneficial microbiological aspects, environmental aspects, such as temperature and rain in the agricultural region, and economic aspects, such as the cost of production and marketing of agricultural commodities that receive agricultural management combined with artificial light(s) supplementation according to the present invention.

The increase in agricultural production, according to the present invention, is the result of the interaction among stimulated crop 202a physiological processes by light(s) supplementation, the time defined for sowing, irrigation volume, time of application, formulation, frequency, and dosage of fertilizers, climate variation, management of insect pests and plant diseases and their impacts on the relationships with the environment. Agricultural cultivation with this integration of adequate technical knowledge (agricultural management) and artificial light(s) supplementation, according to the present invention, increases the resilience and stability of crop production, which increases regional and global food security.

It is noteworthy here that artificial light(s) supplementation improves the result of good management but does not correct poor management. In other words, according to the present invention, artificial light(s) supplementation enhances the development of plants that are well nourished, with good water distribution throughout the crop cycle, and that present soil physical and chemical structure suitable for high yields. Under these conditions, supplement artificial light(s) will generate the best results. However, if light(s) supplementation is not combined with adequate agricultural management, then light(s) supplementation alone cannot fix preexisting limitations for the full development of plants, such as nutritional deficiencies, lack of water, insect infestations, or the presence of agricultural pathogens.

The application of agricultural management and artificial light(s) supplementation, according to the present invention, does not present

contraindications regarding - crop 202a species (any cultivated plant specie would benefit from adequate agricultural management and artificial light(s) supplementation); - phenological stage during crop 202a cycle (vegetative or flowering/reproductive); - joint application, or not, with water irrigation.

In addition, the application of agricultural management and artificial light(s) supplementation, according to the present invention - can be handled to raise the levels of specific substances in the final product (e.g., grains, fruits, and fibers); - recommend the dimerization/polarization of the light spectrum to be applied with the development of the crop 202a (e.g., modification of the bluish spectrum in the vegetative to the reddish spectrum in the reproductive stage); and - recommend the application of artificial light(s) supplementation at specific periods of the crop 202a cycle, and not applied throughout the crop cycle, from sowing to harvest.

Without getting in the light of any specific theory, it was observed that light dimerization/polarization effects are beneficial, including changes in plant morphology, crop cycle extension, physiological responses, and plant productivity.

For example, it was observed that the bluish spectrum (spectral band of approximately 400 to 500 nm) is a stimulant of vegetative growth, which is appropriate for plants before flowering. After flowering, plants paralyze growth investments and start investing in grain, fiber, fruit, or essence production.

In turn, it was observed that the reddish spectrum (spectral band of approximately 600 to 750 nm) is a stimulant of reproductive growth, with beneficial effects for flowering, the rate of photosynthesis, and fruit formation. In this post-flowering period, the photosynthetic activity for biomass accumulation and the translocation of these reserves produced to “fill” production is essential. Therefore, avoiding the blue spectrum, or having less blue, is important in the reproductive phenological stage because blue is a stimulant of the vegetative stage, which would cause nutrient reserves to be consumed and not destined to fill the production. On the other hand, having the red spectrum, or having redder to stimulate photosynthesis and the distribution of reserves, is essential for the best results in the reproductive stage.

In a preferred embodiment, the balance between red-green-blue spectral bands presents at least 40% blue color for vegetative phenological stages and about 60% or at least 40% red color for the reproductive phenological stage of the crop 202a under cultivation. More than 40% red color in the artificial light(s) supplementation is recommended for any plant phenological stage.

Figure 3 illustrates the agricultural management method 500 combined with artificial light(s) supplementation for the cultivation of a crop 202a in an agricultural field 200, which comprises the stages a) adjusting 501, in the intervals of the electromagnetic spectrum, the balance between the spectral bands emitted by a plurality of light-emitting diodes of a plurality of artificial lighting sources 10a, 10b, 10c, 10d, 10e; and b) determine and implement an irrigation routine 502 of a modular agricultural irrigation device 101; and/or a routine of artificial light(s) supplementation 503 of a plurality of artificial lighting sources 10a, 10b, 10c, 10d, 10e in which the irrigation routine 502 and the supplementation routine are independent of each other, and in which stages a) and b) are determined through an artificial intelligence model considering at least one of the type of crop 202a under cultivation; the phenological stage of the crop 202a under cultivation; the photoperiod, station and current weather conditions under which the agricultural field 200 is subjected; and the objective(s) intended for the crop 202a development.

Method 500 also comprises stage c) determining and suggesting a soil treatment routine based on soil nutritional data from the agricultural field 200, stage c) being defined through the artificial intelligence model considering at least one of the same parameters considered for stages a) and b), in addition to considering the irrigation routine 502 and/or the routine of artificial light(s) supplementation 503.

In a preferred embodiment, the objective(s) with crop 202a development is to stimulate or inhibit the production of leaves, branches, roots, grains, fibers, fruits, and essences and, also, to stimulate or inhibit vegetative and reproductive growth and photosynthesis.

In a preferred embodiment, the routine of artificial light(s) supplementation 503 occurs, preferably, between the phenological stages V3-V4 to R5-R6 of the crop 202a under cultivation, and the balance between the spectral bands is adjusted 501, the balance between red-green-blue spectral bands presents at least 40% blue color for vegetative phenological stages and about 60% or at least 40% red color for the reproductive phenological stage of the crop 202a under cultivation. More than 40% red color in the artificial light(s) supplementation is recommended for any plant phenological stage.

EXAMPLE 1

Reference is made to an example (technically adequate and representative study) in which the present invention was carefully implemented in order

to verify its effectiveness. According to the present invention, this example evaluated the soybean 202a plant responses related to plant development and crop productivity in an open commercial area 200 (field scale) cultivated under agricultural management conditions and artificial light(s) supplementation. An irrigation pivot 101, irrigating a commercial cropping area 200, received an artificial lighting source 10a, 10b, 10c, 10d, 10e, according to the present invention, in internal pivot 101 spans for artificial light(s) supplementation of the soybean plants 202a.

According to the example, about 40 hours of artificial light(s) supplementation was applied to soybean plants 202a during the soybean crop 202a cycle. The number of plant internodes, soybean plant height, and the number of pods per soybean plant were evaluated weekly to calculate the area below the variable progression curve. Grain yield at harvest was also evaluated. Later, the area below the progression curve of the number of internodes, soybean plants height, and pods per soybean plant was positively affected by the system and method of adequate agricultural management combined with artificial light(s) supplementation 100, 500, according to the present invention.

The regular soybean 202a cycle, without artificial light(s) supplementation, is about 15 to 17 weeks; however, soybean harvesting occurred two weeks later when no artificial light(s) supplementation was applied. The artificial light(s) supplementation increased soybean grain yield by 57.3% and profitability by 180% when compared to soybean cropping without artificial light(s) supplementation.

<u>METHODOLOGY EXPERIMENTAL AREA AND SOYBEAN CULTIVATION</u>

The experiment with light(s) supplementation on soybean was carried out in an irrigation pivot 101, on a commercial farm in Monte Carmelo, Minas Gerais state, Brazil. Located at a latitude and longitude of 18º 57" South, 47° 25" West, at 980 m above sea level. The most common and representative biome of the region is the Cerrado (savannah-like biome). The climate of the region is humid tropical, with rainy summers and dry winters.

Physical analyses of the soil in the agricultural area 200, from 0 to 0.4 m deep, indicated 450, 100, and 450 g kg^{-1} of sand, silt, and clay, respectively. The chemical analyses of the soil up to the depth of 0.4 m did not indicate the acute deficiency of any nutrient necessary for the crops to complete their cultivation cycle fully. The soil analyses are presented in Table 1.

TABLE 1

pH H_2O	Ca	Mg	Al	H+Al	CEC	V	P	K	S.O.M
1-2.5	----cmol$_c$ dm^{-3}----					%	---mg dm^{-3}---		g kg^{-1}
----0-0.2 m soil depth----									
6.9	6.03	2.87	0	1.26	10.44	88	188	96	2.9
----0.2-0.4 m soil depth----									
6.8	5.70	2.78	0	1.08	9.77	89	158	82	2.3

B	Co	Cu	Fe	Mn	Mo	Si	Zn
----mg dm^{-3}----							
----0-0.2 m soil depth----							
0.19	1.7	9.0	14.0	1.9	2.9	12.4	12.8
----0.2-0.4 m soil depth----							
0.14	1.3	7.7	17.0	3.5	2.3	11.4	11.1

Despite the large soil clay proportion and high soil fertility, 3,000 kg ha^{-1} of soil remineralizer (rock powder) (FMX® Tratto. Aparecida from Goiânia, Brazil) was applied throughout the experimental area 200, 30 days before the soybean sowing 202a; 400 kg ha^{-1} of organomineral 6-30-05 (% of N, P_2O_5, K_2O) (Valoriza Agro Ltda. Patos de Minas, Brazil) and 150 kg ha^{-1} of KCl was applied at the time of sowing, and 2 L ha^{-1} of Mn was sprayed on the aerial parts of the soybean plants 202a, 40 days after the crop 202a seed germination.

The soybean cultivar 202a evaluated in this example was Desafio 8473 RSF (Brasmax® GDM. Cambé, Brazil), which is a soybean variety with indeterminate growth and 7.4 maturity group. Fourteen seeds per linear meter (280,000 plants per hectare) were sowed in lines spaced by 0.5 m; plants 202a were harvested approximately 4 months later. The soybean plants cultivated with no artificial light(s) supplementation were harvested first. The average daily air temperature during the experimental period ranged from 24 to 34 °C.

In the experimental area, insects, pests, plant diseases, and weeds were controlled with products registered for soybeans as indicated by the manufacturer. All areas were monitored before and after the first application, and the products were reapplied as needed. The management of crop plants 202a and water irrigation were similar between the areas that received the artificial light(s) supplementation and the control [area with no without artificial light(s) supplementation].

EXPERIMENTAL TREATMENTS AND RESEARCH

The central irrigation pivot 101 that was implemented with the artificial light(s) supplementation light source had ten spans and an irrigation radius of about 571 m. In the four internal spans of the referred irrigation pivot 101, which corresponds to an area of 33.5 ha, the artificial light source 10a, 10b, 10c, 10d, 10e was installed, but the six external spans of irrigation pivot 101, corresponding to an area of 69.5 ha, did not receive artificial light(s) supplementation (control). The main composition of the red-green-blue (RGB) light delivered to the soybean plants presented about 59% red, 33% green, and 8% blue. A continuous light band of approximately 40 m wide by 230 m long was projected below the arm extension of the four internal spans of the irrigation pivot 101.

Each light-emitting diode has a power ranging from 50 to 200 W. About 600 W h^{-1} ha^{-1} were consumed during the artificial light(s) supplementation process. The light-emitting diode module were positioned about 3 meters above the aerial parts of the crop 202a plants and distributed to ensure an equally distributed light power in each span of the circular pivot. The luminous flux per unit area at the level of the aerial parts of soybean 202a plants was about 30 lx.

The artificial light(s) supplementation system 100, according to the present invention, was turned on every night after the full sunset and on very cloudy days. Approximately 480 hours of artificial light(s) supplementation was applied throughout the area during the soybean crop 202a cycle. As irrigation pivot 101 completes a turnover the cultivation area 200 in 12.8 hours in a circular routine, each crop 202a plant received about 40 hours of artificial light(s) supplementation during its cycle. During the soybean cycle, foliar fertilizers containing micronutrients, such as boron and manganese, were applied throughout the area [with and without artificial light(s) supplementation] to compensate for the intense development of plants stimulated by artificial light(s) supplementation.

Artificial light(s) supplementation began in V3-V4 (third to fourth fully expanded trifoliated leaf) soybean phenological stage and ended in the R5-R6 soybean phenological stage (full grain stage). The choice of vegetative phenological stage V3-V4 for the beginning of artificial light(s) supplementation allows crop 202a to close the space between lines in the agricultural field 200 and begin cultivation area covering (a situation where the plant's growth is enough to shelter all exposed soil from an up-sight perspective). If artificial light(s) supplementation is applied before soybean plants cover the cropping area, weed plants start to compete for resources with crop

202a. The plant competition for resources such as water, nutrients, and light, impairs crop performance and yield and increases herbicide costs. In turn, the choice of the end of artificial light(s) supplementation in the reproductive phenological stage R5-R6 is due to the fact that at this stage, the soybean crop 202a reached its final development. However, it should be noted that artificial light(s) supplementation could continue after R5-R6 stage, favoring some extra crop 202a production; however, the benefits would not be higher than the energy costs related to artificial light(s) supplementation beyond this plant stage.

Between the first and second pivot span towers 103a; 103b, a homogeneous area of 50 by 40 m was delimited, corresponding to an area of 2,000 m^2 to be evaluated as the treatment “supplemented by artificial light(s)”. The schematization of irrigation pivot 101 according to the experiment can be seen in figure 4, in which the crop 202as under the green span of irrigation pivot 101 received artificial light(s) supplementation, while the rectangles indicate the position of both treatments, with and without artificial light(s) supplementation, and the dots in each rectangle indicate the sampling points.

<u>SOYBEAN EVALUATIONS</u>

The evaluations of plant internode number, plant height from the soil level to the highest node, and pods per plant 202a were assessed weekly from the R3 soybean phenological stage (beginning of the pod formation) to R7 (beginning of soybean maturity). During nine weeks, evaluations were performed weekly; no further evaluation was possible after R7 because the plants in the treatment without artificial light(s) supplementation reached physiological maturity earlier than the plants in the treatment of artificial light(s) supplementation.

In this sense, it is important to highlight the delay of physiological maturity induced by the treatment with artificial light(s) supplementation. This extension of the crop 202a cycle stimulated by artificial light supplementation depends on factors such as the crop 202a species, the geographic region of the cropping area, prevailing climate, crop phenological stage, period of suspension of artificial light(s) supplementation, and the crop management.

The soybean crop 202a, for example, extended its cycle between 5 and 20 days, depending on the cultivar, light management, and cropping region. However, this extension was not prominent in grass crops tested, such as corn, sorghum, and wheat, being only a few days longer than where artificial light(s) supplementation was

not applied. Avoiding any specific theory, this crop cycle extension as affected by artificial light(s) supplementation may be a consequence of a series of metabolic and morphological reactions, such as photomorphogenesis (morphological modification of the 202a culture stimulated by light, which could favor photosynthesis during the day), alteration of the crop 202a predominant photoperiod and crop 202a circadian cycle (modification of the crop 202a routine compared to the period of natural light), regulation of crop 202a secondary metabolism (regulation of natural defenses of crop 202a to stresses), and crop 202a phytochrome activities (photoresponsive substances and response modulators in culture 202a).

Amazingly, it was concluded that through these reactions or stimuli (and other possible causes or joint action of these responses) caused by artificial light(s) supplementation, as well as the correct management of soil and water resources, the crop 202a ends up producing more biomass through a more efficient photosynthesis process. Even after the study, it was observed that the plant stand (quantity of plants per area) could be reduced by about 20%, considering this greater amount of biomass produced (larger canopy and larger root systems). Overall, good productive results were observed, even with smaller stands, which reduces investment in seeds and their agrochemical treatment for sowing, in addition to increasing the sustainability of agricultural activity by producing more food using precise resources and technologies.

The mean measurement of each evaluated variable was estimated from a representative evaluation of the plants 202a in 10 sampling points in each area (2,000 m^2). Each sample point evaluated was considered a replication.

The influence of artificial light(s) supplementation or no artificial light(s) supplementation in each variable was evaluated using the area below the progression curve of each specific variable to interpret the results of the evaluations in various times. The area below the progression curve was calculated by trapezoidal integration area below the progression curve= (dti × ((Yi + Yi+d)/ 2))

Where *dti* is the time interval between every two observations, *Yi* and *Yi + d*. The area below the variable progression curve was calculated based on nine evaluations. Correlations between the area below the progression curve of the evaluated variables were computed to determine whether there was, or not, a linear relationship between them.

The agricultural areas used for each treatment (2,000 m^2) were harvested at 115 and 136 days after sowing without and with artificial light(s) supplementation,

respectively. Grain yield in each area was expressed in kilograms per hectare (kg ha^{-1}).

STATISTICAL ANALYSIS

Extreme values (outliers) in the area below the progression curve of each variable were identified using boxplot graphs of the data residuals. When outliers' values were identified, these were replaced by an average dataset value that does not include the outlier(s). The boxplots were generated in the Software SPSS Statistics®, which was also used to calculate Pearson's correlation coefficients and the basic premises for analysis of variance (ANOVA), normality of residue distribution by Shapiro-Wilk, and homogeneity of variances by Levene, both at $p > 0.01$.

Variance analysis (ANOVA, F test) was performed after confirmation of its assumptions and considering a completely randomized experimental design. When significant differences were observed ($p < 0.05$) in ANOVA, the area below the progression curve of the variables was compared using the Tukey test of averages ($p < 0.05$) to distinguish treatments with artificial light(s) supplementation and without artificial light(s) supplementation. The ANOVA and Tukey test were performed using SISVAR® statistical program. Sigma Plot® v.12 software was used to generate the graphics.

RESULTS

The weekly evaluation data of all variables (number of soybean internodes, plant height, and number of pods per soybean plant) for both treatments with artificial light(s) supplementation and without artificial light(s) supplementation did not include extreme values. This observation indicates that the responses were grouped around an average with low standard error. The soybean variables and their respective standard errors during the nine weeks are presented in Figures 5, 6, and 7, where the lines on the bars indicate the data standard error.

The number of internodes per soybean plant, plant height, and the number of pods per plant treated with artificial light(s) supplementation 202a were higher when compared to the sample without artificial light(s) supplementation 202b. These superior responses can also be observed in Figure 8, where on the left side are represented soybean plants treated with artificial light(s) supplementation 202a at 80 days after sowing, while on the right are represented soybean plants without artificial light(s) supplementation 202b. Each segment on the measuring tape illustrates 0.1 m.

The ANOVA of the area below the progression curve and the assumptions (normality and homogeneity) are presented in Table 2.

TABLE 2

SV	DF	Internodes	Height	Pods per plant
Light supplementation	1	375**	1,590**	2,649**
Error	18			
CV (%)		1.67	1.17	0.98
KS	20	0.935^{+}	0.985^{+}	0.964^{+}
L	1+18	1.139^{+}	0.106^{+}	0.262^{+}

Table 2. Analysis of variance (F test) and statistics of the ANOVA presumptions of the area below the progression curve of the variables number of soybean internodes, plant height, and the number of pods per soybean plant. ** significant differences at 0.01. CV (%) coefficient of variation. KS Kolmogorov-Smirnov statistics for normality of waste distribution ($p > 0.01$). L Levene statistics for homogeneity of data variances ($p > 0.01$). + normality of the residues (KS) or homogeneity of the variances (L) fulfilled.

All the area data below the progression curve of the soybean variables (number of internodes, plant height, and pods per plant) met the assumptions of ANOVA (normality of residue distribution and homogeneity of variances). In addition, the coefficients of variation, CV (%), were very low (< 2%). Thus, it was appropriate to proceed with ANOVA, which indicated significant differences ($p < 0.01$) between treatments [with artificial light(s) supplementation and without artificial light(s) supplementation].

The area below the progression curve of the number of internodes per soybean plant, plant height, and the number of pods per plant in the treatment with light(s) supplementation were 15.6, 23.3, and 25.3% higher than the treatment without artificial light(s) supplementation.

Pearson's calculation and interpretation of correlation require that data be normally distributed and without outliers. These requirements were met, as presented in Table 1. All correlations observed in Table 3 were strong ($r > 0.9$) and obtained statistical significance ($p < 0.01$).

TABLE 3

	Internodes	Plant height	Pods per plant
Internodes	1	0.962**	0.970**
Plant height		1	0.990**
Pods per plant			1

Table 3. Pearson correlation (r) between the area below the progression curve of the variables studied. Internodes number of soybean internodes; Plant height soybean plant height; Pods per plant number of pods per soybean plant. ** significant differences at 0.01.

The evaluated soybean cultivar has a cycle of approximately 17 weeks. On day 115 after sowing, soybean plants from the area without artificial light(s) supplementation 202b (2,000 m^2) were harvested; however, the harvest of soybean plants in the area with artificial light(s) supplementation occurred three weeks later, representing a 17.6% longer crop 202a cycle.

The estimated productivity of the area without artificial light(s) supplementation was about 4,500 kg ha^{-1} (75 bags ha^{-1}; 1 bag = 60 kg), while treatment with artificial light(s) supplementation was about 7,080 kg ha^{-1} (118 bags ha^{-1}). Grain yield under artificial light(s) supplementation was 57.3% higher and 109.5% above the average Brazilian soybean yield (3,379 kg ha^{-1}).

The average cost to produce soybean from soil management to harvesting is about 55 bags of soybean per hectare. The average cost required by artificial light(s) supplementation was about 7 bags ha^{-1}. Thus, the profitability of soybean traditionally produced (without artificial light(s) supplementation) and soybean produced with artificial light(s) supplementation was about 20 and 56 bags ha^{-1}, respectively.

The extension of the soybean crop 202a cycle by three weeks due to artificial light(s) supplementation also increased the period of plant 202a photosynthetic activity. This prolonged cycle also contributes to increasing biomass accumulation via natural daily photosynthesis, an absent process in the regular soybean cultivar cycle (17 weeks) where no artificial light(s) supplementation 202b was applied. This combination of factors resulted in taller soybean plants, with more internodes, more pods, and, consequently, more than 57% extra grain yield.

In the exposed example, the extra yield generated by the application of adequate crop management and artificial light(s) supplementation cannot be attributed only to the hours of artificial light(s) supplementation provided to each soybean crop

202a (about 40 hours). As mentioned above, in addition to the extension of the soybean cycle through artificial light(s) supplementation, other factors should be taken into account, such as photomorphogenesis, alteration of the plant photoperiod and circadian cycle of culture 202a, upper or lower regulation of phytohormones and phytochromes, as well as changes in secondary metabolism of the crop 202a plant, which are factors responsive to artificial light(s) supplementation.

Agricultural inputs such as fertilizers, plant inoculants, and plant protection products, applied during crop 202a cycle 202b, are intended to maximize agricultural production and economic returns. Although such agricultural inputs have adverse effects on soil dynamics and these effects are often overlooked. However, according to the present invention, artificial light(s) supplementation 200 to field crops can potentially reduce the proportional need for such inputs, mainly fertilizers.

The efficiency of fertilization in this exemplified study probably resulted from a significant increase in shoot biomass followed by artificial light(s) supplementation. The increase in the biomass of the shoots, in turn, causes a proportional increase in the biomass of the roots. This improved root development increases the efficiency of absorption of nutrients by the roots, thus increasing fertilizer efficiency.

The present invention is used as a response model to reproducibly understand and apply the consequences and interactions of nutritional, microbiological, environmental, and economic aspects around agricultural production by integrating valuable information on physiological processes, sowing time, irrigation frequency, and time, fertilizer doses, management of insects and plant diseases, and soil relations with the environment. The inclusion of climate information may clarify the relationship between agricultural production and weather fluctuations. This integrated approach increases the resilience of the global food production system and food security against unexpected climate shocks.

Currently, there is a rapid continuous increase in the integration of technologies and digitization in agriculture. This movement is also aligned with the sustainability of the ecosystems explored for agricultural activities. In this sense, before starting cropping, other factors must be considered for a productive and sustainable agricultural activity. Such other factors include crop management strategies and their consequences, the level of technologies implemented, and soil water and nutrient

availability. Although the use of artificial light(s) supplementation on a field scale 200 is a challenge to control, the present invention makes it possible.

The present invention also has great potential to reduce deforestation of new native areas for agricultural production purposes since more food can be produced in the same agricultural area. Although crop 202a productivity can be increased with adequate implementation of artificial light(s) supplementation throughout the crop 202a cycle, the *state of the art* does not reveal the interactions between the different factors. For example, soil, plant, climate, agronomic management, crop 202a performance, yield formation, and cost-benefit ratio indicate its inherent complexity. In addition, the present invention has the potential to reduce the use of agrochemicals, fertilizers, and water since the plant becomes more efficient in soil exploration through an improved root system stimulated by artificial light(s) supplementation and other technologies implemented.

According to the present invention, the production costs of crops 202a cultivated by the artificial light(s) supplementation system 100 depend on several factors. These factors include the efficiency of the available cropping structure, for example, machinery and farm administration; the technology implemented, for example, genetic materials and fertilizers; and the use of precise agricultural systems. Other factors include the characteristics of the irrigation system, for example, the irrigated area and the height of the irrigation pivot 101 that affects light dissipation, artificial light(s) supplementation in areas of static irrigation, soil structuring, for example without physical or chemical limitation, and with healthy microbiota; electricity supply, for example, source, spinning, constancy, and stability, in addition to the internet of things and agronomic management of agricultural crops 202a. Thus, the cost and profitability in this example reflect a specific scenario of soybean production that may vary on a case-by-case basis. Despite this observation, according to the present invention, artificial light(s) supplementation presents an opportunity to improve crop 202a production.

In conclusion, in the exemplified study, the present invention was implemented and delivered approximately 40 hours of artificial light(s) supplementation to each soybean plant were required during the crop 202a cycle to positively affect the number of internodes, pods, plant height, and crop 202a cycle.

Artificial light(s) supplementation, according to the present invention, increased soybean yield by 57.3% and its profitability by 180% in relation to cultivation

processes without artificial light(s) supplementation and proved to be a viable and promising technique to improve sustainably of crop production in the same agricultural field.

Due to the youth of *outdoor* artificial light(s) supplementation technology and due to its success being associated with its application integrated with technically adequate and balanced agriculture, preliminary studies were conducted for other crops besides soybeans (*Glycine max*). However, the results obtained have been positive for biomass production by plants were light(s) supplementation was(were) present. The responses observed for other crops and perceptions of the application of artificial light(s) supplementation integrated with appropriate agronomic technologies and management will be briefly discussed below.

BEANS (*PHASEOLUS VULGARIS*)

The common bean was cultivated in the winter crop season and received artificial light(s) supplementation from post-sowing until pre-harvest. Soil remineralizers and biological products were applied before sowing. The plant stand was reduced by 15% compared to the regular stand recommendation for traditional crop cultivation without artificial light(s) supplementation.

A lower number of fungicide applications and 36% more grain yield were observed in the area that received artificial light(s) supplementation. Other studies with beans were conducted in different regions and confirmed the positive response of this crop when artificial light(s) supplementation is applied according to the present invention.

CORN (*ZEA MAYS*)

Corn was grown in spring/summer and received artificial light(s) supplementation from post-sowing until pre-harvest, as well as soil remineralizers, organominerals, and biological products that were applied to the soil before sowing. In this study, the plant stand (plant number per hectare) was 60% higher than the stand regularly used in traditional cultivation without artificial light(s) supplementation.

Differences were observed among the studied varieties (hybrids), such as plants generally higher (> 4 m), higher average ear number per plant, and greater crop health. Healthier plants in the area that received artificial light(s) supplementation allowed crop cultivation with fewer fungicide applications. Grain yield was 183% higher than the regional grain yield average for the same year.

TOMATO (*SOLANUM LYCOPERSICUM*)

Different varieties of tomato for pulp were evaluated, and the area that received artificial light(s) supplementation presented plants with superior development of the aerial plant part compared to the area without artificial light(s) supplementation. This further development of the aerial part allowed the early plant cover of the space between planting lines and doubled the production of tomato fruits.

Only the area that did not receive artificial light(s) supplementation had problems with calcium deficiency, causing the "*blossom end rot*" symptom in the fruits. In the area that received artificial light(s) supplementation, no such stress was observed that would impair the development of the plants and their respective productions.

Both areas received soil remineralizers and foliar nutrients. Artificial light(s) supplementation occurred throughout the crop cycle in the respective area, and the light color combination used in soybean (59% red, 33% green, and 8% blue) showed excellent results in tomato plant development.

COTTON (*GOSSYPIUM HIRSUTUM*)

Cotton was tested in different regions and different varieties. As observed for the other crops, the aerial part of the cotton plants that received the artificial light(s) supplementation project was significantly higher than the plants that did not receive artificial light(s) supplementation.

The cotton tree that received the artificial light(s) supplementation project produced 20 to 40% more "apples" (structure containing the plume, the cotton fiber) per plant and about 12% more final fiber production. The artificial light(s) supplementation positively impacted the final production and quality of the cotton fiber. The presence of insects in the area that received artificial light(s) supplementation was reduced compared to traditional cotton cultivation without artificial light(s) supplementation.

SUGARCANE (*SACCHARUM OFFICINARUM*)

Artificial light(s) supplementation in sugarcane has brought many beneficial effects. The area received the application of soil remineralizer and was cultivated without any fungicide application. Initially, sugarcane with artificial light(s) supplementation showed a higher number of tillers (seedlings) per clump, which increased the production of crop biomass.

Stem height, total soluble solids content, apparent sucrose, and recovered total sugars were higher in sugarcanes grown with artificial light(s)

supplementation. The "*brown spot*" was a foliar fungal disease that occurred only in the area that did not receive artificial light(s) supplementation, indicating how the present invention promotes not only increases in yield, but also increases the plant resistance to stresses and reduces the cost and environmental impacts with lower frequencies of fungicide application.

TOBACCO (*NICOTIANA TABACUM*)

More vigorous tobacco plants, larger leaves, and higher leaf production were commonly observed in the area that received artificial light(s) supplementation. The tobacco cropping area received the application of soil remineralizer and was cultivated without any application of insecticide or fungicide. Light supplementation with the predominance of blue collors favored the development of tobacco plants.

GARLIC (*ALLIUM SATIVUM*) AND ONION (*ALLIUM CEPA*)

Areas that received the application of soil remineralizer and organominerals were cultivated without any insecticide application and with a reduced amount of fungicide applications. The yields were higher than 80% in the areas that received artificial light(s) supplementation all night during specific periods, both for garlic and onion.

The application of foliar fertilizers was similar between the areas [with or without light(s) supplementation]; however, the excellent plant development caused by artificial light(s) supplementation turned the plant more sensitive to the lack of essential nutrients, especially those required in smaller amounts (micronutrients).

PEA (*PISUM SATIVUM*)

Pea is a crop that responds satisfactorily well to artificial light(s) supplementation. Depending on its application (grain production or cover crop), it should be changed the color composition of artificial light(s) supplementation.

The high pea biomass production, which increased the crop residues added to the soil surface, was produced with a predominance of blue coloration in the artificial light(s) supplementation; however, for exclusive grain production, the composition of artificial light(s) supplementation in soybean (59% red, 33% green and 8% blue) was more adequate.

SUNFLOWER (*HELIANTHUS ANNUUS*)

Artificial light(s) supplementation increased the size of the sunflowers, increasing the production of larger seeds with improved quality parameters such as

size and integrity. Sunflower areas cultivated with artificial light(s) supplementation showed high vegetative-productive development and plant sanity.

In areas where artificial light(s) supplementation was applied, insecticides or fungicides were not applied to the crop plants. The production of sunflower seeds was 44% higher in the area that received the artificial light(s) supplementation compared to the traditional cultivation area without artificial light(s) supplementation.

POTATO (*SOLANUM TUBEROSUM*)

Different varieties and planting stands were studied for potatoes that received artificial light(s) supplementation. Artificial light(s) supplementation in this crop can be used from emergence until about ten days before harvest desiccation. The production occurred with lower use of fungicides compared to the area without artificial light(s) supplementation and the commercial cropping area adjacent to the experimental area 200.

There was a large production of root tubers, and production was about 38% higher than in traditional cultivation without artificial light(s) supplementation. Soil and organomineral remineralizers were used in both areas to complement the basic fertilization and support higher root tuber productions.

HOPS (*HUMULUS LUPULUS*)

The artificial light(s) supplementation applied to hop plants generated promising results. It was possible to develop and harvest the second crop of hops in the same agricultural year, which was not observed in the area without artificial light(s) supplementation. The number of floral cones (structures used as raw material for beer) was much higher, and their dimensions were larger in plants that received artificial light(s) supplementation.

The beer produced using the hops produced with artificial light(s) supplementation did not present any harm in relation to traditional cultivation. Therefore, artificial light(s) supplementation allowed more than doubling the productive capacity of hops in an area, besides not negatively affecting beer production and quality.

STRAWBERRY (*FRAGARIA × ANANASSA*)

Production, fruit sanity, and shelf time were superior for strawberries produced with artificial light(s) supplementation applied throughout the crop cycle. Some strawberry varieties respond better to artificial light(s) supplementation. In

general, reddish artificial light(s) supplementation provides better results in fruit production and seedlings of plant development.

Pitaya (*Hylocereus Undatus*)

The number of crops and fruits was positively affected by artificial light(s) supplementation. The harvests became continuous with adequate crop management and artificial light(s) supplementation. About 4 to 6 hours of artificial light(s) supplementation per night were enough to maintain this fruit harvest constancy and increase the number of fruits per plant. With increased harvests per year and fruits per plant, the required amounts of fertilizers, soil pH correctors and conditioners, soil remineralizers, and organominerals were necessary to support the production.

This situation of great fertilizer need to compensate for a higher total production is further indication that the full functioning of artificial light(s) supplementation, according to the present invention, is dependent on other factors that need to be available so that plant responses are not limited by factors whose deficiency may compromise crop full development and yield.

Lettuce (*Lactuca Sativa*) and Arugula (*Eruca vesicaria ssp. Sativa*)

All experiments with horticultural crops with artificial light(s) supplementation showed more accelerated plant development from seedlings to adult plants, allowing for more year-round harvests. In addition, they presented more intense colors and more pleasant flavors.

The use of more bluish artificial light(s) supplementation allowed better results; however, there are significant differences in responses between the varieties studied in each plant species. This observation indicates that each region should be studied for adequate crop varieties to select those with better responses to artificial light(s) supplementation.

Cover Crops

Different cover crops were responsive to artificial light(s) supplementation, and all responses were positive. The higher the plant biomass (e.g., leaves, stems, and roots) growth, the faster the covering of the cropping area, which improves soil protection and reduces crop competition with invasive plants (weeds). The cropping of solitary crop species (only one predominant species) or mixtures of different species presented improved results under artificial light(s) supplementation.

The use of more bluish artificial light(s) supplementation also allowed better results. However, it was clear how each cover crop (such as Sudan grass, fodder

turnip, millet, crotalaria, wheat, and buckwheat) in different regions presented differentiated responses to the same spectral signature of artificial light(s) supplementation, indicating that different crop species would have distinct and unique spectral band composition for each plant species and edaphoclimatic condition.

The achievements exposed above indicated that the present invention accomplishes significant advances in the application and development of artificial light(s) supplementation, highlighting the beneficial effects of the use of artificial lighting sources 10a, 10b, 10c, 10d, 10e in the metabolism and agronomic management of plants, in the efficiency of light absorption and photosynthesis in their respective aerial parts, as well as in the mitigation of stresses such as insect pests and plant pathogens that can be repelled or controlled in the areas that receive a light(s) supplementation. These effects benefit the agricultural production process by extending the plant resistance to adverse conditions during crop development, improving qualitative and nutritional aspects of the final crop product, and elevating the sustainability of the agricultural activity.

Despite the description of crop yield achievements to specific accomplishments, the present invention may present modifications in its implementation so that the scope of protection of the invention is limited to the content of the attached claims, including possible equivalent variations.

SET OFCLAIMS

1. AGRICULTURAL MANAGEMENT SYSTEM (100) is characterized by comprising:

- a modular agricultural irrigation pivot-like device (101) positioned on an agricultural field (200) in the cultivation of a crop (202a) species, the modular agricultural irrigation pivot-like device (101) comprising:

- a plurality of artificial lighting sources (10a, 10b, 10c, 10d, 10e) arranged along the modular agricultural irrigation pivot-like device (101) at a predetermined distance above the aerial parts of the crop (202a), comprising a plurality of light-emitting diodes; and

- a plurality of energy sources that feed the plurality of artificial lighting sources (10a, 10b, 10c, 10d, 10e),

the agricultural management system (100) further comprising:

a processor in communication with a dimerizer and/or a polarizer of the plurality of artificial lighting sources (10a, 10b, 10c, 10d, 10e) and with the plurality of energy sources, wherein the processor is configured to:

a) adjust (501), in the intervals of the electromagnetic spectrum, the balance between the spectral bands emitted by the plurality of light-emitting diodes; and

b) determine and implement:

- an irrigation routine (502); and/or

- an artificial light(s) supplementation routine (503);

wherein stages a) and b) are determined by the processor considering at least one among:

- a crop (202a) species under cultivation;

- a phenological stage of the crop (202a) under cultivation;

- a photoperiod, a season and current weather conditions under which the agricultural field (200) is subjected; and

- one or more objective(s) intended for the crop (202a) development.

2. SYSTEM (100), according to claim 1, characterized in that stages a) and b) determined by the processor using an artificial intelligence model.

3. SYSTEM (100), according to any of claims 1 and 2, characterized in that the modular agricultural irrigation pivot-like device (101) comprises:

- a drive device for the displacement of the modular agricultural irrigation device (101) over the agricultural field (200); and

- sprinkler devices comprising a plurality of sprinklers,

wherein the processor is in communication with the drive device and with the sprinkler device for the execution of stage b).

4. SYSTEM (100), according to any of claims 1 to 3, characterized by in that a plurality of soil sensors under the agricultural field (200) captures nutritional data of the soil of the agricultural field (200).

5. SYSTEM (100), according to claim 4, characterized in that the processor using all data available from the agricultural field (200):

c) determines and suggests the routines for crop and artificial light(s) supplementation management.

6. SYSTEM (100), according to claim 5, characterized in that stage c) determined by the processor using the artificial intelligence model, considers one of the following:

- the irrigation routine (502);

- the routine of artificial light(s) supplementation (503);

- the crop (202a) species under cultivation;

- the phenological stage of the crop (202a) under cultivation;

- the photoperiod responses, the season and the current weather conditions under which the agricultural field (200) is subjected; and

- the one or more objective(s) intended for the crop (202a) development.

7. SYSTEM (100), according to any of claims 1 to 6, characterized in that the one or more objectives intended for the crop (202a) development under cultivation is/are:

- stimulating or inhibiting a production of leaves, branches, and roots;

- stimulating or inhibiting a production of grains, fibers, fruits, and essences

- stimulating or inhibiting vegetative growth; and

- stimulating photosynthesis.

8. SYSTEM (100), according to any of the claims 1 to 7, characterized in that the routine of artificial light(s) supplementation (503), majorly occurs, but not exclusively, between phenological stages V3-V4 to R5-R6 of the crop (202a) under cultivation.

9. SYSTEM (100), according to any of claims 7 to 8, characterized in that the balance between spectral bands being adjusted (501) to understand compositions of red-green-blue spectral bands presenting at least 40% blue color for vegetative phenological stages and about 60% or at least 40% red color for the reproductive phenological stage of the crop 202a under cultivation, more than 40% red color in the artificial light(s) supplementation is recommended for any plant phenological stage.

10. SYSTEM (100), according to any of the claims 1 to 9, characterized in that the processor further considers:

- the geolocation of the agricultural field (200) and climatic indicators for the determination of agricultural zoning of climatic risk (ZARC) to suggest a crop (202a) to be cultivated, if regional information regarding the most adapted crop varieties is unavailable.

11. SYSTEM (100), according to any of claims 5 to 10, characterized in that an user interface is in communication with the processor, wherein an user feeds the following information to the processor:

- history of crops previously cultivated in the agricultural field (200);

- history of agricultural inputs used in the agricultural field (200);

- occurrence of stresses during the crop (202a) cycle, such as at least one of the following: the occurrence of phytopathology; the occurrence of pests and the occurrence of weeds;

- productivity results from previous harvests; and

- characteristics of the modular agricultural irrigation device (101), among irrigated area, irrigation flow, pivot working speed and height of the agricultural irrigation modular device (101);

wherein stages a), b) and c) are determined by the processor using the artificial intelligence model, considering at least one of the following:

- the crop (202a) species under cultivation;

- the phenological stage of the crop (202a) under cultivation;

- the photoperiod, the season and the current weather conditions under which the agricultural field (200) is subjected;

- the one or more objective(s) for crop (202a) development and responses; and

- the user-fed information through the user interface.

12. SYSTEM (100), according to claim 11, characterized in that the processor using information on the height of the modular agricultural irrigation device (101) to adjust (501) the illumination emitted by the LEDs as a function of the distance of the plurality of artificial lighting sources (10a, 10b, 10c, 10d, 10e) for the crop (202a) under cultivation.

13. SYSTEM (100), according to claims 1 to 12, characterized in that the plurality of energy sources being a plurality of photovoltaic and wind cells for energy production to support the energy needed for the artificial light(s) supplementation working during nights (majorly).

14. SYSTEM (100), according to claim 13, characterized in that the processor, in communication with a plurality of photosensor cells, determines a threshold of incidence of sunlight in the photovoltaic cells, for which below this, and depending on a certain routine of artificial light(s) supplementation (503), a processor commands the performance of the plurality of light-emitting diodes.

15. SYSTEM (100), according to any of claims 1 to 12, characterized in that the plurality of energy sources being at least one of the following: wind, thermal, or combustion generators.

16. SYSTEM (100), according to claim 15, characterized in that the processor using information of insolation index and cloudiness to determine a threshold of incidence of sunlight in the agricultural field (200) for which below this, and depending on a certain routine of artificial light(s) supplementation (503), the processor commands the performance of the plurality of light-emitting diodes.

17. SYSTEM (100), according to any of claims 1 to 16, characterized in that the crop under cultivation being at least one of: soybean, beans, corn, tomato, carrot, cotton, sugar cane, tobacco, garlic, onion, pea, sunflower, sorghum, potato, hops, strawberry, pitaya, lettuce, arugula, oats, coffee, and soil cover crops and grasses.

18. AGRICULTURAL MANAGEMENT METHOD (500), for the cultivation of a crop (202a) in an agricultural field (200), characterized by comprising the steps of:

a) adjusting (501), in intervals of the electromagnetic spectrum, the balance between the spectral bands emitted by a plurality of light-emitting diodes of a plurality of artificial lighting sources (10a, 10b, 10c, 10d, 10e); and

b) determining and implementing:

- an irrigation routine (502) of a modular agricultural irrigation device (101); and/or

- a routine of artificial light(s) supplementation (503) of the plurality of artificial lighting sources (10a, 10b, 10c, 10d, 10e);

wherein stages a) and b) are determined considering at least one among:

- a crop (202a) species under cultivation;

- a phenological stage of the crop (202a) under cultivation;

- a season, a photoperiod, and current weather conditions under which the agricultural field (200) is subjected; and

- one or more objective(s) intended for the crop (202) development.

19. METHOD (500), according to claim 18, characterized in that stages a) and b) are determined by the processor using an artificial intelligence model.

20. METHOD (500), according to any of the claims 18 to 19, is characterized by further comprising a stage c) of determining a routine of soil management in the agricultural field (200) based on soil analyses from the agricultural field (200).

21. METHOD (500), according to claim 20, characterized in that stage c) of determining through the artificial intelligence model considers at least one of the following:

- the irrigation routine (502);

- the routine of artificial light(s) supplementation (503);

- the crop (202a) species under cultivation;

- the phenological stage of the crop (202a) under cultivation;

- the photoperiod, the season and the current weather conditions under which the agricultural field (200) is subjected; and

- the one or more objective(s) intended for the crop (202a) development.

22. METHOD (500), according to any of the claims 18 to 21, characterized in that the one or more objectives intended for the crop (202a) development to:

- stimulate or inhibit the production of leaves, branches, and roots;

- stimulate or inhibit the production of grains, fibers, fruits, and essences - stimulate or inhibit vegetative growth; and - stimulate photosynthesis.

23. METHOD (500), according to any of the claims 18 to 22, characterized in that the routine of artificial light(s) supplementation (503) that majorly,

but not always, occurs between phenological stages V3-V4 to R5-R6 of the crop (202a) under cultivation.

24. METHOD (500), according to any of the claims 22 to 23, characterized in that the balance between the spectral bands being adjusted (501) to understand compositions of red-green-blue spectral bands that should present at least 40% blue color for vegetative phenological stages and about 60% or at least 40% red color for the reproductive phenological stage of the crop 202a under cultivation, more than 40% red color in the artificial light(s) supplementation is recommended for any plant phenological stage.

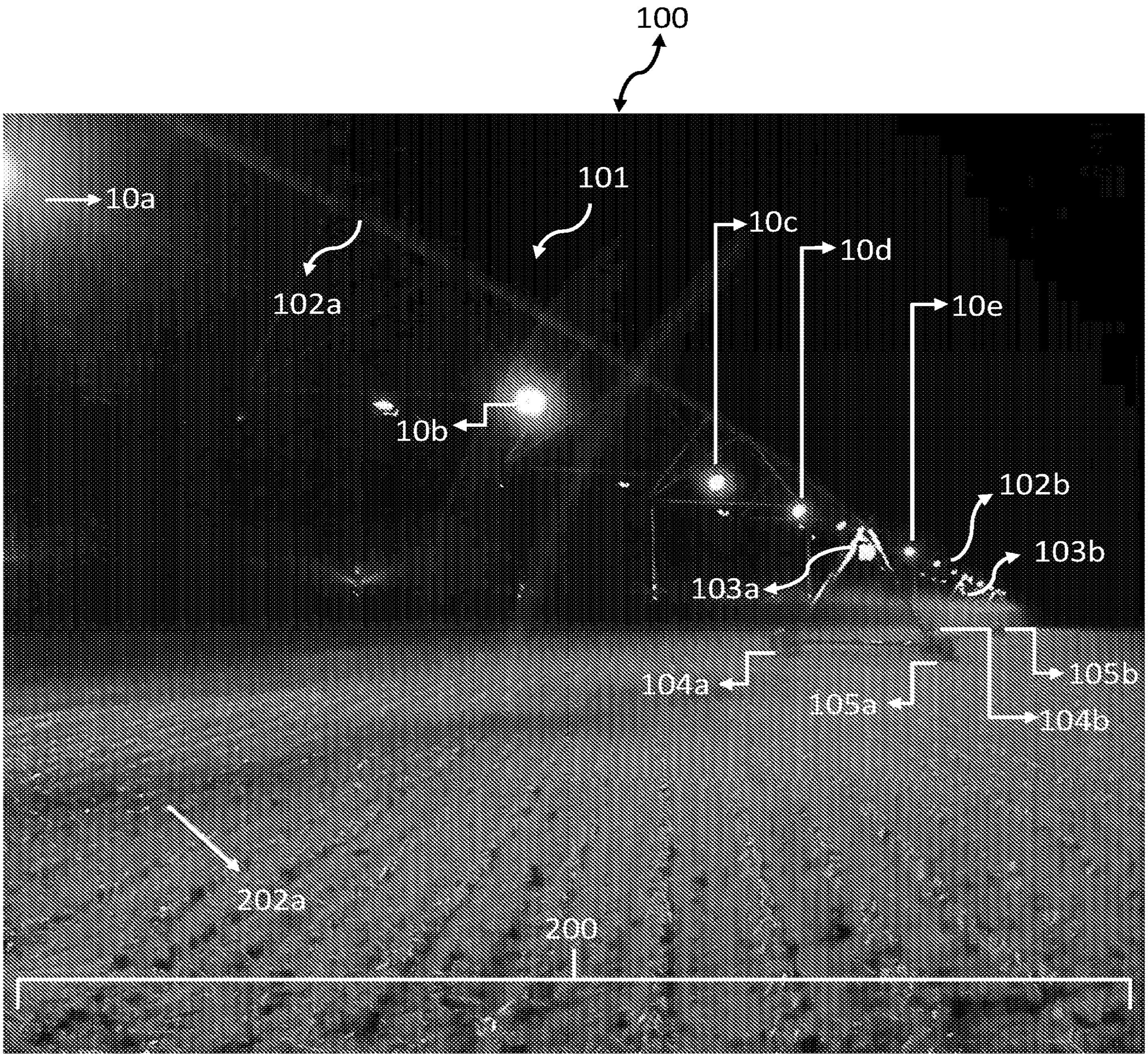
100
10a
101
102a
10c
10d
10e
10b
102b
103b
103a
104a
105a
105b
104b
202a
200

Figure 1

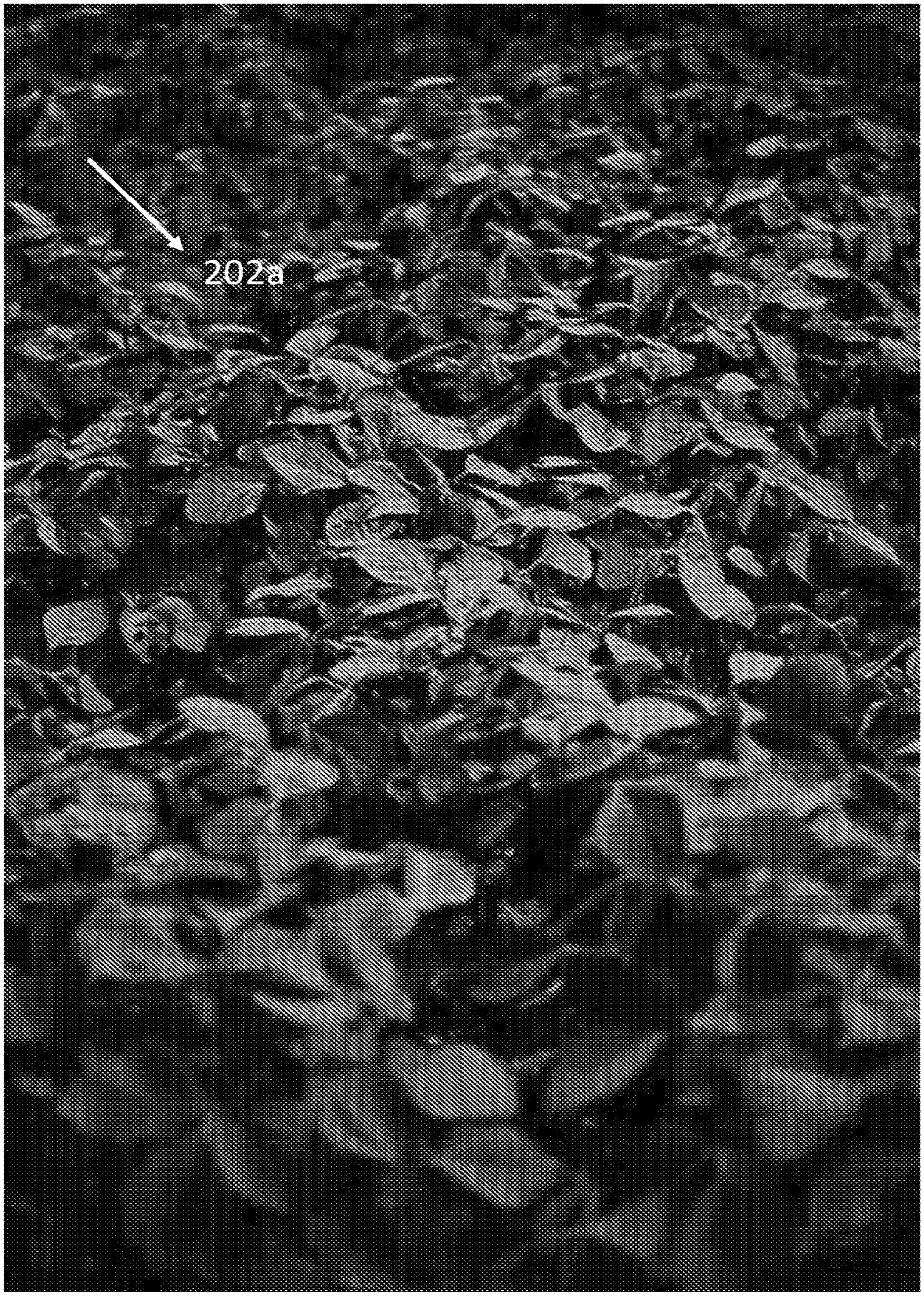

Figure 2

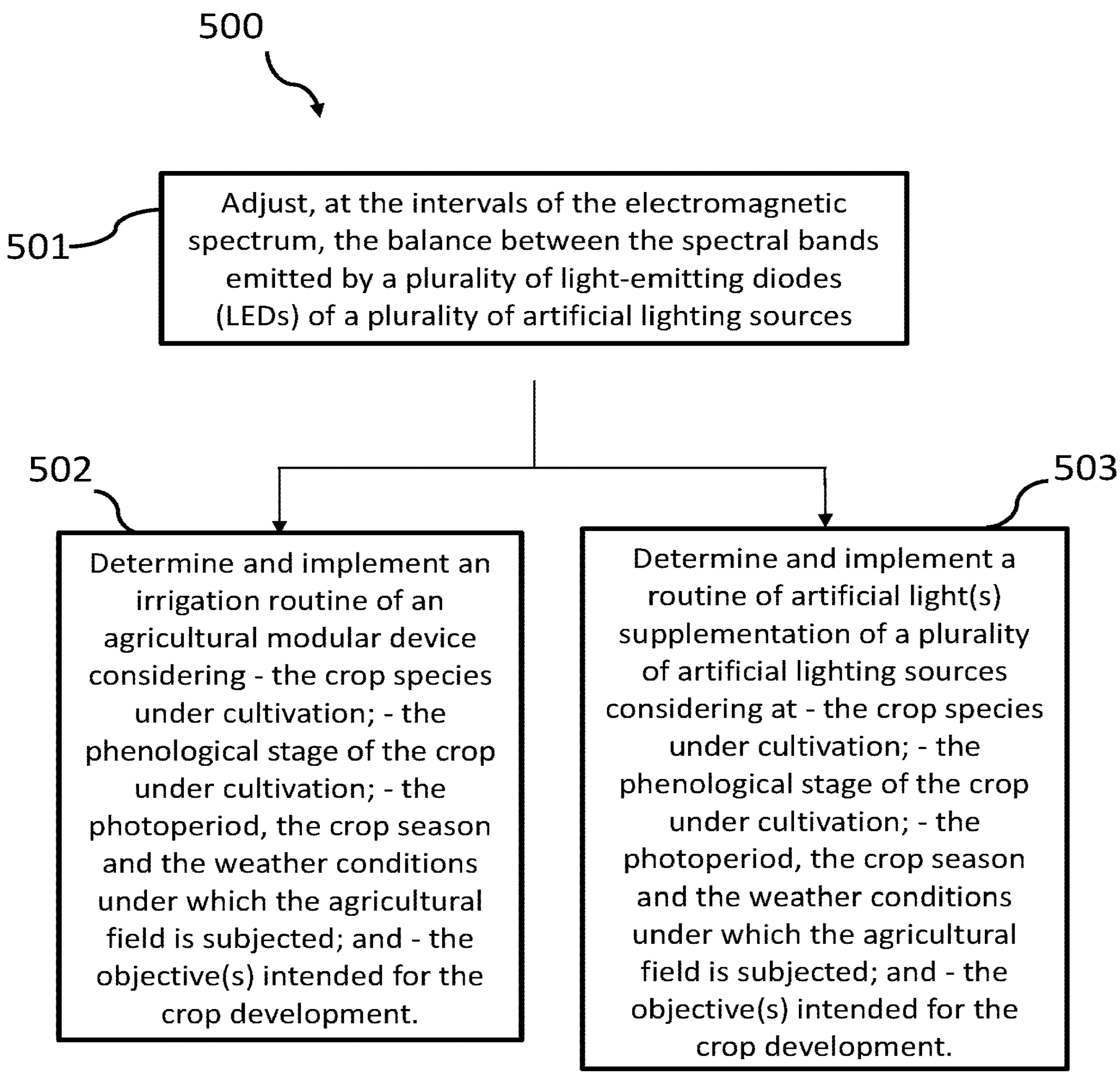
500
501
Adjust, at the intervals of the electromagnetic spectrum, the balance between the spectral bands emitted by a plurality of light-emitting diodes (LEDs) of a plurality of artificial lighting sources
502
Determine and implement an irrigation routine of an agricultural modular device considering - the crop species under cultivation; - the phenological stage of the crop under cultivation; - the photoperiod, the crop season and the weather conditions under which the agricultural field is subjected; and - the objective(s) intended for the crop development.
503
Determine and implement a routine of artificial light(s) supplementation of a plurality of artificial lighting sources considering at - the crop species under cultivation; - the phenological stage of the crop under cultivation; - the photoperiod, the crop season and the weather conditions under which the agricultural field is subjected; and - the objective(s) intended for the crop development.

Figure 3

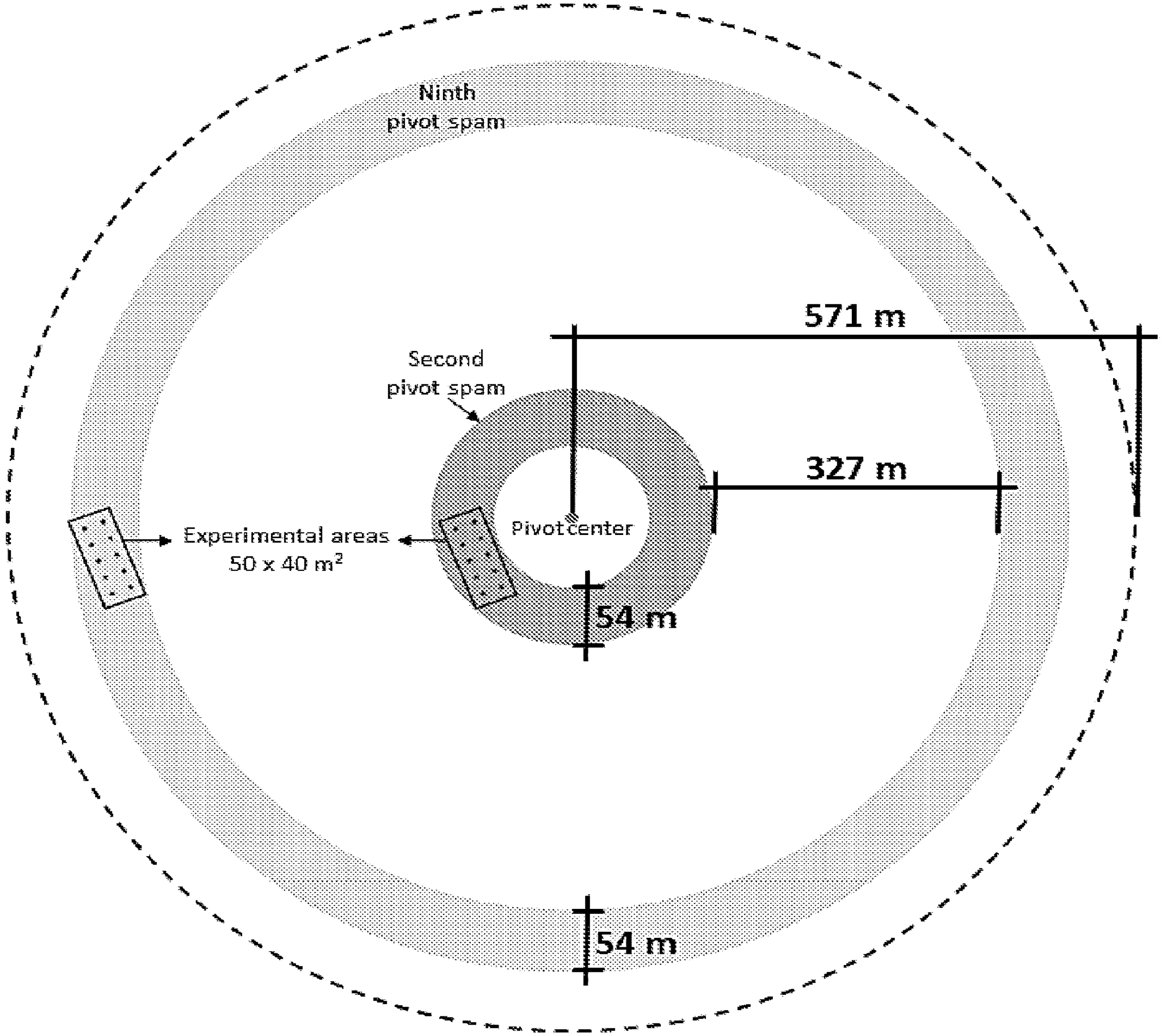
Ninth
pivot spam
571 m
Second
pivot spam
327 m
Experimental areas
50 x 40 m²
Pivot center
54 m
54 m

Figure 4

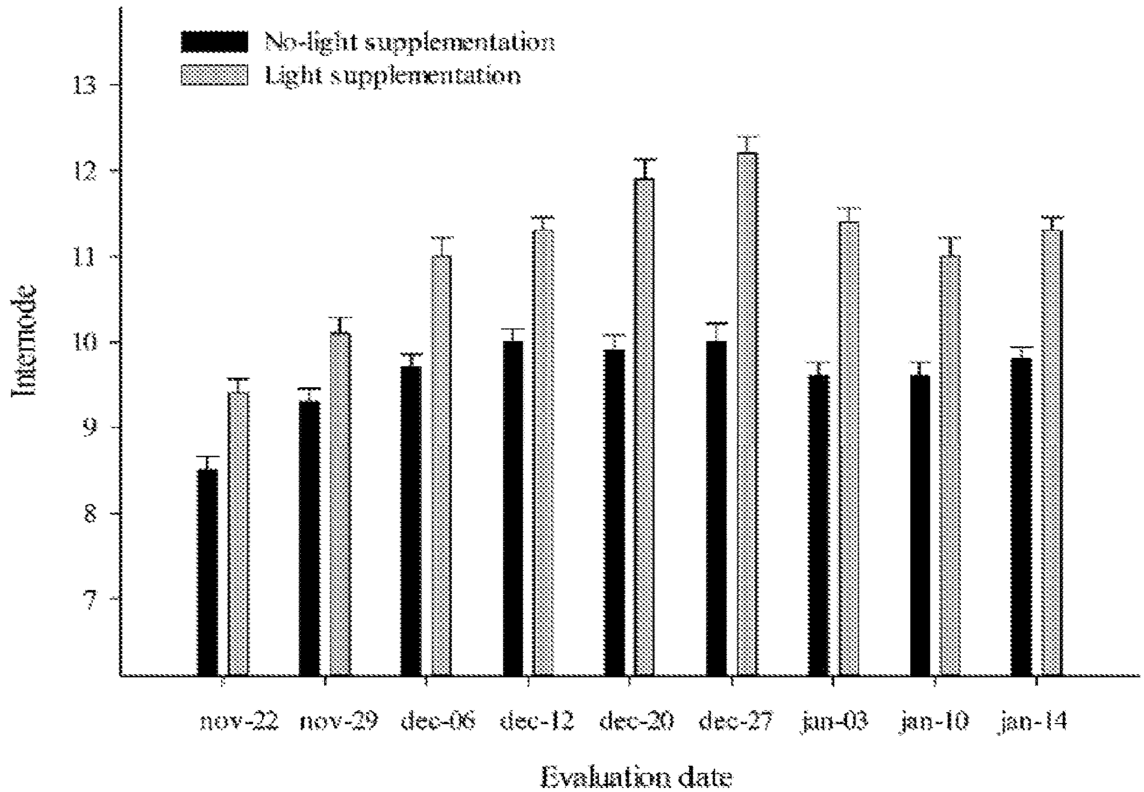
No-light supplementation
Light supplementation
13
12
11
10
9
8
7
Internode
nov-22
nov-29
dec-06
dec-12
dec-20
dec-27
jan-03
jan-10
jan-14
Evaluation date

Figure 5

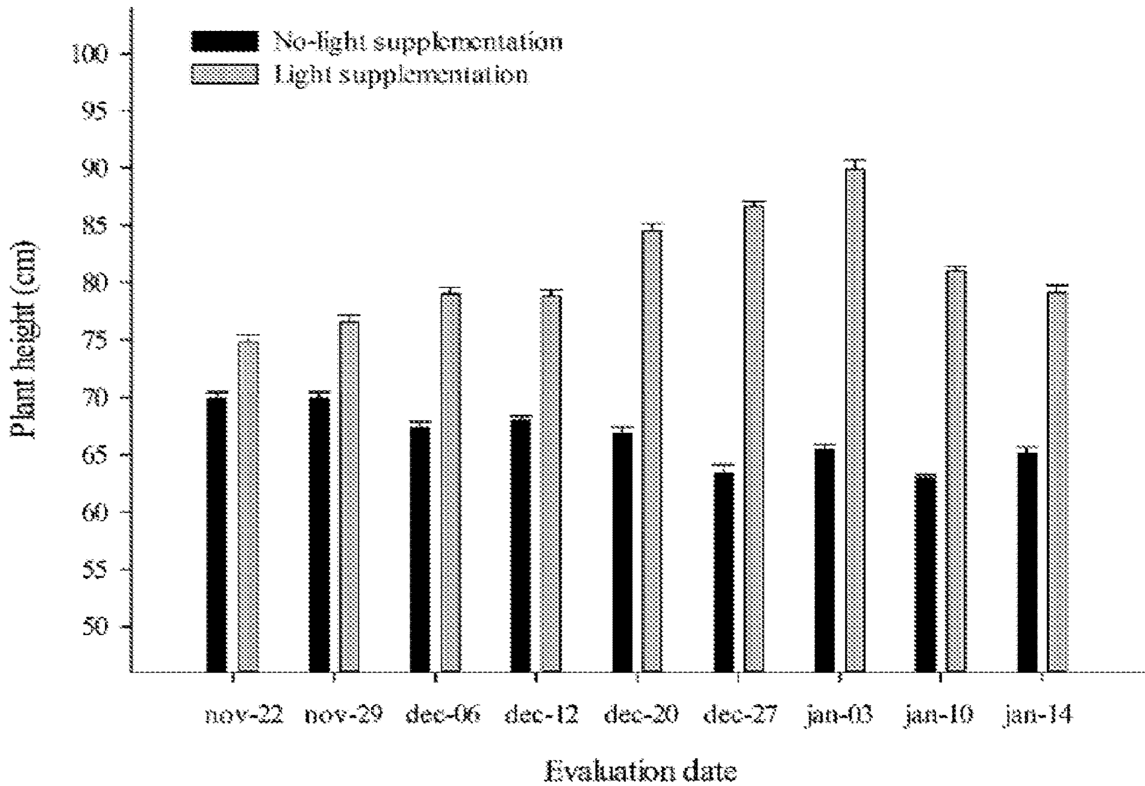
No-light supplementation
Light supplementation
Plant height (cm)
100
95
90
85
80
75
70
65
60
55
50
nov-22
nov-29
dec-06
dec-12
dec-20
dec-27
jan-03
jan-10
jan-14
Evaluation date

Figure 6

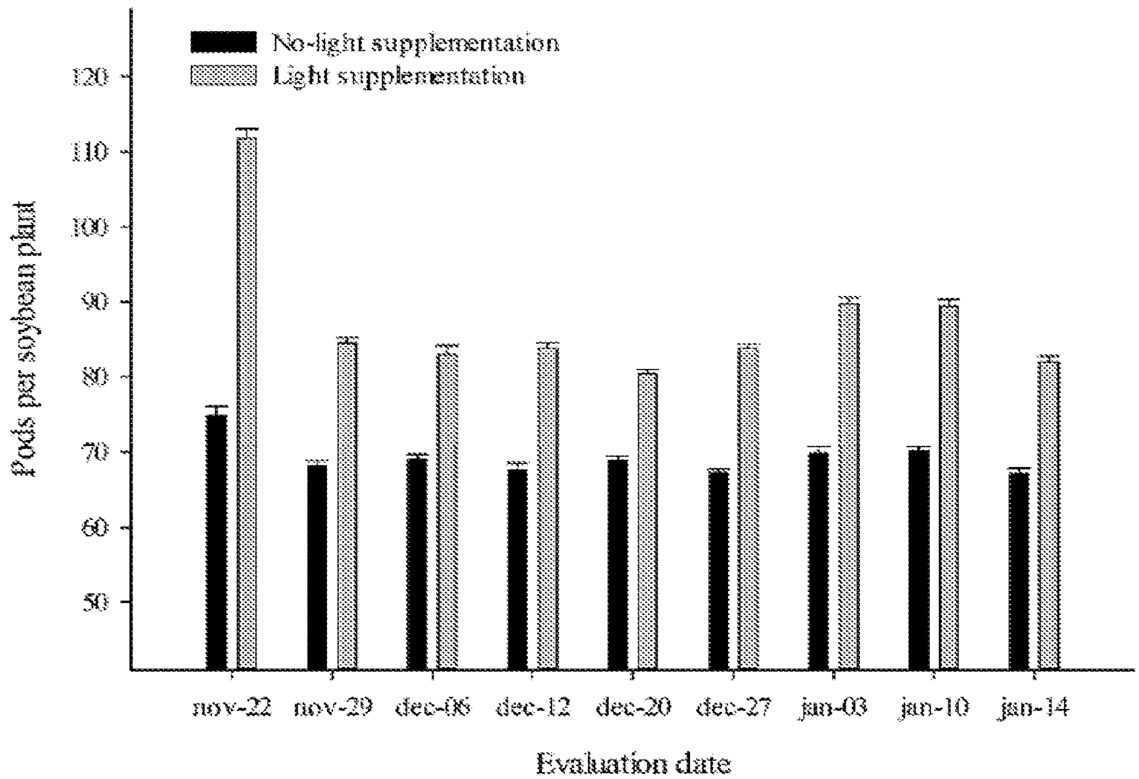
No-light supplementation
Light supplementation
Pods per soybean plant
120
110
100
90
80
70
60
50
nov-22
nov-29
dec-06
dec-12
dec-20
dec-27
jan-03
jan-10
jan-14
Evaluation date

Figure 7

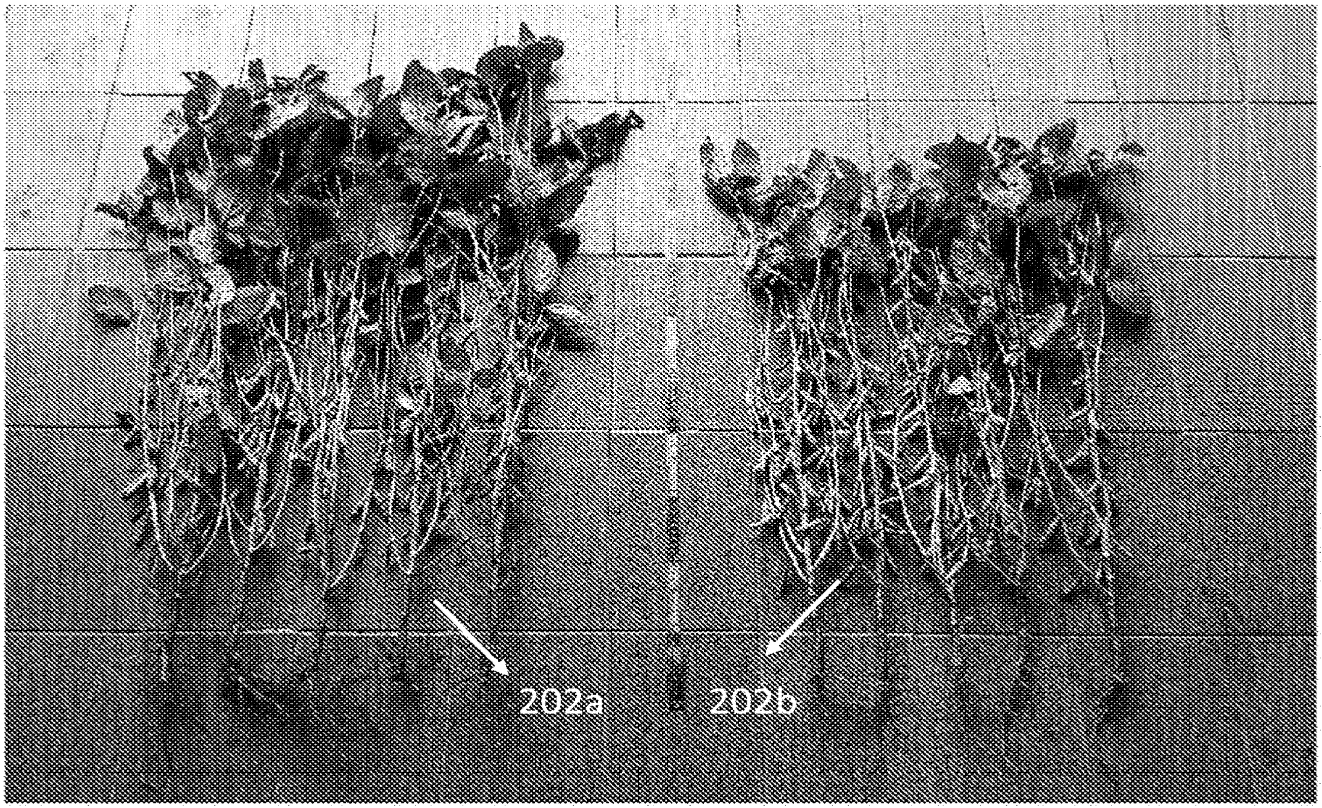

Figure 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/BR 22/50461

A. CLASSIFICATION OF SUBJECT MATTER
IPC - INV. A01G 7/04, A01G 9/20, H05B 47/10 (2023.01)
ADD. A01G 25/09 (2023.01)
CPC - INV. A01G 7/045, A01G 9/20, A01G 9/249, H05B 47/10
ADD. A01G 25/09

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
See Search History document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2020/0359550 A1 (Tran), 19 November 2020 (19.11.2020), entire document, especially Fig. 1A-6; para [0233]-[0236], [0244], [0245], [0270], [0271], [0305]-[0312].	1-3, 18-21
A	US 2013/0263503 A1 (Firefly-One, LLC), 10 October 2013 (10.10.2013), entire document, especially Fig. 1-6; para [0025]-[0030].	1-3, 18-21
A	US 2016/0262313 A1 (LED Living Technology), 15 September 2016 (15.09.2016), entire document.	1-3, 18-21
A	US 2012/0038281 A1 (Verfuerth), 16 February 2012 (16.02.2012), entire document.	1-3, 18-21
A	US 2002/0154504 A1 (Fang et al.), 24 October 2002 (24.10.2002), entire document.	1-3, 18-21

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 March 2023 (30.03.2023)	APR 24 2023

Name and mailing address of the ISA/US	Authorized officer
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Kari Rodriquez Telephone No. PCT Helpdesk: 571-272-4300

Form PCT/ISA/210 (second sheet) (July 2022)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/BR 22/50461

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 4-17, 22-24
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2022)

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DOCUMENT MADE AVAILABLE UNDER THE PATENT COOPERATION TREATY (PCT)

International application number:		**PCT/BR2022/050461**
International filing date:		**24 November 2022 (24.11.2022)**
Document type:		**Certified copy of priority document**
Document details:	Country/Office: Number: Filing date:	**BR** **1020220072728** **14 April 2022 (14.04.2022)**
Date of receipt at the International Bureau:		**25 November 2022 (25.11.2022)**

Remark: Priority document submitted or transmitted to the International Bureau in compliance with Rule 17.1(a),(b) or (b-*bis*)

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CÓPIA OFICIAL

PARA EFEITO DE REIVINDICAÇÃO DE PRIORIDADE

O documento anexo é cópia fiel de um Pedido de Depósito de Patente regularmente depositado no Instituto Nacional da Propriedade Industrial, sob número BR 102022007272-8 de data 14/04/2022

Rio de Janeiro, 29 de Agosto de 2022

Assinado eletronicamente por:
Instituto Nacional da Propriedade Industrial

Pedido nacional de Invenção, Modelo de Utilidade, Certificado de Adição de Invenção e entrada na fase nacional do PCT

Número do Processo: BR 10 2022 007272 8

Dados do Depositante (71)

Depositante 1 de 1

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Tipo de Pessoa: [redacted]
CPF/CNPJ: [redacted]
Nacionalidade: [redacted]
Qualificação Jurídica: [redacted]
Endereço: [redacted]
Cidade: [redacted]
Estado: [redacted]
CEP: [redacted]
País: [redacted]
Telefone: [redacted]
Fax:
Email: [redacted]

Dados do Pedido

Natureza Patente: 10 - Patente de Invenção (PI)

Título da Invenção ou Modelo de Utilidade (54): SISTEMA E MÉTODO DE SUPLEMENTAÇÃO LUMINOSA ARTIFICIAL

Resumo: O sistema (100) compreende: um dispositivo modular de irrigação (101) posicionado sobre um campo (200) no cultivo de uma cultura (202a) e compreendendo um dispositivo de acionamento para o deslocamento do dispositivo modular (101) sobre o campo (200); um dispositivo de aspersão compreendendo uma pluralidade de aspersores; uma pluralidade de fontes de iluminação artificial (10a, 10b, 10c, 10d, 10e) dispostas ao longo do dispositivo modular (101) a uma distância predeterminada acima da parte aérea da cultura (202a), compreendendo uma pluralidade de diodos emissores de luz (LED) do tipo espectro total (full-spectrum); e uma pluralidade de células fotovoltaicas que alimentam a pluralidade de fontes de iluminação (10a, 10b, 10c, 10d, 10e), o sistema (100) compreendendo ainda: um processador em comunicação com o dispositivo de aspersão, o dispositivo de acionamento um dimerizador ou polarizador das fontes de iluminação (10a, 10b, 10c, 10d, 10e), e com a pluralidade de células fotovoltaicas em que o processador é configurado para: a) ajustar (501), no intervalo do espectro eletromagnético, o balanço entre as bandas espectrais emitidas pela pluralidade de diodos; e b) determinar e inicializar: uma rotina de irrigação (502); e uma rotina de suplementação luminosa artificial (503), independentes entre si, sendo que as etapas a) e b) são determinadas pelo processador considerando pelo menos um dentre: o tipo de cultura (202a) sob cultivo; o estágio fenológico da cultura (202a); o fotoperíodo e as condições meteorológicas sob as quais o campo (200) está submetido; e um ou mais objetivos de desenvolvimento da cultura (202a).

Figura a publicar: 01

Dados do Procurador

Procurador:

Nome ou Razão Social: [redacted]

Numero OAB:

Numero API: [redacted]

CPF/CNPJ: [redacted]

Endereço: [redacted]

Cidade: [redacted]

Estado: [redacted]

CEP: [redacted]

Telefone: [redacted]

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Email: [redacted]

Dados do Inventor (72)

Inventor 1 de 1

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CPF: [redacted]

Nacionalidade: [redacted]

Qualificação Física: [redacted]

Endereço: [redacted]

Cidade: [redacted]

Estado: [redacted]

CEP: [redacted]

País: [redacted]

Telefone:

Fax:

Email:

Documentos anexados

Tipo Anexo	Nome
Procuração	3610-0013_Depósito_POA.PDF
Relatório Descritivo	3610-0013_Depósito_Relatório Descritivo.PDF
Reivindicação	3610-0013_Depósito_Reivindicações.PDF
Desenho	3610-0013_Depósito_Desenhos.PDF
Resumo	3610-0013_Depósito_Resumo.PDF
Comprovante de pagamento de GRU 200	3610-0013_Depósito_GRU.pdf

Acesso ao Patrimônio Genético

☑ Declaração Negativa de Acesso - Declaro que o objeto do presente pedido de patente de invenção não foi obtido em decorrência de acesso à amostra de componente do Patrimônio Genético Brasileiro, o acesso foi realizado antes de 30 de junho de 2000, ou não se aplica.

Declaração de veracidade

☑ Declaro, sob as penas da lei, que todas as informações acima prestadas são completas e verdadeiras.

"SISTEMA E MÉTODO DE SUPLEMENTAÇÃO LUMINOSA ARTIFICIAL"

CAMPO DA INVENÇÃO

[001] A presente invenção refere-se, de uma maneira geral, a um sistema de suplementação luminosa artificial. A presente invenção refere-se também a um método de suplementação luminosa artificial. Particularmente, o sistema e método de suplementação luminosa artificial de acordo com a presente invenção são direcionados para o cultivo de uma cultura em um campo agrícola.

ANTECEDENTES DA INVENÇÃO

[002] A produção agrícola em larga escala sempre esteve intimamente interligada a e dependente de variáveis múltiplas tais como fatores nutricionais e microbiológicos do solo de plantio, características intrínsecas a uma determinada região, tal como o clima e o fotoperíodo, bem como uma pluralidade de estresses bióticos e abióticos que pairam sobre as cultivares, tais como inoculações de organismos nocivos às cultivares como patógenos de solo, infestações de pragas agrícolas, plantas invasoras, bem como a deficiência hídrica, irradiação, entre outros.

[003] No contexto do atual cenário agroindustrial, o Brasil notadamente se destaca como um dos maiores produtores e exportadores de *commodities* agrícolas, tais como a soja *(Glycine max)* e o milho *(Zea mays)* com uma produção anual de grãos de 124,8 milhões de toneladas. Neste sentido, é evidente que o desenvolvimento de novas técnicas e tecnologias de manejo agrícola têm grande impacto econômico e industrial. Além disso, a intensificação da produção agrícola é pressionada pela crescente população mundial e por consequência pelo aumento da demanda internacional por tais *commodities*.

[004] Neste sentido, além de ferramentas dinâmicas e macroscópicas como a determinação de zoneamentos agroecológicos e de

risco climático (ZARC) para uma dada cultivar, diversos têm sidos os esforços de novas tecnologias a fim de modelar e monitorar variáveis como a pedologia do solo e condições edafoclimáticas a fim de entender as consequências e interações que estas causam a uma determinada cultura. Como exemplo, cita-se o uso de tecnologias e estratégias de manejo do solo e recursos hídricos, o uso inteligente de agroquímicos, a aplicação eficiente de fertilizantes, a integração de *Internet of Things (IoT)* às práticas de monitoramento agrícola e climático.

[005] Além do monitoramento e controle de fatores externos, também é desejado pelos produtores agrícolas a implementação de tecnologias biológicas, tais como cultivares geneticamente modificadas *(GMOs)*, que sejam benéficas aos produtores, consumidores e à economia de modo geral, bem como o uso de compostos bioativos, como fito-hormônios reguladores de crescimento da cultivar, resultando na alteração de aspectos desde a germinação até processos metabólicos como a senescência plantar, podendo também estimular o desenvolvimento e a relação fonte-dreno de fotoassimiados de uma cultivar. Tais tecnologias trazem benefícios ao produto, que pode melhor suportar condições adversas ao seu desenvolvimento, bem como a incrementação do valor nutricional ao consumidor final.

[006] Ao longo das últimas décadas, o uso de tais tecnologias tornou-se constante a fim de intensificar produções agrícolas ao redor do globo, visto que a frequência de uso de tais tecnologias como na Ásia e América do Sul quase se equiparou à frequência de uso na Europa e América do Norte. No entanto, o uso de tais tecnologias em larga escala em adição às crescentes mudanças climáticas recentemente causaram uma nova demanda pela intensificação da produção agrícola, desta vez por meio de abordagens tecnológicas mais sustentáveis.

[007] Desta forma, foram feitos avanços recentes em estudos sobre suplementação luminosa artificial destacando-se efeitos benéficos do uso de diodos emissores de luz *(LEDs)* no metabolismo de cultivares, na eficiência de absorção de luz em suas partes aéreas (ou seja, as partes das plantas que estão acima do nível do solo), bem como a mitigação de estresses bióticos como o controle de pragas e patógenos na produção agrícola, ao passo que se aplica um manejo consciente de recursos energéticos para tal.

[008] O documento US 2016/0198640 A1 revela um pivô de irrigação móvel dotado de aspersores e uma pluralidade de diodos emissores de luz *(LEDs)* configurados para emitir diferentes frequências de luz polarizada em bandas espectrais desde o violeta, o vermelho e o vermelho extremo, sobre plantas de dias curtos ou dias longos em um campo agrícola durante a operação móvel do pivô, conforme ilustrado pela figura 1 do referido documento.

[009] O pivô de irrigação descrito pode compreender também, um circuito de controle configurado para controlar a operação dos diodos emissores de luz *(LEDs)*, dos aspersores ou de rodas do pivô de irrigação.

[010] No entanto, fica claro que o estado da técnica carece de melhorias tecnológicas em relação ao gerenciamento consciente de recursos energéticos e hídricos em conjunto com um sistema de suplementação luminosa artificial que leve em consideração as condições meteorológicas sob as quais um campo agrícola está submetido.

OBJETIVOS E DESCRIÇÃO DA INVENÇÃO

[011] Portanto, um objetivo da presente invenção é prover um sistema de suplementação luminosa artificial capaz de eliminar ou ao menos reduzir as limitações das técnicas conhecidas atualmente.

[012] Além disso, é um objetivo da presente invenção prover um sistema de suplementação luminosa artificial versátil e que possa ser adaptado

e implementado em qualquer pivô de irrigação pré-existente em uma plantação agrícola no cultivo de uma cultura, em que uma rotina de suplementação luminosa independa de uma rotina de irrigação.

[013] Ainda, a presente invenção tem por objetivo prover um sistema de suplementação luminosa artificial que seja capaz de estimular uma ou mais características de uma determinada cultura, por exemplo, a germinação ou floração de plantas de dias longos por meio do estabelecimento de uma rotina de suplementação luminosa artificial, por exemplo, após o fim do período matutino e vespertino, estabelecendo um fotoperiodismo da referida cultura superior ou pelo menos igual ao seu fotoperíodo crítico.

[014] Outro objetivo da presente invenção é prover um sistema de suplementação luminosa artificial que seja capaz de estimular uma ou mais características de uma determinada cultura, por exemplo, a germinação ou floração de plantas de dias curtos por meio do estabelecimento de uma rotina de suplementação luminosa artificial, por exemplo, em consideração de condições meteorológicas adversas à fotossíntese por meio da luz natural durante o período matutino e vespertino, compensando pela baixa luminosidade durante o dia, estabelecendo um fotoperiodismo da referida cultura inferior ao seu fotoperíodo crítico.

[015] É ainda um objetivo da presente invenção prover meios para automaticamente dimerizar ou polarizar bandas do espectro eletromagnético total emitidas em virtude da rotina de suplementação luminosa artificial conforme as diferentes demandas e condições ideais de desenvolvimento de uma ou mais culturas, em considerações de um ou mais fatores tais como o tipo de cultura, a região do cultivo e o tipo de sistema produtivo agrícola em uso.

[016] A presente invenção adicionalmente objetiva manter e adaptar a rotina de irrigação e suplementação luminosa em diferentes períodos

fenológicos durante todas as etapas de desenvolvimento de uma cultura, promovendo uma produção agrícola em quantidade e qualidade.

[017] A presente invenção também tem por objetivo proteger a cultura sob cultivo ao repelir pragas agrícolas por meio da modulação da luz impedindo a inoculação de doenças na cultura, o que reduz a necessidade da aplicação de produtos fitossanitários e por consequência mitiga os danos a longo prazo que tal aplicação poderia causar ao solo.

[018] Por fim, a presente invenção objetiva o aumento da eficiência da irrigação e do uso de fertilizantes e agroquímicos (inseticidas, fungicidas, bactericidas,...), em virtude dos efeitos causados pela suplementação luminosa artificial, tal como o desenvolvimento do sistema radicular da cultura.

[019] Um ou mais objetivos da presente invenção acima mencionado(s), dentre outros, é(são) alcançado(s) por meio de um sistema de suplementação luminosa artificial, que compreende:

- um dispositivo modular de irrigação agrícola posicionado sobre um campo agrícola no cultivo de uma cultura e compreendendo:

- um dispositivo de acionamento para o deslocamento do dispositivo modular de irrigação agrícola sobre o campo agrícola;

- um dispositivo de aspersão compreendendo uma pluralidade de aspersores;

- uma pluralidade de fontes de iluminação artificial dispostas ao longo do dispositivo modular de irrigação agrícola em pontos equidistantes e a uma distância predeterminada acima das partes aéreas da cultura, compreendendo uma pluralidade de diodos emissores de luz *(LED)* do tipo espectro total (*full-spectrum*); e

- uma pluralidade de células fotovoltaicas que alimentam a pluralidade de fontes de iluminação artificial.

[020] O sistema de suplementação luminosa artificial compreende ainda:

- um processador em comunicação com o dispositivo de aspersão, o dispositivo de acionamento, um dimerizador ou polarizador da pluralidade de fontes de iluminação artificial, e com a pluralidade de células fotovoltaicas, em que o processador é configurado para:

a) ajustar, nos intervalos do espectro eletromagnético, o balanço entre as bandas espectrais emitidas pela pluralidade de diodos emissores de luz *(LED)* do tipo espectro total *(full-spectrum)*; e

b) determinar e inicializar:

- uma rotina de irrigação; e

- uma rotina de suplementação luminosa artificial,

em que as rotinas de irrigação e de suplementação luminosa artificial são independentes entre si, sendo que as etapas a) e b) são determinadas pelo processador considerando pelo menos um dentre:

- o tipo de cultura sob cultivo;

- o estágio fenológico da cultura sob cultivo;

- o fotoperíodo e as condições meteorológicas sob as quais o campo agrícola está submetido; e

- um ou mais objetivos de desenvolvimento da cultura sob cultivo a serem alcançados.

[021] Um ou mais objetivos da presente invenção acima mencionado(s), dentre outros, é(são) também alcançado(s) por meio de um método de suplementação luminosa artificial para o cultivo de uma cultura em um campo agrícola, compreendendo as etapas de:

a) ajustar, nos intervalos do espectro eletromagnético, o balanço entre as bandas espectrais emitidas por uma pluralidade de diodos emissores de luz *(LED)* do tipo espectro total *(full-spectrum)* de uma pluralidade de fontes de iluminação artificial; e

b) determinar e inicializar:

- uma rotina de irrigação de um dispositivo modular de irrigação agrícola; e

- uma rotina de suplementação luminosa artificial da pluralidade de fontes de iluminação artificial,

em que as rotinas de irrigação e de suplementação luminosa artificial são independentes entre si, sendo que as etapas a) e b) são determinadas considerando pelo menos um dentre:

- o tipo de cultura sob cultivo;

- o estágio fenológico da cultura sob cultivo;

- o fotoperíodo e as condições meteorológicas sob as quais o campo agrícola está submetido; e

- um ou mais objetivos de desenvolvimento da cultura sob cultivo a serem alcançados.

BREVE DESCRIÇÃO DOS DESENHOS

[022] Os objetivos, efeitos técnicos e vantagens da presente invenção serão aparentes aos técnicos no assunto a partir da descrição detalhada a seguir que faz referência às figuras anexas, que ilustram realizações exemplificadoras, mas não limitadoras, dos objetos reivindicados:

- a Figura 1 ilustra um sistema de suplementação luminosa artificial 100 operando junto a um dispositivo modular de irrigação agrícola 101 sobre um campo agrícola 200, de acordo com a presente invenção;

- a Figura 2 mostra uma ampliação de uma cultura 202a no campo agrícola 200 sob a atuação do sistema de suplementação luminosa artificial 100, de acordo com a presente invenção;

- a Figura 3 ilustra as etapas da lógica de funcionamento do método de suplementação luminosa artificial 500, conforme uma realização da presente invenção;

- a Figura 4 ilustra uma vista superior de uma esquematização de um pivô de irrigação no qual o sistema de suplementação luminosa artificial 100 foi instalado, de acordo com um exemplo da presente invenção;

- a Figura 5 ilustra um primeiro gráfico de uma análise de uma primeira variável da cultura 202a ao longo do tempo, sob a atuação do sistema de suplementação luminosa artificial 100, de acordo com o exemplo da presente invenção;

- a Figura 6 ilustra um segundo gráfico de uma análise de uma segunda variável da cultura 202a ao longo do tempo, sob a atuação do sistema de suplementação luminosa artificial 100, de acordo com o exemplo presente invenção;

- a Figura 7 ilustra um terceiro gráfico de uma análise de uma terceira variável da cultura 202a ao longo do tempo, sob a atuação do sistema de suplementação luminosa artificial 100, de acordo com o exemplo da presente invenção;

- a Figura 8 mostra uma comparação entre uma primeira amostra da cultura 202a sob a atuação do sistema de suplementação luminosa artificial 100, e uma segunda amostra da cultura 202b fora da atuação do sistema de suplementação luminosa artificial 100, de acordo com o exemplo da presente invenção.

Descrição de Realizações da Invenção

[023] Inicialmente, cumpre destacar que o sistema e método da presente invenção serão descritos a seguir de acordo com realizações particulares, mas não limitativas, uma vez que suas realizações poderão ser

executadas de diferentes formas e variações e conforme a aplicação desejada pelo técnico no assunto.

[024] Em uma realização, a presente invenção revela um sistema de suplementação luminosa artificial 100 para o cultivo de uma cultura 202a em um campo agrícola 200.

[025] Em uma outra realização, a presente invenção revela um método de suplementação luminosa artificial 500 para o cultivo de uma cultura 202a em um campo agrícola 200.

[026] Cumpre notar que as expressões "planta" ou "cultura" devem ser entendidas como quaisquer cultivares, sejam de dias longos, tais como aveia *(Avena sativa)* ou batata *(Solanum tuberosum)* ou dias curtos, como soja *(Glycine max)* ou café *(Coffea sp.)*, que se beneficiem da suplementação luminosa artificial de acordo com a presente invenção. Exemplos não exaustivos de tais cultivares são soja *(Glycine max)*, feijão *(Phaseolus vulgaris)*, milho *(Zea mays)*, tomate *(Solanum lycopersicum)*, cenoura *(Daucus carota)* algodão *(Gossypium L)*, cana-de-açúcar *(Saccharum officinarum)*, tabaco *(Nicotiana tabacum)*, alho *(Allium sativum)*, cebola *(Allium cepa)*, ervilha *(Pisum sativum),* girassol *(Helianthus annuus),* batata-inglesa *(Solanum tuberosum), lúpulo (Humulus lupulus), morango (Fragaria × ananassa),* pitaya *(Hylocereus undatus)* entre outros, cabendo ajustes na suplementação luminosa artificial para cada cultura 202a e região de cultivo, bem como outros fatores tais como o estágio fenológico da cultura 202a sob cultivo, o fotoperíodo e as condições meteorológicas sob as quais o campo agrícola 200 está submetido e um ou mais objetivos de desenvolvimento da cultura 202a a serem alcançados.

[027] Conforme pode ser visto através das figuras 1 e 2, o sistema de suplementação luminosa artificial 100 de acordo com uma realização da presente invenção, pode ser adaptado a um pivô de irrigação já

existente em um campo agrícola 200, tal como um pivô de irrigação central, seja ele rebocável ou não rebocável ou mesmo um pivô de irrigação linear. No presente relatório descritivo o pivô é descrito de uma maneira geral como "dispositivo modular de irrigação agrícola 101".

[028] Este dispositivo modular de irrigação agrícola 101 é posicionado sobre o campo agrícola 200 sobre o qual ocorre o cultivo de uma cultura 202a, sendo que o dispositivo modular 101 compreende um primeiro módulo, tendo um primeiro braço de irrigação 102a que possui um formato substancialmente oblongo, tendo uma extremidade distal do primeiro braço de irrigação 102a suportada por, e mecanicamente associada a, uma primeira torre de deslocamento 103a dotada de um primeiro dispositivo de acionamento, tal como um motor ou equivalente, e de primeiras rodas 104a; 105a, sendo que uma extremidade proximal do primeiro braço de irrigação 102a é mecanicamente associada de forma rotativa, ao pivô central, de maneira a permitir o movimento circular do primeiro módulo em relação ao pivô central, quando a primeira torre de deslocamento 103a é acionada pelo primeiro dispositivo de acionamento.

[029] O dispositivo modular 101 pode adicionalmente compreender pelo menos um segundo módulo dotado de um segundo braço de irrigação 102b que possui um formato substancialmente oblongo, em que uma extremidade distal do segundo braço de irrigação 102b é suportada por, e mecanicamente associada a, uma segunda torre de deslocamento 103b dotada de um segundo dispositivo de acionamento, tal como um motor ou equivalente, e de segundas rodas 104b; 105b, sendo que uma extremidade proximal do segundo braço de irrigação 102b é mecanicamente associada de forma rotativa, à primeira torre de deslocamento 103a, de maneira a permitir o movimento circular do primeiro módulo e do pelo menos um segundo módulo em relação ao pivô central.

[030] O dispositivo modular 101 compreende também um dispositivo de aspersão dotado de uma linha hidráulica de pressão em comunicação hídrica com um reservatório que pode estar disposto, por exemplo, no pivô central, a linha hidráulica se estendendo ao longo do primeiro e do pelo menos um segundo braço de irrigação 102a; 102b, os quais são dotados de uma pluralidade de aspersores a fim de promover a irrigação do campo agrícola 200.

[031] O sistema de suplementação luminosa artificial 100 incorpora uma pluralidade de fontes de iluminação artificial 10a, 10b, 10c, 10d, 10e dispostas, por exemplo, ao longo dos braços de irrigação 102a; 102b do dispositivo modular de irrigação agrícola 101 podendo estar localizadas em pontos equidistantes e a uma distância predeterminada acima das partes aéreas da cultura 202a, a distância em relação ao solo e às demais fontes de iluminação artificial 10a, 10b, 10c, 10d, 10e pode ainda ser ajustada conforme necessário, a depender do tipo de dispositivo modular 101 que receberá as referidas fontes, e do tipo de cultura 202a sob cultivo.

[032] Além disso, a pluralidade de fontes de iluminação artificial 10a, 10b, 10c, 10d, 10e compreendem uma pluralidade de diodos emissores de luz *(LED)* do tipo espectro total *(full-spectrum)* capazes de emitir radiação fotossinteticamente ativa, com comprimentos de ondas que variam de 280nm, no limite do espectro UV-C com o UV-B, até 1200nm, no espectro infravermelho próximo, os quais estão diretamente associados à produção de biomassa, à morfologia vegetal e ao desenvolvimento de culturas 202a de maneira geral. Em uma realização, o intervalo de comprimento de ondas aplicado podem ser os mesmos no período diurno ou noturno, mas com intensidades de fluxo luminoso variáveis.

[033] O sistema 100 compreende ainda, uma pluralidade de células fotovoltaicas que alimentam a pluralidade de fontes de iluminação

artificial 10a, 10b, 10c, 10d, 10e, bem como um processador em comunicação com o dispositivo de aspersão, o dispositivo de acionamento e um dimerizador ou polarizador da pluralidade de fontes de iluminação artificial (10a, 10b, 10c, 10d, 10e), em que o processador é configurado para ajustar, em intervalos do espectro eletromagnético, o balanço entre as bandas espectrais emitidas pela pluralidade de diodos emissores de luz *(LED)* do tipo espectro total *(full-spectrum)*; e determinar e inicializar uma rotina de irrigação; e uma rotina de suplementação luminosa artificial, em que as rotinas de irrigação e de suplementação luminosa artificial são independentes entre si. Em outras palavras, o processador pode comandar a atuação do dispositivo de acionamento, do dispositivo de aspersão e do dimerizador ou polarizador de forma individual, de acordo com a rotina estabelecida, as quais são determinadas pelo processador considerando pelo menos um dentre: o tipo de cultura 202a sob cultivo; o estágio fenológico da cultura 202a sob cultivo; o fotoperíodo e as condições meteorológicas sob as quais o campo agrícola 200 está submetido; e um ou mais objetivos de desenvolvimento da cultura 202a sob cultivo a serem alcançados.

[034] Em uma realização, o processador pode adicionalmente estar em comunicação com a pluralidade de células fotovoltaicas, a fim de determinar um limiar de incidência de luz solar nas referidas placas fotovoltaicas, para o qual abaixo deste, e a depender de uma determinada rotina de suplementação luminosa artificial, o processador comanda a atuação da pluralidade de diodos emissores de luz *(LED)* do tipo espectro total *(full-spectrum)*, compensando por adversidades meteorológicas sob as quais o campo agrícola 200 está submetido, tais como dias nublados com baixa incidência de luz solar.

[035] Destaca-se ainda, que o limiar de incidência de luz pode adicionalmente ser dependente de demais fatores, tais como o tipo de cultura

202a sob cultivo, do atual estágio fenológico da cultura 202a, bem como do local de desenvolvimento e do manejo aplicado à cultura 202a.

[036] Em outras palavras, o fluxo luminoso, bem como o balanço entre as bandas espectrais emitidas pela pluralidade de diodos emissores de luz *(LED)* são variáveis por meio do dimerizador ou polarizador e controláveis pela interação entre as células fotovoltaicas e o processador, bem como de acordo com dada rotina de suplementação luminosa artificial, que por sua vez leva em consideração os fatores mencionados anteriormente. Por exemplo, para as culturas 202a de modo geral, os estágios fenológicos básicos são o vegetativo (V) (onde ocorre o pré florescimento) e o reprodutivo (R) (que se inicia com a primeira flor ou estrutura reprodutiva), em que cada estágio fenológico além dos estágios básicos recebe um balanço de bandas espectrais específicos para cada estágio e para cada cultura 202a. Além disso, em aplicações noturnas, o fluxo luminoso pode ser ajustado para ser menor, por exemplo, do que o fluxo luminoso em aplicações diurnas, intendendo apenas causar estímulos na cultura 202a, que serão comentados adiante. Especialmente em aplicações diurnas, o fluxo luminoso pode ser ajustado para ser maior em períodos nublados, intendendo mitigar os efeitos da redução fotossintética.

[037] Isto é especialmente vantajoso, visto que a nebulosidade pode reduzir a capacidade fotossintética de culturas 202a em mais de 50% em situações críticas muito nebulosas, fazendo com que a cultura 202a produza menos açúcares, o que resulta em menores quantidades de exsudatos radiculares liberados ao solo e aos microrganismos simbiontes, que por sua vez têm a função de obter nutrientes à cultura 202a, tornando-as mais resistentes à patógenos e pragas agrícolas. Desta forma, fica evidente que a compensação pela baixa incidência de luz solar é fator decisivo para o combate à patógenos e pragas agrícolas.

[038] Especificamente culturas consideradas de dias curtos tais como a soja *(Glycine max),* são largamente influenciadas por fatores abióticos como o fotoperíodo e a temperatura. Seu florescimento e ciclo reprodutivo regular ocorrem sob um fotoperiodismo curto, ou seja, em dias cujo tempo de ausência de luz (noite) é maior do que o tempo de presença de luz (dia). Ao passo que o contrário, isto é, dias mais longos que noites, podem atrasar ou inibir o florescimento e o início do ciclo reprodutivo. Dessa forma, nota-se que a extensão do ciclo da cultura 202a, o número de nós, vagens e sementes por vagem e a distribuição de vagens nas partes aéreas da soja são positivamente afetados por fotoperíodos estendidos por meio de suplementação luminosa artificial, uma vez que se aumenta o período de atividade fotossintética da cultura 202a e o acúmulo de biomassa devido ao ciclo estendido.

[039] É importante mencionar também, que para realização da fotossíntese com saldo positivo geralmente o fluxo luminoso fica entre 200 e 600 μmol m^{-2} s^{-1}. Contudo, a suplementação luminosa artificial atua em outros aspectos fisiológicos que afetam direta e indiretamente a fotossíntese na planta, e não necessariamente a suplementação luminosa artificial é aplicada para ser a fonte luminosa para causar a fotossíntese.

[040] Em geral, fontes de iluminação artificial (10a, 10b, 10c, 10d, 10e) com fluxo luminoso inferior a 200 μmol m^{-2} s^{-1} não são capazes de causar quantidades consideráveis de fotossíntese positiva. Contudo, mesmo fluxos luminosos menores podem causar estímulos nas culturas 202a que podem direta ou indiretamente afetar positivamente a fotossíntese a ser realizada no dia seguinte. Portanto, tanto uma luminosidade baixa, capaz apenas de causar reações, mas incapaz de causar quantidades consideráveis de fotossíntese positiva, quanto uma luminosidade maior, terão aplicações distintas e úteis de acordo com a presente invenção.

[041] Por sua vez, a figura 3 ilustra o método de suplementação luminosa artificial 500 para o cultivo de uma cultura 202a em um campo agrícola 200, compreender as etapas de: ajustar 501, nos intervalos do espectro eletromagnético, o balanço entre as bandas espectrais emitidas por uma pluralidade de diodos emissores de luz *(LED)* do tipo espectro total *(full-spectrum)* de uma pluralidade de fontes de iluminação artificial 10a, 10b, 10c, 10d, 10e; e determinar e inicializar: uma rotina de irrigação 502 de um dispositivo modular de irrigação agrícola 101; e uma rotina de suplementação luminosa artificial 503 da pluralidade de fontes de iluminação artificial 10a, 10b, 10c, 10d, 10e, em que as rotinas de irrigação 502 e de suplementação luminosa artificial 503 são independentes entre si, sendo que o ajuste 501 e as rotinas de irrigação e suplementação luminosa artificial 502; 503 são determinadas considerando pelo menos um dentre: o tipo de cultura 202a sob cultivo; o estágio fenológico da cultura 202a sob cultivo; o fotoperíodo e as condições meteorológicas sob as quais o campo agrícola 200 está submetido; e um ou mais objetivos de desenvolvimento da cultura 202a sob cultivo a serem alcançados.

EXEMPLO 1

[042] Referência é feita a um exemplo no qual a presente invenção foi implementada a fim de constatar sua eficácia. O referido exemplo avaliou as respostas relativas à produtividade das plantas de soja 202a em uma área comercial aberta 200 (escala de campo) cultivada sob condições de suplementação luminosa artificial, de acordo com a presente invenção. O pivô de irrigação 101 que irriga a área comercial 200, recebeu uma pluralidade de fontes de iluminação artificial 10a, 10b, 10c, 10d, 10e, de acordo com a presente invenção, em um vão interno do pivô 101 para a suplementação luminosa artificial das plantas de soja 202a.

[043] De acordo com o exemplo, cerca de 40 horas de suplementação luminosa artificial foram aplicadas nas plantas de soja 202a durante o ciclo da cultura da soja 202a. A área sob os vãos externos do pivô de irrigação 101 não receberam suplementação luminosa artificial. O número de entrenós, a altura das plantas de soja 202a, bem como a quantidade de vagens por planta de soja 202a foram avaliadas semanalmente para calcular a área sob a curva de progresso. A produtividade de grãos na colheita também foi avaliada. Como será aparente mais adiante, a área sob a curva de progresso do número de entrenós, altura das plantas de soja 202a e vagens por planta de soja 202a foram afetadas positivamente pelo sistema e método de suplementação luminosa artificial 100; 500, de acordo com a presente invenção.

[044] O ciclo regular da soja 202a, sem suplementação luminosa artificial, é de cerca de 15 a 17 semanas; no entanto, a colheita da soja ocorreu três semanas depois. Como será entendido adiante, a suplementação luminosa artificial aumentou o rendimento de grãos de soja em 57,3% e a lucratividade em 180% quando comparado à colheita sem suplementação luminosa artificial.

METODOLOGIA: ÁREA EXPERIMENTAL E CULTIVO DE SOJA

[045] O experimento foi implantado em uma fazenda comercial em Monte Carmelo, Minas Gerais, Brasil. Localizada a uma latitude e longitude de 18º 57" Sul, 47° 25" Oeste, a 980 m acima do nível do mar, a fazenda utiliza pivô de irrigação 101. O bioma mais comum e representativo da região é o Cerrado. O clima da região é Cw; subtropical úmido com inverno seco.

[046] A análise física do solo, de 0 a 0,4 m de profundidade, indicou 450, 100 e 450 g kg^{-1} de areia, silte e argila, respectivamente. As características químicas do solo até a profundidade de 0,4 m são apresentadas na Tabela 1.

TABELA 1

pH H_2O	Ca	Mg	Al	H+Al	CTC	V	P	K	M.O.S
1-2.5	cmolc dm^{-3}					%	mg dm^{-3}		g kg^{-1}
0-0.2 m Profundidade do solo									
6.9	6.03	2.87	0	1.26	10.44	88	188	96	2.9
0.2-0.4 m Profundidade do solo									
6.8	5.70	2.78	0	1.08	9.77	89	158	82	2.3

B	Co	Cu	Fe	Mn	Mo	Si	Zn
mg dm^{-3}							
0-0.2 m Profundidade do solo							
0.19	1.7	9.0	14.0	1.9	2.9	12.4	12.8
0.2-0.4 m Profundidade do solo							
0.14	1.3	7.7	17.0	3.5	2.3	11.4	11.1

Tabela 1. Caracterização química do solo em 0 a 0,2 e 0,2 a 0,4 m de camada de solo, em que CTC = capacidade de troca de cátions em pH = 7; V = saturação de bases; e M.O.S = matéria orgânica do solo.

[047] Apesar de possuir uma grande proporção de argila no solo e uma alta fertilidade, 3.000 kg ha^{-1} de remineralizante de solo (pó de rocha) (FMX® Tratto. Aparecida de Goiânia, Brasil) foi aplicado em toda a área experimental 200, 30 dias antes da semeadura da soja 202a; 400 kg ha^{-1} de organomineral 06-30-05 (% de N, P_2O_5, K_2O) (Valoriza Agro Ltda. Patos de Minas, Brasil) e 150 kg de KCl foi aplicado na época da semeadura, e 2 L ha^{-1} de Mn foi pulverizado nas partes aéreas das plantas 202a, 40 dias após a emergência da cultura 202a.

[048] A cultivar de soja 202a avaliada neste experimento foi a Desafio 8473 RSF (Brasmax® GDM. Cambé, Brasil) de crescimento indeterminado, grupo de maturidade 7.4. Foram semeadas quatorze sementes por metro quadrado (280.000 plantas por hectare); as plantas 202a foram colhidas aproximadamente 4 meses depois. A temperatura média diária do ar durante o período experimental variou de 24 a 34 °C.

[049] Na área experimental, insetos, pragas, doenças de plantas e plantas daninhas foram controladas com produtos registrados para soja conforme indicações do fabricante. Todas as áreas foram monitoradas antes e após a primeira aplicação e os produtos reaplicados conforme necessário. Os manejos das culturas 202a e irrigação hídrica também foram semelhantes entre os tratamentos de suplementação luminosa artificial e sem suplementação luminosa artificial.

TRATAMENTOS E INVESTIGAÇÃO EXPERIMENTAL

[050] O pivô de irrigação 101 onde a presente invenção foi implementada possui dez vãos e um raio de cerca de 571 m. Nos quatro vãos internos do pivô de irrigação 101, que corresponde a uma área de 33,5 ha, foi instalada a pluralidade de fontes de iluminação artificial 10a, 10b, 10c, 10d, 10e compreendendo a pluralidade de placas de diodos emissores de luz *(LED)* do tipo espectro total *(full-spectrum)*. As principais bandas espectrais RGB foram cerca de 59% vermelho, 33% verde e 8% azul. Uma faixa de luz contínua de aproximadamente 40 m de largura por 230 m de comprimento foi projetada abaixo da extensão dos quatro vãos internos do pivô de irrigação 101.

[051] Cada placa de diodos emissores de luz, (*LED)* tem uma potência que varia entre 50 e 200 W. Cerca de 600 W h^{-1} ha^{-1} foram consumidos durante o processo de suplementação luminosa artificial. As placas de diodos emissores de luz *(LED)* foram posicionadas cerca de 3 metros acima das partes aéreas das plantas 202a e distribuídas para garantir uma potência de luz igualmente distribuída, independentemente das diferentes velocidades de movimento dos vários vãos do pivô de irrigação 101. O fluxo luminoso por unidade de área ao nível das partes aéreas da soja 202a foi de cerca de 30 lx.

[052] O sistema de suplementação luminosa artificial 100, de acordo com a presente invenção, foi ligado todas as noites após o pôr do sol

completo e em dias muito nublados. Aproximadamente 480 horas de suplementação luminosa artificial foram aplicadas em toda a área durante o ciclo da cultura da soja 202a. Como o pivô de irrigação 101 completa uma volta completa sobre a área de cultivo 200 em 12,8 horas em rotina circular, cada planta 202a recebeu cerca de 40 horas de suplementação luminosa artificial durante seu ciclo.

[053] A suplementação luminosa artificial iniciou-se no estágio fenológico da soja V3 - V4 da terceira a quarta folha trifoliada totalmente expandida e terminou no estágio fenológico R5 - R6 no início do grão cheio. A escolha do estágio fenológico vegetativo V3 – V4 para o início da suplementação luminosa artificial permite com que a cultura 202a feche a entrelinha no campo agrícola 200 e comece a cobrir a área de cultivo. Surpreendentemente descobriu-se que caso a suplementação luminosa artificial seja aplicada antes deste estágio, aumenta-se as chances de proliferação de plantas infestantes, tais como ervas daninhas, que podem competir significativamente com a cultura 202a por recursos como água, nutrientes e luz, prejudicando o desempenho da produção e aumentando os gastos com herbicidas. Por sua vez, a escolha do término da suplementação luminosa artificial no estágio fenológico reprodutivo R5 - R6 deve-se ao fato de que neste estágio, a cultura de soja 202a atinge seu desenvolvimento final. Entretanto, salienta-se que a suplementação luminosa artificial poderia continuar após o estágio R5 - R6, adicionalmente favorecendo a cultura 202a, contudo, os benefícios não seriam superiores aos custos relativos à suplementação luminosa artificial para além desse estágio. Finalmente, os seis vãos externos do pivô de irrigação 101, correspondente a uma área de 69,5 ha, não receberam suplementação luminosa artificial.

[054] Entre a primeira e a segunda torre de deslocamento 103a; 103b, delimitou-se uma área homogênea de 50 por 40 m, correspondente a uma área de 2.000 m^2 para ser avaliada como o tratamento “suplementado por

iluminação artificial". A esquematização do pivô de irrigação 101 de acordo com o experimento pode ser visto a partir da figura 4, na qual as culturas 202a sob o vão verde do pivô de irrigação 101 receberam suplementação luminosa artificial, ao passo que os retângulos indicam a posição de ambos os tratamentos, com e sem suplementação luminosa artificial, e os pontos em cada retângulo indicam os pontos de amostragem.

AVALIAÇÕES DA SOJA

[055] As avaliações do entrenó, altura das plantas 202a do nível do solo até o nó mais alto do folíolo e vagens por planta 202a foram feitas semanalmente a partir dos estágios fenológicos da soja R3, no início da vagem, ao R7, no início da maturidade da soja. Durante essas nove semanas, as avaliações foram feitas uma vez por semana; nenhuma avaliação adicional foi possível após R7 porque as plantas no tratamento sem suplementação luminosa artificial atingiram a maturidade fisiológica mais cedo do que as plantas no tratamento de suplementação luminosa artificial.

[056] Neste sentido, é importante salientar que o atraso da maturidade fisiológica induzido pelo tratamento de suplementação luminosa artificial, ou em outras palavras, a extensão do ciclo da cultura 202a, ocorre com períodos variáveis a depender de determinados fatores, tais como a cultura 202a sob cultivo, a região de cultivo e o estágio de início e suspensão da suplementação luminosa artificial e o próprio manejo da cultura pelo produtor.

[057] A cultura de soja 202a, por exemplo, estendeu seu ciclo entre 5 e 20 dias, a depender da cultivar, do manejo da luz e do local de cultivo. Essa extensão, contudo, não foi proeminente em culturas gramíneas testadas, tais como milho, sorgo e trigo, sendo de apenas poucos dias em relação às áreas onde a suplementação luminosa artificial não foi aplicada. Sem querer se ater a nenhuma teoria específica, esta extensão de ciclo como efeito da

suplementação luminosa artificial pode ser consequência de uma série de reações metabólicas e morfológicas da cultura 202a, tais como a fotomorfogênese (modificação morfológica da cultura 202a estimulada pela luz, que poderia favorecer a fotossíntese durante o dia), a alteração do fotoperíodo e do ciclo circadiano da cultura 202a (modificação da rotina da cultura 202a em relação ao período de presença natural de luz), a regulação do metabolismo secundário da cultura 202a (regulação das defesas naturais da cultura 202a a estresses) e das atividades de fitocromos (substâncias foto responsivas e moduladoras de respostas na cultura 202a).

[058] Supreendentemente, como será visto adiante, concluiu-se que através dessas reações ou estímulos (e de outras possíveis causas ou uma ação conjunta dessas respostas) causadas pela suplementação luminosa artificial, bem como o correto manejo do solo e dos recursos hídricos, a cultura 202a acaba por produzir mais biomassa através de uma fotossíntese mais eficiente durante o dia.

[059] A medição média de cada variável avaliada foi estimada a partir de uma avaliação representativa das plantas 202a em 10 pontos amostrais em cada área (2.000 m^2) sendo cada ponto amostral avaliado considerado uma replicação.

[060] A influência da suplementação luminosa artificial ou não suplementação luminosa artificial em cada variável foi avaliada usando a área sob a curva de progresso de cada variável. A área sob a curva de progresso foi calculada pela integração trapezoidal:

$$\text{área sob a curva de progresso} = \Sigma(\text{dti} \times ((\text{Yi} + \text{Yi} + \text{d})/\,2)) \quad \text{(I)}$$

[061] Onde dti é o intervalo de tempo entre cada duas observações de Yi e Yi + d. A área sob a curva de progresso das variáveis foi calculada com base em nove avaliações. Correlações entre a área sob a curva

de progresso das variáveis avaliadas foram computadas para determinar se havia uma relação linear entre elas.

[062] As áreas utilizadas para cada tratamento (2.000 m^2), foram colhidas aos 115 e 136 dias após a semeadura para a amostra não suplementada por iluminação artificial e para a amostra suplementada por iluminação artificial, respectivamente. A produtividade de grãos em cada área foi expressa em kg ha^{-1}.

ANÁLISE ESTATÍSTICA

[063] Valores extremos (atípicos) na área sob a curva de progresso de cada variável foram identificados usando gráficos boxplot dos resíduos. Quando valores atípicos foram identificados, estes foram substituídos usando um valor médio do conjunto de dados que não inclui o valor atípico. Os boxplots foram gerados no software SPSS Statistics®, que também foi utilizado para calcular os coeficientes de correlação de Pearson e as premissas básicas para a análise de variância (normalidade da distribuição de resíduos por Shapiro-Wilk e homogeneidade de variâncias por Levene, ambos em $p > 0,01$).

[064] A análise de variância (ANOVA, teste F) foi realizada após confirmação de seus pressupostos e considerando um design experimental inteiramente randomizado. Quando foram observadas diferenças significativas ($p < 0,05$) na ANOVA, a área sob a curva de progresso do número de entrenós, altura das plantas 202a e vagens por planta 202a foram comparados usando o teste de médias de Tukey ($p < 0,05$) para distinguir os tratamentos com suplementação luminosa artificial e sem suplementação luminosa artificial. As análises de ANOVA e teste de Tukey foram realizadas por meio do programa estatístico SISVAR®. O software Sigma Plot® v.12 foi utilizado para gerar os gráficos.

RESULTADOS

[065] Os dados das avaliações semanais de todas as variáveis (número de entrenós de soja, altura das plantas e número de vagens por planta de soja) para ambos os tratamentos com suplementação luminosa artificial e sem

suplementação luminosa artificial não incluíram valores atípicos com base nos boxplots de todas as variáveis e tratamentos. Essa observação indica que as respostas foram agrupadas em torno de uma média com baixo erro padrão. As variáveis da soja e seus respectivos erros padrão durante as nove semanas são apresentados nas Figuras 5, 6 e 7, onde as linhas sobre as barras indicam o erro padrão.

[066] O número de entrenós por planta de soja, a altura da planta e o número de vagens por planta do tratamento com suplementação luminosa artificial 202a foram maiores quando comparados à amostra sem suplementação luminosa artificial 202b. Essas respostas superiores das plantas alvo do tratamento com suplementação luminosa artificial 202a também podem ser observadas na Figura 8, onde à esquerda são representadas plantas de soja alvo do tratamento com suplementação luminosa artificial 202a aos 80 dias após a semeadura, no estágio fenológico R5.3, ao passo que à direita são representadas plantas de soja sem tratamento com suplementação luminosa artificial 202b, no estágio fenológico R6 – R7. Cada trecho azul na fita métrica representa 0,1 m.

[067] A análise de variância da área sob a curva de progresso e os pressupostos (normalidade e homogeneidade) são apresentados na Tabela 2.

TABELA 2

SV	DF	Entrenós	Altura	Vagens por planta
Erro de suplementação luminosa	1 18	375**	1,590**	2,649**
CV (%)		1.67	1.17	0.98
KS	20	0.935+	0.985+	0.964+
L	1+18	1.139+	0.106+	0.262+

Tabela 2. Análise de variância (teste F) e estatística das premissas da área sob a curva de progresso das variáveis de número de entrenós de soja, altura de planta e número de vagens por planta de soja. **: diferenças significativas a 0,01. CV (%): coeficiente de variação. KS: Estatística de Kolmogorov-Smirnov

para normalidade da distribuição de resíduos (p > 0,01). L: Estatística de Levene para homogeneidade das variâncias dos dados (p > 0,01). $^{+}$: normalidade dos resíduos (KS) ou homogeneidade das variâncias (L) cumpridas.

[068] Todos os dados de área sob a curva de progresso das variáveis da soja (número de entrenós, altura da planta e vagens por planta) atenderam aos pressupostos da ANOVA (normalidade da distribuição dos resíduos e homogeneidade das variâncias). Além disso, os coeficientes de variação, CV (%), foram muito baixos (< 2%). Assim, foi adequado proceder com a ANOVA, que indicou diferenças significativas (p < 0,01) entre os tratamentos (com suplementação luminosa artificial e sem suplementação luminosa artificial).

[069] A área sob a curva de progresso dos entrenós por planta de soja, a altura da planta e o número de vagens por planta do tratamento com suplementação luminosa foram 15,6, 23,3 e 25,3% superiores ao tratamento sem suplementação luminosa artificial.

[070] O cálculo e a interpretação da correlação de Pearson requerem que os dados sejam normalmente distribuídos e sem valores atípicos; esses requisitos foram atendidos, conforme apresentados na Tabela 1. Todas as correlações observadas na Tabela 3 foram fortes (r > 0,9) e obtiveram significância estatística (p < 0,01).

TABELA 3

	Entrenós	Altura da planta	Vagens por planta
Entrenós	1	0.962**	0.970**
Altura da planta		1	0.990**
Vagens por planta			1

Tabela 3. Correlação de Pearson (r) entre a área sob a curva de progresso das variáveis estudadas. Entrenós: número de entrenós de soja; Altura da planta:

altura da planta de soja; Vagens por planta: número de vagens por planta de soja. **: diferenças significativas a 0,01.

[071] A cultivar de soja avaliada tem um ciclo de aproximadamente 17 semanas. No dia 115 após a semeadura, as plantas de soja da área sem suplementação luminosa artificial 202b (2.000 m^2) foram colhidas; no entanto, a colheita das plantas de soja na área com suplementação luminosa artificial 202a foi feita três semanas depois, representando um ciclo de crescimento 17,6% mais longo.

[072] A produtividade estimada da área sem suplementação luminosa artificial foi de cerca de 4.500 kg ha^{-1} (75 sacas ha^{-1}; 1 saca = 60 kg), enquanto o tratamento com suplementação luminosa artificial foi de cerca de 7.080 kg ha^{-1} (118 sacas ha^{-1}). A produtividade de grãos sob suplementação luminosa artificial foi 57,3% superior, e 109,5% acima da média da produtividade brasileira de soja (3.379 kg ha^{-1}).

[073] O custo médio para produzir a soja desde o manejo do solo até a colheita é de cerca de 55 sacas de soja por hectare. O custo médio exigido pela suplementação luminosa artificial foi de cerca de 7 sacas ha^{-1}. Assim, a rentabilidade da soja tradicionalmente produzida (sem suplementação luminosa artificial) e a soja produzida com suplementação luminosa artificial foi de cerca de 20 e 56 sacas ha^{-1}, respectivamente.

[074] A extensão do ciclo da cultura da soja 202a em três semanas devido à suplementação luminosa artificial também aumentou o período de atividade fotossintética da planta 202a. Este ciclo prolongado aumentou o acúmulo de biomassa via fotossíntese diária natural; processo ausente no ciclo regular da cultivar de soja (17 semanas) onde não há suplementação luminosa artificial 202b. Essa conjunção de fatores resultou em plantas de soja mais altas, com mais entrenós, mais vagens e, consequentemente, mais de 57% a mais de produtividade de grãos.

[075] Neste exemplo, o rendimento extra de 57,3% gerado pela suplementação luminosa artificial não pode ser atribuído apenas às horas de suplementação luminosa artificial fornecida a cada cultura de soja 202a (cerca de 40 horas). Tal como mencionado anteriormente, além da extensão do ciclo da soja por meio da suplementação luminosa artificial, outros fatores devem ser levados em conta, tais como a fotomorfogênese, a alteração do fotoperíodo e do ciclo circadiano da cultura 202a, a sobre regulação ou sub regulação de fito-hormônios e fitocromos, bem como a alteração no metabolismo secundário da cultura 202a, os quais são fatores responsivos ao tratamento de suplementação luminosa artificial.

[076] Os insumos agrícolas, como fertilizantes, inoculantes de plantas e produtos fitossanitários, aplicados durante o ciclo da cultura 202a; 202b, destinam-se exclusivamente a maximizar a produção agrícola e os retornos econômicos. Embora tais insumos tenham efeitos adversos na dinâmica do solo, esses efeitos são frequentemente negligenciados. No entanto, a suplementação luminosa artificial para cultivos de campo 200 de acordo com a presente invenção, tem o potencial de reduzir a necessidade desses insumos, principalmente fertilizantes.

[077] A eficiência da fertilização neste exemplo provavelmente resultou do aumento significativo da biomassa dos brotos seguido da suplementação luminosa artificial. O aumento da biomassa dos brotos, por sua vez, causa um aumento proporcional na biomassa das raízes. Este desenvolvimento radicular melhorado aumenta a eficiência da absorção de nutrientes da raiz, aumentando assim a eficiência do fertilizante.

[078] A presente invenção é utilizada como um modelo de resposta para entender e aplicar de modo reprodutível as consequências e interações de aspectos nutricionais, microbiológicos, ambientais e econômicos em torno da produção agrícola ao integrar informações valiosas sobre

processos fisiológicos, época de semeadura, lâmina de irrigação, doses de fertilizantes, manejo de pragas de insetos e doenças de plantas e seus impactos nas relações do solo com o meio ambiente. Além disso, a inclusão de informações climáticas pode esclarecer a relação entre a produção agrícola e as oscilações climáticas e que, por sua vez, podem ser usadas para aumentar a resiliência do sistema alimentar global e a segurança alimentar contra choques climáticos inesperados.

[079] Atualmente, há um rápido aumento contínuo na digitalização e integração de tecnologias na agricultura que está alinhada com a sustentabilidade dos ecossistemas a serem aprimorados. Essas mudanças provavelmente impulsionarão as culturas modernas para um nível mais alto de produtividade. Neste sentido, Antes de projetar fatores de cultivo, como o material genético a ser semeado, vários fatores devem ser avaliados. Esses fatores incluem o manejo fitossanitário e o nível de tecnologias implementadas em outros fatores primários como a disponibilidade de nutrientes, abastecimento de água e luz (geralmente de uma fonte natural). Embora o uso da suplementação luminosa artificial em escala de campo 200 seja um desafio para controlar, a presente invenção torna possível o controle da suplementação luminosa artificial para produção de culturas 202a em grandes áreas comerciais 200.

[080] A presente invenção também tem um grande potencial para diminuir o desmatamento de novas áreas nativas para fins de produção agrícola. Embora a produtividade da cultura 202a possa ser aumentada com uma implementação adequada de suplementação luminosa artificial ao longo do ciclo da cultura 202a, o estado da técnica não revela as interações entre os diferentes fatores, por exemplo, solo, planta, clima, manejo, desempenho da cultura 202a, construção do rendimento e a relação custo-benefício.

[081] Os custos de produção das culturas 202a gerados pelo sistema de suplementação luminosa artificial 100, de acordo com a presente invenção, dependem de vários fatores. Esses fatores incluem a eficiência da estrutura disponível, por exemplo: maquinário e administração da fazenda; e a tecnologia implementada, por exemplo: materiais genéticos, fertilizantes e o uso de sistemas agrícolas precisos. Outros fatores incluem características do sistema de irrigação, por exemplo: a altura do pivô de irrigação 101 que afeta a dissipação da luz, a suplementação luminosa artificial em áreas de irrigação estática, a estruturação do solo, por exemplo: sem limitação física ou química, e com microbiota saudável, o fornecimento de energia, por exemplo: fiação, constância e estabilidade, além de *internet of things (IOT)* e manejo de culturas 202a. Assim, o custo e a rentabilidade no presente exemplo refletem um cenário específico da produção de soja que pode variar caso a caso. Apesar desta observação, a suplementação luminosa artificial, de acordo com a presente invenção, apresenta uma oportunidade para melhorar a produção das culturas 202a.

[082] Em conclusão, no contexto do exemplo no qual a presente invenção foi implementada, foram necessárias aproximadamente 40 horas de suplementação luminosa artificial por planta de soja durante o ciclo da cultura 202a para positivamente afetar o número de entrenós, vagens, altura da planta e o ciclo da cultura 202a.

[083] A suplementação luminosa artificial, de acordo com a presente invenção, aumentou a produtividade de grãos de soja em 57,3% e sua rentabilidade em 180% em relação aos processos de cultivo sem suplementação luminosa artificial, e provou-se uma técnica viável e promissora para melhorar de forma sustentável a produção de culturas na mesma área agrícola em que são cultivadas atualmente.

[084] Apesar da descrição das realizações particulares acima fazer referência a determinadas realizações, a presente invenção pode

apresentar modificações em sua forma de implementação, de modo que o escopo de proteção da invenção se limita tão somente pelo teor das reivindicações anexas, incluindo aí as possíveis variações equivalentes.

REIVINDICAÇÕES

1. SISTEMA DE SUPLEMENTAÇÃO LUMINOSA ARTIFICIAL (100) caracterizado por compreender:

- um dispositivo modular de irrigação agrícola (101) posicionado sobre um campo agrícola (200) no cultivo de uma cultura (202a) e compreendendo:

- um dispositivo de acionamento para o deslocamento do dispositivo modular de irrigação agrícola (101) sobre o campo agrícola (200);

- um dispositivo de aspersão compreendendo uma pluralidade de aspersores;

- uma pluralidade de fontes de iluminação artificial (10a, 10b, 10c, 10d, 10e) dispostas ao longo do dispositivo modular de irrigação agrícola (101) em pontos equidistantes e a uma distância predeterminada acima das partes aéreas da cultura (202a), compreendendo uma pluralidade de diodos emissores de luz *(LED)* do tipo espectro total; e

- uma pluralidade de células fotovoltaicas que alimentam a pluralidade de fontes de iluminação artificial (10a, 10b, 10c, 10d, 10e),

o sistema de suplementação luminosa artificial (100) compreendendo ainda:

um processador em comunicação com o dispositivo de aspersão, o dispositivo de acionamento, um dimerizador ou polarizador da pluralidade de fontes de iluminação artificial (10a, 10b, 10c, 10d, 10e) e com a pluralidade de células fotovoltaicas, em que o processador é configurado para:

a) ajustar (501), nos intervalos do espectro eletromagnético, o balanço entre as bandas espectrais emitidas pela pluralidade de diodos emissores de luz *(LED)*; e

b) determinar e inicializar:

- uma rotina de irrigação (502); e

- uma rotina de suplementação luminosa artificial (503),

em que as rotinas de irrigação (502) e de suplementação luminosa artificial (503) são independentes entre si, sendo que as etapas a) e b) são determinadas pelo processador considerando pelo menos um dentre:

- o tipo de cultura (202a) sob cultivo;

- o estágio fenológico da cultura (202a) sob cultivo;

- o fotoperíodo e as condições meteorológicas sob as quais o campo agrícola (200) está submetido; e

- um ou mais objetivos de desenvolvimento da cultura (202a) sob cultivo a serem alcançados.

2. MÉTODO DE SUPLEMENTAÇÃO LUMINOSA ARTIFICIAL (500), para o cultivo de uma cultura (202a) em um campo agrícola (200), caracterizado por compreender as etapas de:

a) ajustar (501), nos intervalos do espectro eletromagnético, o balanço entre as bandas espectrais emitidas por uma pluralidade de diodos emissores de luz *(LED)* do tipo espectro total de uma pluralidade de fontes de iluminação artificial (10a, 10b, 10c, 10d, 10e); e

b) determinar e inicializar:

- uma rotina de irrigação (502) de um dispositivo modular de irrigação agrícola (101); e

- uma rotina de suplementação luminosa artificial (503) da pluralidade de fontes de iluminação artificial (10a, 10b, 10c, 10d, 10e),

em que as rotinas de irrigação (502) e de suplementação luminosa artificial (503) são independentes entre si, sendo que as etapas a) e b) são determinadas considerando pelo menos um dentre:

- o tipo de cultura (202a) sob cultivo;

- o estágio fenológico da cultura (202a) sob cultivo;

- o fotoperíodo e as condições meteorológicas sob as quais o campo agrícola (200) está submetido; e

- um ou mais objetivos de desenvolvimento da cultura (202a) sob cultivo a serem alcançados.

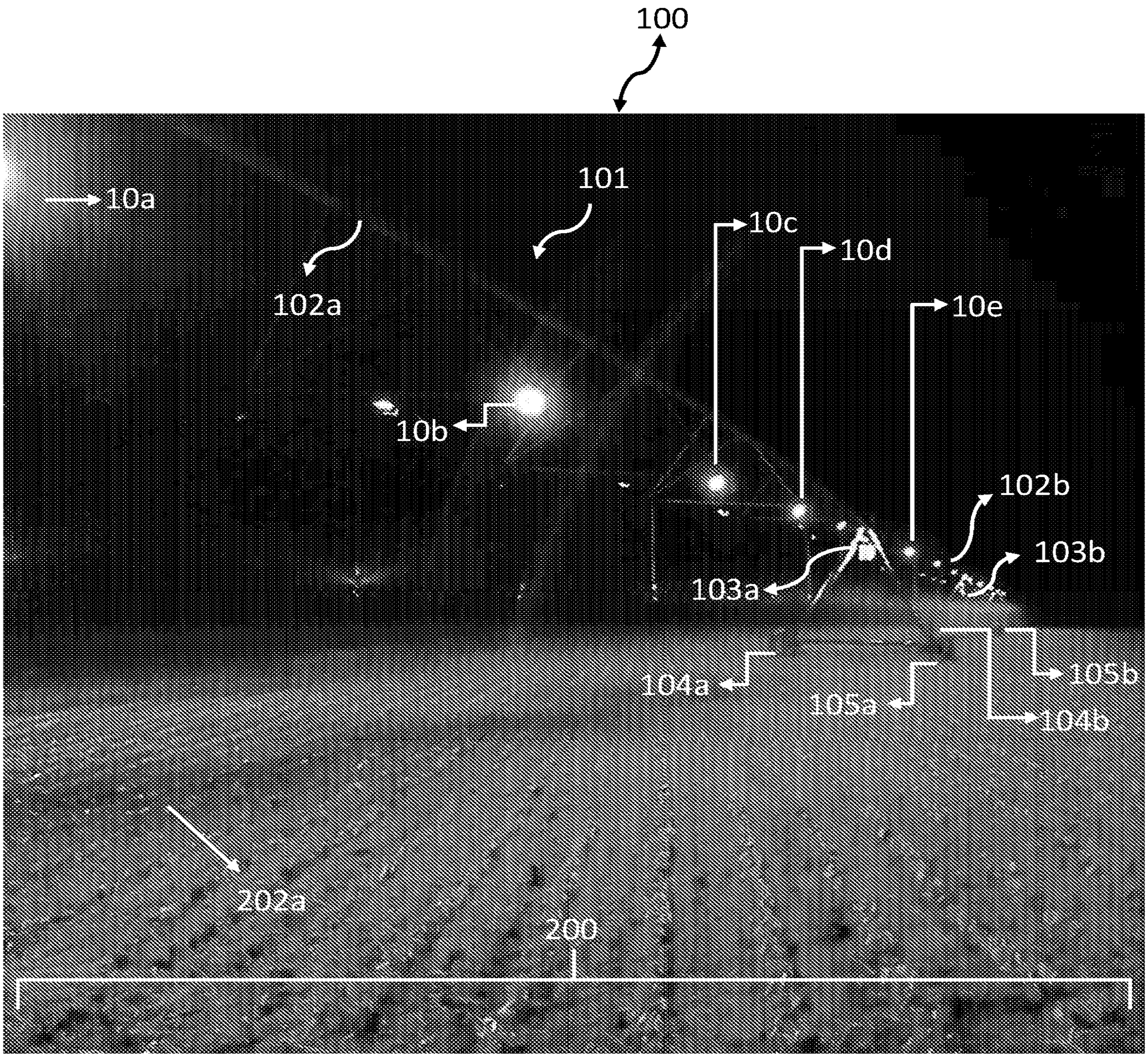

100
10a
101
102a
10c
10d
10e
10b
102b
103b
103a
104a
105b
105a
104b
202a
200

Figura 1

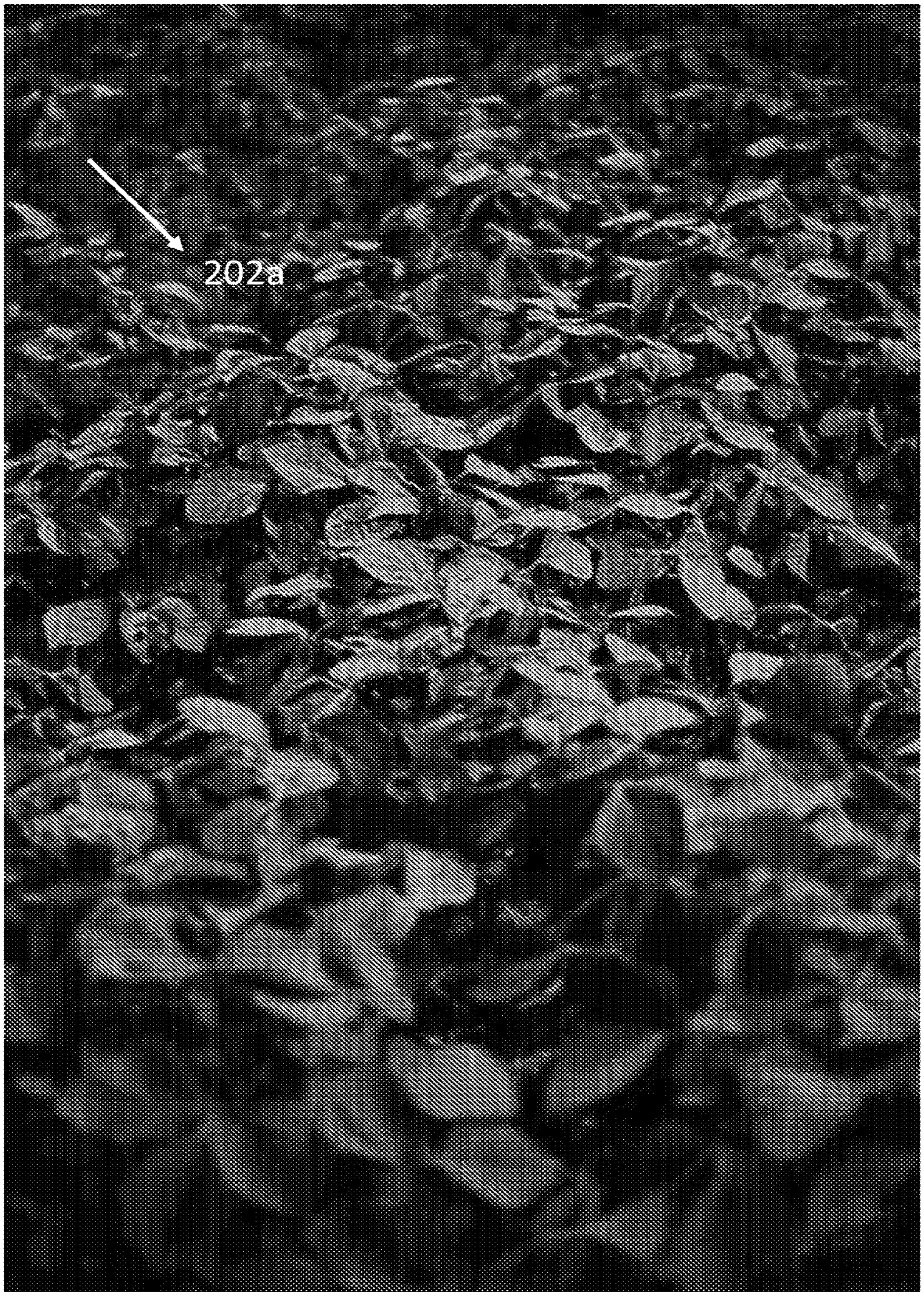


Figura 2

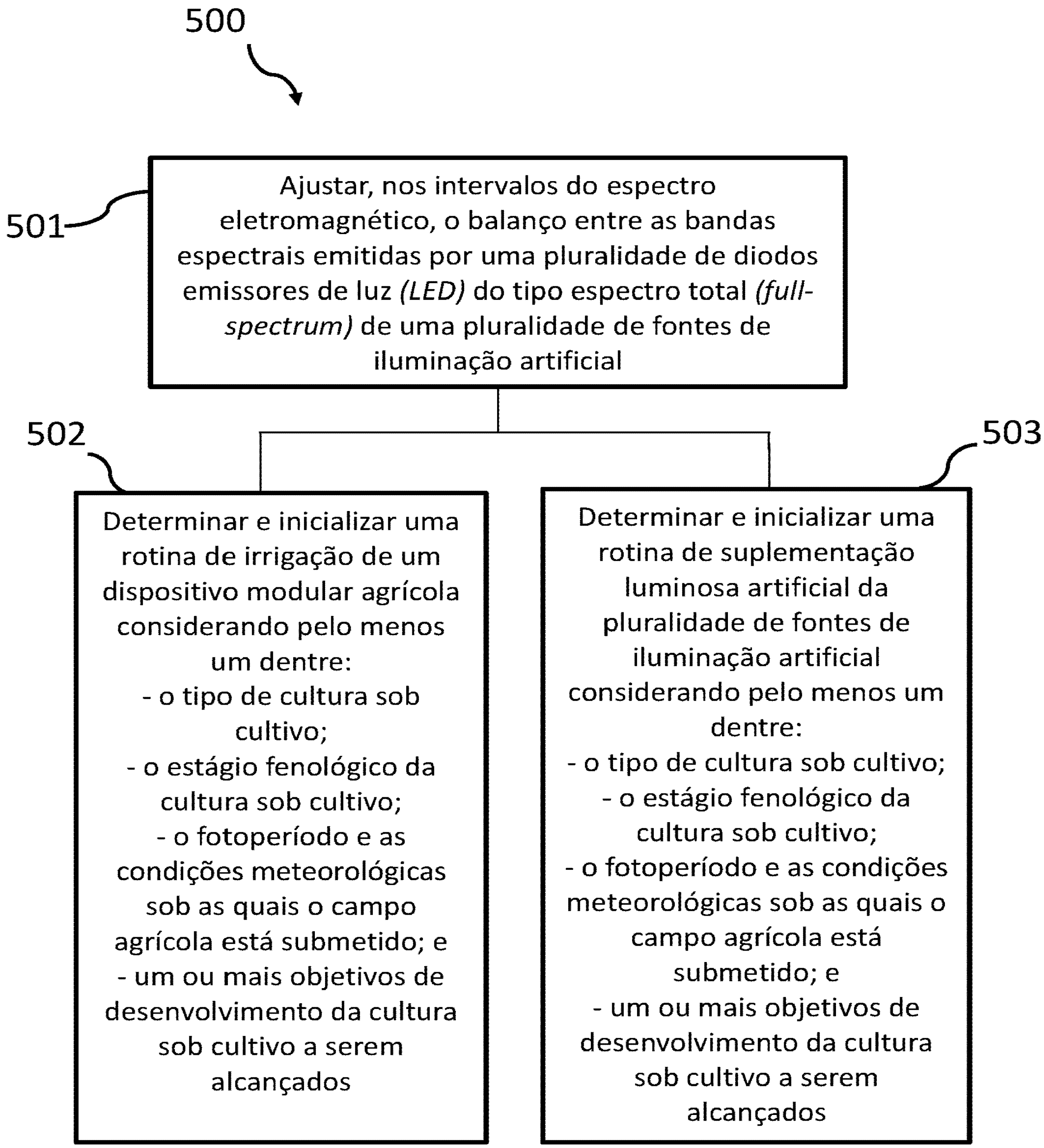

500
501
Ajustar, nos intervalos do espectro eletromagnético, o balanço entre as bandas espectrais emitidas por uma pluralidade de diodos emissores de luz *(LED)* do tipo espectro total *(full-spectrum)* de uma pluralidade de fontes de iluminação artificial
502
Determinar e inicializar uma rotina de irrigação de um dispositivo modular agrícola considerando pelo menos um dentre:
- o tipo de cultura sob cultivo;
- o estágio fenológico da cultura sob cultivo;
- o fotoperíodo e as condições meteorológicas sob as quais o campo agrícola está submetido; e
- um ou mais objetivos de desenvolvimento da cultura sob cultivo a serem alcançados
503
Determinar e inicializar uma rotina de suplementação luminosa artificial da pluralidade de fontes de iluminação artificial considerando pelo menos um dentre:
- o tipo de cultura sob cultivo;
- o estágio fenológico da cultura sob cultivo;
- o fotoperíodo e as condições meteorológicas sob as quais o campo agrícola está submetido; e
- um ou mais objetivos de desenvolvimento da cultura sob cultivo a serem alcançados

Figura 3

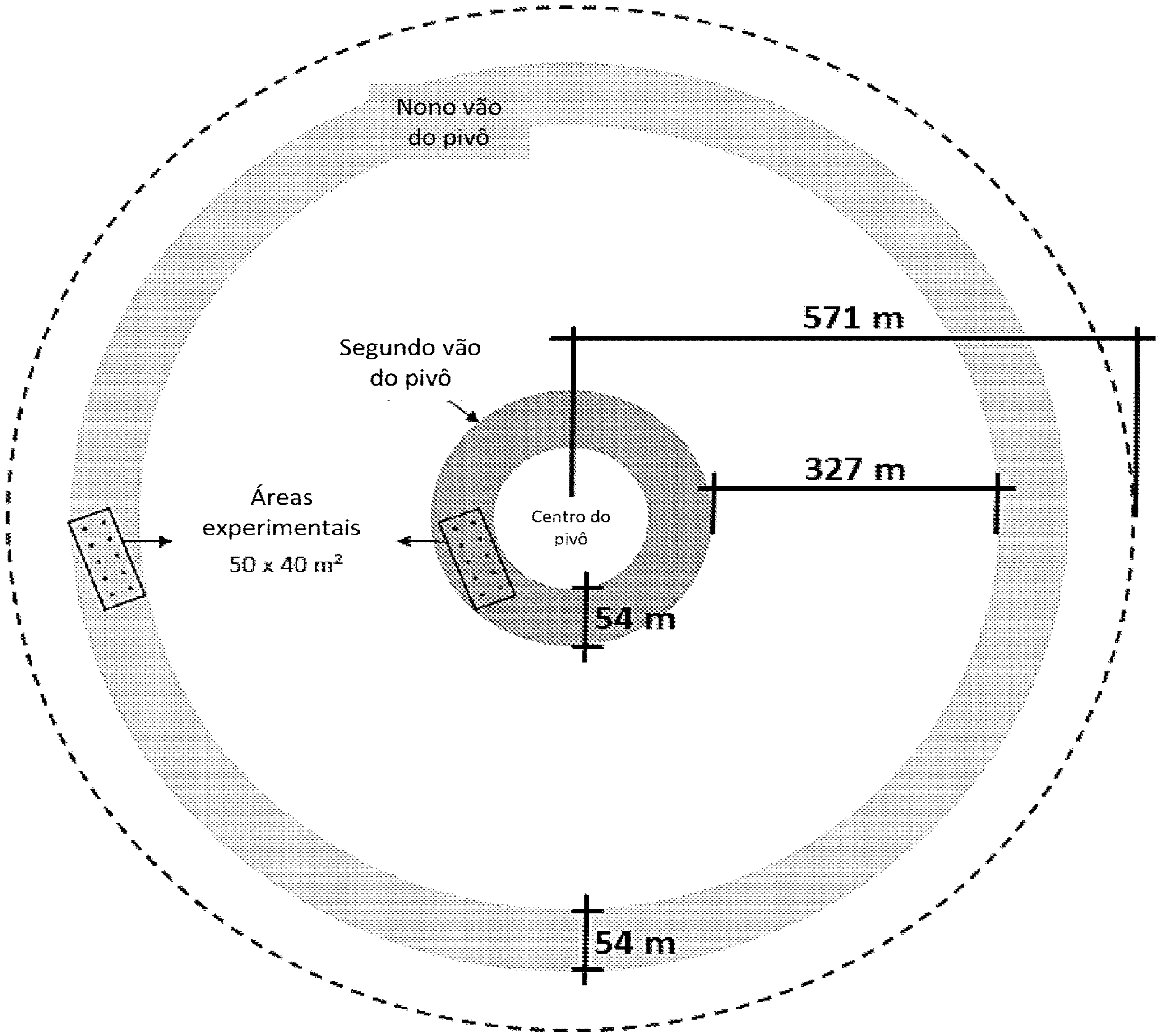

Nono vão
do pivô
571 m
Segundo vão
do pivô
327 m
Áreas
experimentais
50 x 40 m²
Centro do
pivô
54 m
54 m

Figura 4

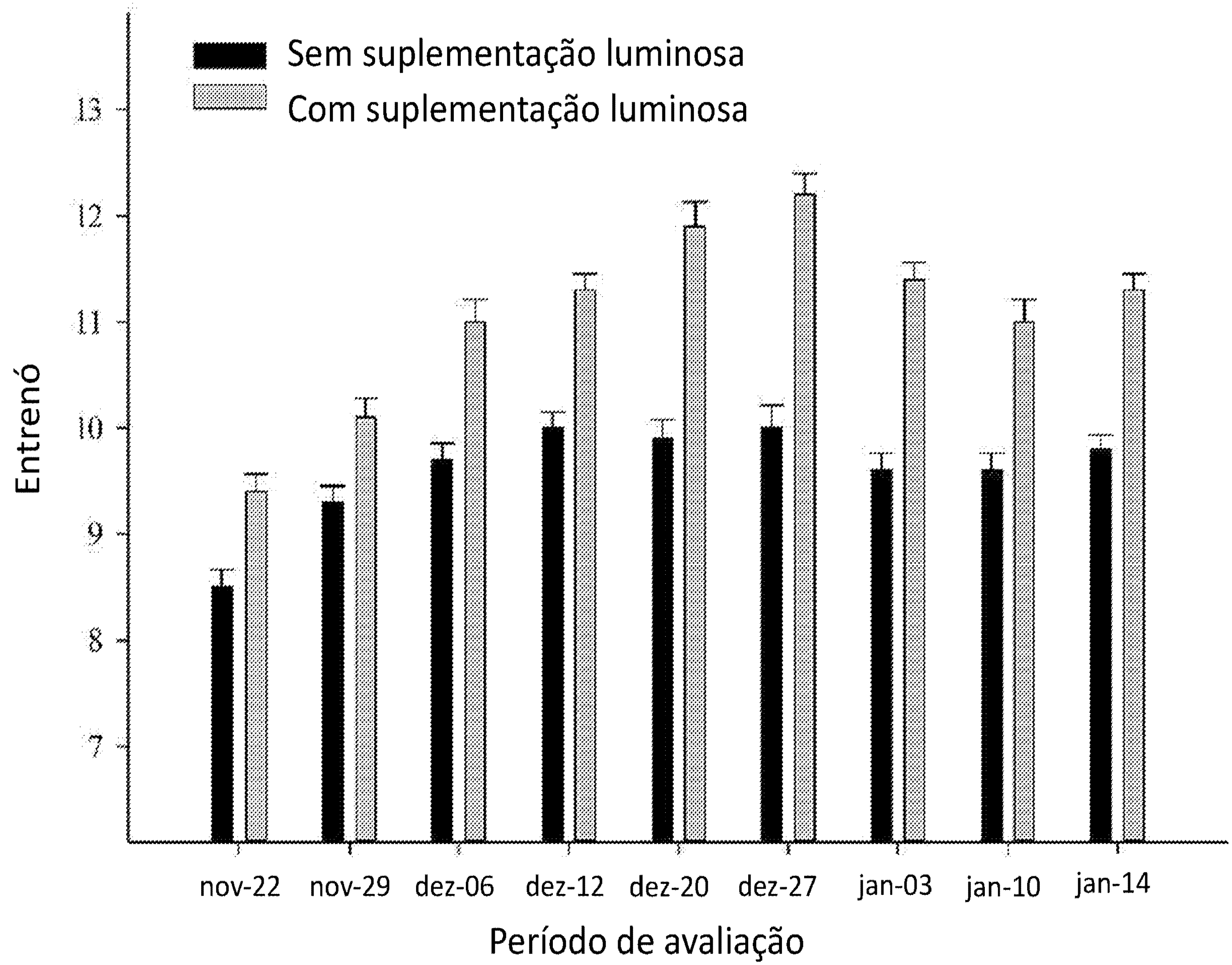

Sem suplementação luminosa
Com suplementação luminosa
Entrenó
13
12
11
10
9
8
7
nov-22
nov-29
dez-06
dez-12
dez-20
dez-27
jan-03
jan-10
jan-14
Período de avaliação

Figura 5

Figura 6

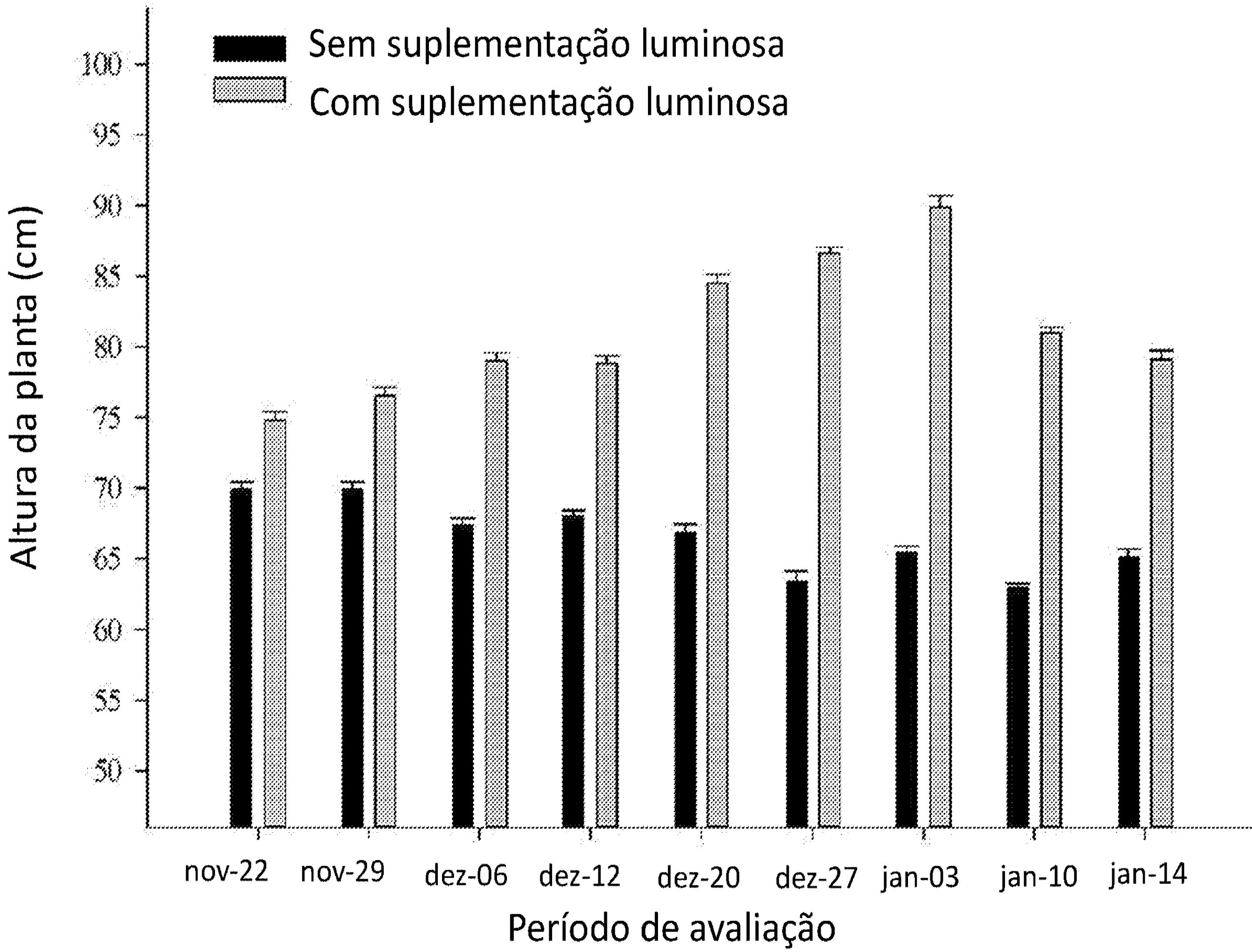
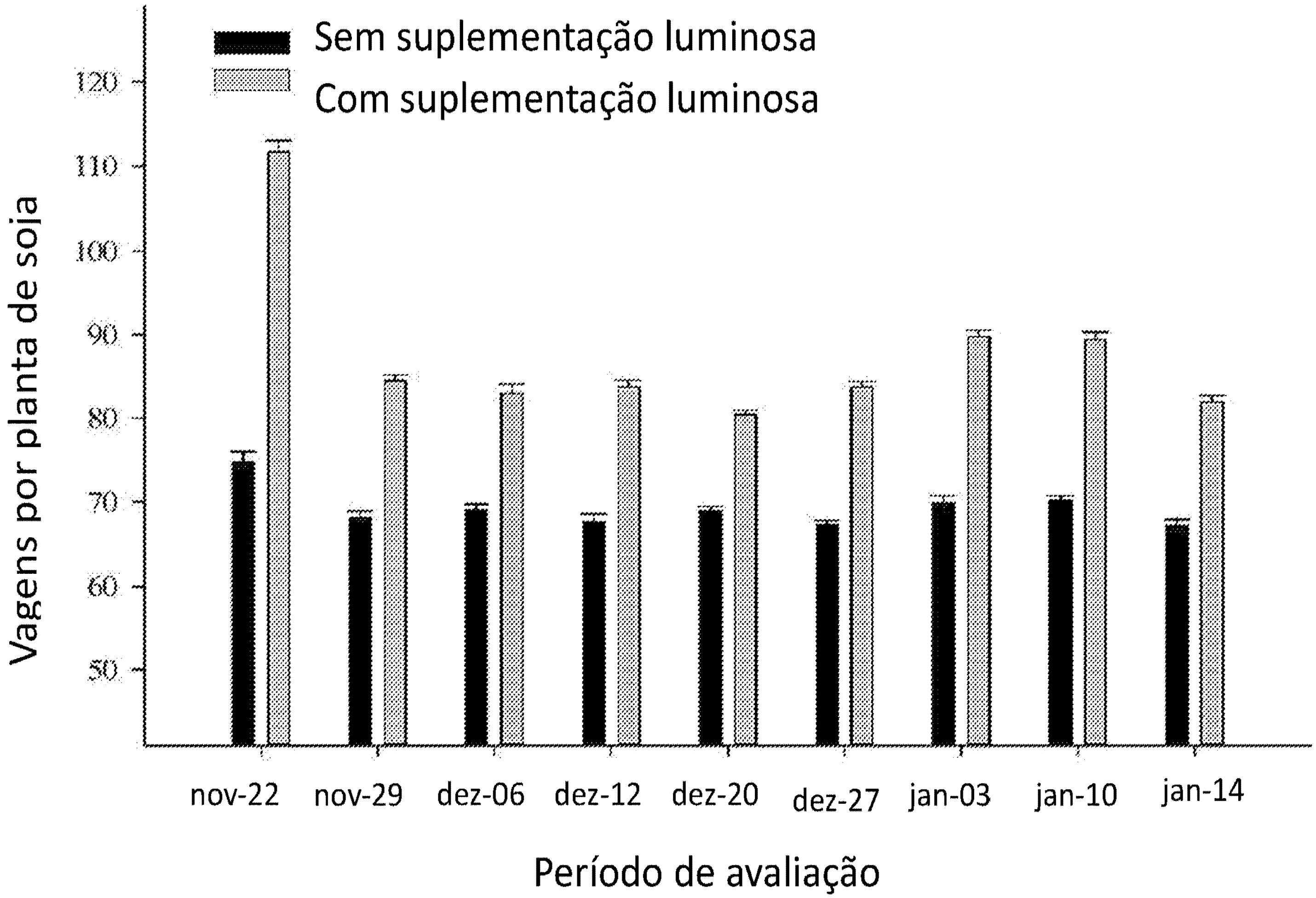

Sem suplementação luminosa
Com suplementação luminosa
Altura da planta (cm)
100
95
90
85
80
75
70
65
60
55
50
nov-22
nov-29
dez-06
dez-12
dez-20
dez-27
jan-03
jan-10
jan-14
Período de avaliação

Figura 7


Sem suplementação luminosa
Com suplementação luminosa
Vagens por planta de soja
120
110
100
90
80
70
60
50
nov-22
nov-29
dez-06
dez-12
dez-20
dez-27
jan-03
jan-10
jan-14
Período de avaliação

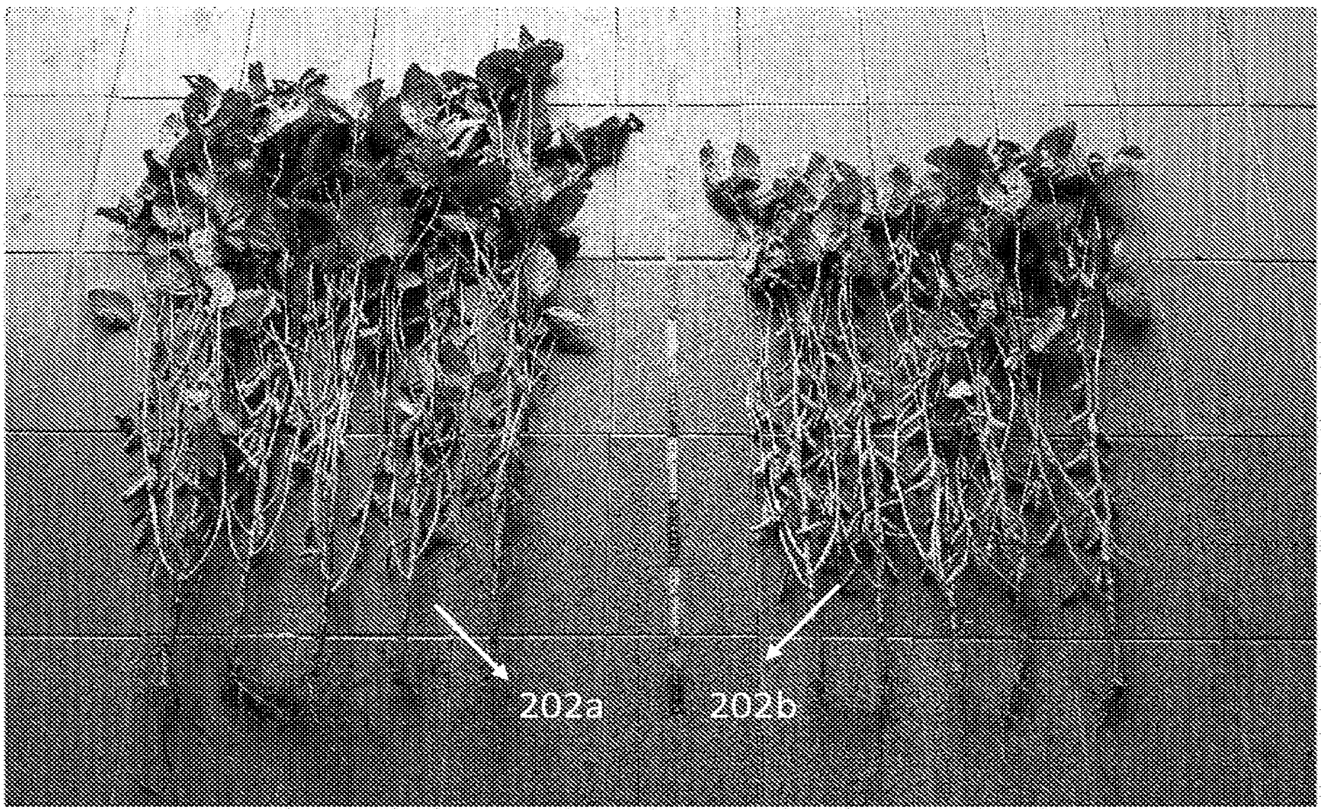


Figura 8

RESUMO

"SISTEMA E MÉTODO DE SUPLEMENTAÇÃO LUMINOSA ARTIFICIAL"

O sistema (100) compreende: um dispositivo modular de irrigação (101) posicionado sobre um campo (200) no cultivo de uma cultura (202a) e compreendendo um dispositivo de acionamento para o deslocamento do dispositivo modular (101) sobre o campo (200); um dispositivo de aspersão compreendendo uma pluralidade de aspersores; uma pluralidade de fontes de iluminação artificial (10a, 10b, 10c, 10d, 10e) dispostas ao longo do dispositivo modular (101) a uma distância predeterminada acima da parte aérea da cultura (202a), compreendendo uma pluralidade de diodos emissores de luz *(LED)* do tipo espectro total *(full-spectrum)*; e uma pluralidade de células fotovoltaicas que alimentam a pluralidade de fontes de iluminação (10a, 10b, 10c, 10d, 10e), o sistema (100) compreendendo ainda: um processador em comunicação com o dispositivo de aspersão, o dispositivo de acionamento um dimerizador ou polarizador das fontes de iluminação (10a, 10b, 10c, 10d, 10e), e com a pluralidade de células fotovoltaicas em que o processador é configurado para: a) ajustar (501), no intervalo do espectro eletromagnético, o balanço entre as bandas espectrais emitidas pela pluralidade de diodos; e b) determinar e inicializar: uma rotina de irrigação (502); e uma rotina de suplementação luminosa artificial (503), independentes entre si, sendo que as etapas a) e b) são determinadas pelo processador considerando pelo menos um dentre: o tipo de cultura (202a) sob cultivo; o estágio fenológico da cultura (202a); o fotoperíodo e as condições meteorológicas sob as quais o campo (200) está submetido; e um ou mais objetivos de desenvolvimento da cultura (202a).

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF RECEIPT OF RECORD COPY

(PCT Rule 24.2(a))

To:

NAKATA, Carolina
AV. BRIGADEIRO FARIA LIMA, 1485 - 11o ANDAR - TORRE NORTE
01452-002 São Paulo-SP
BRÉSIL

Date of mailing *(day/month/year)* 30 November 2022 (30.11.2022)	**IMPORTANT NOTIFICATION**
Applicant's or agent's file reference 3610-0016	International application No. PCT/BR2022/050461

The applicant is hereby **notified** that the International Bureau has received the record copy of the international application as detailed below.

Name(s) of the applicant(s) and State(s) for which they are applicants:

FIENILE AGRONEGÓCIOS LTDA (all designated States)

International filing date:	24 November 2022 (24.11.2022)
Priority date(s) claimed:	14 April 2022 (14.04.2022)
Date of receipt of the record copy by the International Bureau:	25 November 2022 (25.11.2022)

List of designated Offices:

AP: BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW
EA: AM, AZ, BY, KG, KZ, RU, TJ, TM
EP: AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR
OA: BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG
National: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW

ATTENTION: The applicant should carefully check the data appearing in this Notification. In case of any discrepancy between these data and the indications in the international application, the applicant should immediately inform the International Bureau. **In addition, the applicant's attention is drawn to:**

- time limits for entry into the national phase (see www.wipo.int/pct/en/texts/time_limits.html and *PCT Applicant's Guide*, National Phase, especially Chapters 3 and 4)
- requirements regarding priority documents (if applicable) (see *PCT Applicant's Guide*, International Phase, paragraph 5.070)

A copy of this Notification is being sent to the receiving Office and to the International Searching Authority.

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer Agrati Fanny e-mail pct.team9@wipo.int Telephone No. +41 22 338 74 09

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING SUBMISSION, OBTENTION OR TRANSMITTAL OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

To:

NAKATA, Carolina
AV. BRIGADEIRO FARIA LIMA, 1485 - 11o ANDAR - TORRE NORTE
01452-002 São Paulo-SP
BRÉSIL

Date of mailing *(day/month/year)* 01 December 2022 (01.12.2022)	
Applicant's or agent's file reference 3610-0016	**IMPORTANT NOTIFICATION**
International application No. PCT/BR2022/050461	International filing date *(day/month/year)* 24 November 2022 (24.11.2022)
International publication date *(day/month/year)* **Not yet published**	Priority date *(day/month/year)* 14 April 2022 (14.04.2022)
Applicant FIENILE AGRONEGÓCIOS LTDA	

The applicant is hereby notified of the date of receipt (or of obtaining by the International Bureau) of the priority document(s) relating to all earlier application(s) whose priority is claimed. Unless otherwise indicated by the letters "NR", in the right-hand column or by an asterisk appearing next to the date of receipt, **the priority document concerned was submitted or transmitted to or obtained by the International Bureau in compliance with Rule 17.1(a), (b) or (b-*bis*)**. This Form replaces any previously issued notification concerning submission, transmittal or obtaining of priority documents.

Priority date	Priority application No.	Country or regional Office or PCT receiving Office	Date of receipt of priority document
14 April 2022 (14.04.2022)	1020220072728	BR	25 November 2022 (25.11.2022)

The letters "NR" denote a priority document which, on the date of mailing of this Form, had not yet been received or obtained by the International Bureau in compliance with Rule 17.1(a), (b) or (b-*bis*). Where the applicant has failed to either submit, request to prepare and transmit, or to request the International Bureau to obtain the priority document within the applicable time limit under that Rule, the attention of the applicant is directed to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

An asterisk "*" next to a date of receipt, denotes a priority document submitted or transmitted to or obtained by the International Bureau but not in compliance with Rule 17.1(a), (b) or (b-*bis*) (the priority document was received after the time limit prescribed in Rule 17.1(a); the request to prepare and transmit the priority document was submitted to the receiving Office after the applicable time limit under Rule 17.1(b) or the request to the International Bureau to obtain the priority document was made after the applicable time limit under Rule 17.1(b-*bis*)). Even though the priority document was not furnished in compliance with Rule 17.1(a), (b) or (b-*bis*), the International Bureau will nevertheless transmit a copy of the document to the designated Offices, for their consideration. In case such a copy is not accepted by the designated Office as the priority document, Rule 17.1(c) provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Authorized officer
Simin Baharlou
e-mail pct.team9@wipo.int
Telephone No. +41 22 338 74 09

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A SUBMISSION UNDER 35 U.S.C. 371

Attorney Docket No.
092210-786599

U.S. Application No. (if known, see 37 CFR 1.5)

International Application No.	International Filing Date	Priority Date Claimed
PCT/BR2022/050461	November 24, 2022	April 14, 2022

Title of Invention
SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT

First Named Inventor
Gustavo Alexandre GROSSI

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information.

1. ☐ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). NOTE: The express request under 35 U.S.C. 371(f) will not be effective unless the requirements under 35 U.S.C. 371(c)(1), (2), and (4) for payment of the basic national fee, copy of the International Application and English translation thereof (if required), and the oath or declaration of the inventor(s) have been received.
2. ■ A copy of the International Application (35 U.S.C. 371(c)(2)) is attached hereto (not required if the International Application was previously communicated by the International Bureau or was filed in the United States Receiving Office (RO/US)).
3. An English language translation of the International Application (35 U.S.C. 371(c)(2))
   a. ■ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
4. An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4))
   a. ☐ is attached.
   b. ☐ was previously filed in the international phase under PCT Rule 4.17(iv).

Items 5 to 8 below concern amendments made in the international phase.

PCT Article 19 and 34 amendments

5. ☐ Amendments to the claims under PCT Article 19 are attached (not required if communicated by the International Bureau) (35 U.S.C. 371(c)(3)).
6. ☐ English translation of the PCT Article 19 amendment is attached (35 U.S.C. 371(c)(3)).
7. ☐ English translation of annexes (Article 19 and/or 34 amendments only) of the International Preliminary Examination Report is attached (35 U.S.C. 371(c)(5)).

Cancellation of amendments made in the international phase

8a. ☐ Do not enter the amendment made in the international phase under PCT Article 19.

8b. ☐ Do not enter the amendment made in the international phase under PCT Article 34.

NOTE: A proper amendment made in English under Article 19 or 34 will be entered in the U.S. national phase application absent a clear instruction from applicant not to enter the amendment(s).

The following items 9 to 17 concern a document(s) or information included.

9. ■ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
10. ■ A preliminary amendment.
11. ■ An Application Data Sheet under 37 CFR 1.76.
12. ☐ A substitute specification. NOTE: A substitute specification cannot include claims. See 37 CFR 1.125(b).
13. ☐ A power of attorney and/or change of address letter.
14. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13*ter*.3 and 37 CFR 1.821-1.825 (not required if sequence listing in text format was indicated on the PCT Request as part of the International Application and the sequence listing was published as part of the international application).
15. ☐ Assignment papers *(cover sheet and document(s))*. Name of Assignee: ____________________
16. ☐ 37 CFR 3.73(c) Statement *(when there is an Assignee)*.

U.S. APPLN. No. (if known – see 37 CFR 1.5)	INTERNATIONAL APPLICATION No.	ATTORNEY DOCKET No.
	PCT/BR2022/050461	092210-786599

17. ■ Other items or information:

International Search Report and Written Opinion; PCT/RO/101; PCT/RO/105; PCT/IB/301; PCT/IB/304; PCT/IB/311; PCT/ISA/220; Priority Document; PPH Request

The following fees have been submitted.	CALCULATIONS
18. ■ Basic national fee (37 CFR 1.492(a)) ………… **$320**	$ 320.00
19. ■ Examination fee (37 CFR 1.492(c)) • If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4)………… **$0** • All other situations ………… **$800**	$ 800.00
20. ■ Search fee (37 CFR 1.492(b)) • If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4)………… **$0** • Search fee (37 CFR 1.445(a)(2)) has been paid on the international application to the USPTO as an International Searching Authority ………… **$140** • International Search Report prepared by an ISA other than the US and provided to the Office or previously communicated to the US by the IB………… **$540** • All other situations ………… **$700**	$ 540.00
TOTAL OF 18, 19, and 20 =	$ 1,660.00
☐ Additional fee for specification and drawings filed in paper over 100 sheets (excluding sequence listing in compliance with 37 CFR 1.821(c) or (e) in an electronic medium or computer program listing in an electronic medium) (37 CFR 1.492(j)). Fee for each additional 50 sheets of paper or fraction thereof ………… **$420**	$

Total Sheets	Extra Sheets	Number of each additional 50 or fraction thereof (round **up** to a whole number)	RATE
- 100 =	/ 50 =		x **$420**

Surcharge for furnishing any of the search fee, examination fee, or the oath or declaration after the date of commencement of the national stage (37 CFR 1.492(h))………… **$160**	$

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total claims	- 20 =		x **$100**	$
Independent claims	- 3 =		x **$480**	$
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			**+ $860**	$

Fee for submission of Sequence Listing text file of 300 MB to 800 MB (37 CFR 1.21(o)(1))………… **$1,060**	$
Fee for submission of Sequence Listing text file of more than 800 MB (37 CFR 1.21(o)(2))…………**$10,500**	$
Processing fee for furnishing the English translation later than 30 months from the earliest claimed priority date (37 CFR 1.492(i))…………**$140 +**	$
TOTAL OF ABOVE CALCULATIONS =	$ 1,660.00
■ **Applicant asserts small entity status.** See 37 CFR 1.27. Fees above are reduced by 60%.	
☐ **Applicant certifies micro entity status.** See 37 CFR 1.29. Fees above are reduced by 80%. Applicant must attach form PTO/SB/15A or B or equivalent.	
TOTAL NATIONAL FEE =	$ 664.00
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31)………… **$50.00** per property **+**	$
TOTAL FEES ENCLOSED =	$ 664.00

a. ☐ A check in the amount of $____________ to cover the above fees is enclosed.

b. ☒ Please charge my Deposit Account No. 50-1662 in the amount of $664.00 to cover the above fees.

c. ☒ The Director is hereby authorized to charge additional fees which may be required, or credit any overpayment, to Deposit Account No. 50-1662 as follows:

i. ☒ any required fee.

ii. ☐ any required fee except for excess claims fees required under 37 CFR 1.492(d) and (e) and multiple dependent claim fee required under 37 CFR 1.492(f).

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038. The PTO-2038 should only be mailed or faxed to the USPTO. However, when paying the basic national fee, the PTO-2038 may NOT be faxed to the USPTO.

ADVISORY: If filing by EFS-Web, do **NOT** attach the PTO-2038 form as a PDF along with your EFS-Web submission. Please be advised that this is **not** recommended and by doing so your **credit card information may be displayed via PAIR**. To protect your information, it is recommended to pay fees online by using the electronic payment method.

NOTE: Where an appropriate time limit under 37 CFR 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the International Application to pending status.

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013, and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.

NOTE 1: By providing this statement under 37 CFR 1.55 or 1.78, **this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA**.

NOTE 2: A U.S. national stage application may not claim priority to the international application of which it is the national phase. The filing date of a U.S. national stage application is the international filing date. See 35 U.S.C. 363.

Correspondence Address

☒ The address associated with Customer Number: 30678 **OR** ☐ Correspondence address below

Name					
Address					
City		State		Zip Code	
Country		Telephone			
Email					

Signature	/R. James Balls/	Date	January 26, 2024
Name (Print/Type)	R. James Balls	Registration No. (Attorney/Agent)	57703

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The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2024-01-26
	First Named Inventor	Gustavo Alexandre GROSSI
	Art Unit	
	Examiner Name	
	Attorney Docket Number	092210-786599

U.S.PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code1	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

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U.S.PATENT APPLICATION PUBLICATIONS

Examiner Initial*	Cite No	Publication Number	Kind Code1	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20200359550	A1	2020-11-19	Tran et al.	
	2	20130263503	A1	2013-10-10	Bostdorff	
	3	20160262313	A1	2016-09-15	Szeto et al.	
	4	20120038281	A1	2012-02-16	Verfuerth	
	5	20020154504	A1	2002-10-24	Fang et al.	

If you wish to add additional U.S. Published Application citation information please click the Add button.

FOREIGN PATENT DOCUMENTS

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	
	Filing Date	2024-01-26
	First Named Inventor	Gustavo Alexandre GROSSI
	Art Unit	
	Examiner Name	
	Attorney Docket Number	092210-786599

Examiner Initial*	Cite No	Foreign Document Nu	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1							☐

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NON-PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	International Search Report and Written Opinion issued on April 24, 2023 for corresponding PCT Application No. PCT/BR2022/050461	☐

If you wish to add additional non-patent literature document citation information please click the Add button

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**	Application Number	
	Filing Date	2024-01-26
	First Named Inventor	Gustavo Alexandre GROSSI
	Art Unit	
	Examiner Name	
	Attorney Docket Number	092210-786599

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☐ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/R. James Balls/	Date (YYYY-MM-DD)	2024-01-26
Name/Print	R. James Balls	Registration Number	57703

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

UNITED STATES
PATENT AND TRADEMARK OFFICE

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Alexandria, VA 22313 - 1450
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ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
18/292,837	**01/26/2024 06:22:47 PM Z ET**	**092210-786599**

Title of Invention

SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT

Application Information

APPLICATION TYPE	Utility - U.S. National Stage under 35 USC 371	PATENT #	-
CONFIRMATION #	1124	FILED BY	Catalina Paun
PATENT CENTER #	64109241	FILING DATE	-
CUSTOMER #	30678	FIRST NAMED INVENTOR	Gustavo Alexandre GROSSI
INTL. APPLICATION #	PCT/BR2022/050461	INTL. FILING DATE	11/24/2022
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	Robert Balls

Documents

TOTAL DOCUMENTS: 21

DOCUMENT		PAGES	DESCRIPTION	SIZE (KB)
generatedADS64109241.pdf		5	Application Data Sheet	108 KB
Information_Disclosure_Statement.pdf		4	Information Disclosure Statement (IDS) Form (SB08)	39 KB

Warning: This is not a USPTO supplied IDS fillable form. Data in the form cannot be automatically loaded to other USPTO systems.

DOCUMENT		PAGES	DESCRIPTION	SIZE (KB)
First_Preliminary_Amendment.pdf		7	-	177 KB
First_Preliminary_Amendment-A.PE.pdf	(1-1)	1	Preliminary Amendment	115 KB
First_Preliminary_Amendment-SPEC.pdf	(2-2)	1	Specification	83 KB

First_Preliminary_Amendment-CLM.pdf	(3-6)	4	Claims	137 KB
First_Preliminary_Amendment-REM.pdf	(7-7)	1	Applicant Arguments/Remarks Made in an Amendment	84 KB
PCT_IB_304.pdf		1	Documents submitted with 371 (National Stage) Applications	65 KB
PCT_IB_311.pdf		1	Documents submitted with 371 (National Stage) Applications	47 KB
International_Search_Report.pdf		9	Documents submitted with 371 (National Stage) Applications	363 KB
PCT_IB_301.pdf		1	Documents submitted with 371 (National Stage) Applications	51 KB
PCT_ISA_220.pdf		1	Documents submitted with 371 (National Stage) Applications	70 KB
PCT_RO_105.pdf		1	Documents submitted with 371 (National Stage) Applications	37 KB
PCT_RO_101.pdf		4	Documents submitted with 371 (National Stage) Applications	129 KB
Drawings.pdf		8	Drawings-only black and white line drawings	1941 KB
International_Publication.pdf		51	Documents submitted with 371 (National Stage) Applications	3270 KB
PPH_Form.pdf		3	Petition to make Special under Patent Prosecution Highway	97 KB
Transmittal_of_New_Application.pdf		4	Transmittal of New Application	131 KB
Written_Opinion_of_ISA_USA.pdf		6	Documents submitted with 371 (National Stage) Applications	237 KB
Specification.pdf		40	-	1027 KB
Specification-SPEC.pdf	(1-39)	39	Specification	1020 KB
Specification-ABST.pdf	(40-40)	1	Abstract	121 KB
Priority_Document.pdf		47	Interim Copy of the Foreign Priority Document	2714 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
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This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To: CAROLINA NAKATA AV. BRIGADEIRO FARIA LIMA, 1485 - 11O ANDAR- TORRE NORTE 01452-002 SAO PAULO-SP BRASIL	**PCT** NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT AND THE WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY, OR THE DECLARATION (PCT Rule 44.1)
	Date of mailing *(day/month/year)* APR 24 2023
Applicant's or agent's file reference 3610-0016	**FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No. PCT/BR 22/50461	International filing date *(day/month/year)* 24 November 2022 (24.11.2022)
Applicant FIENILE AGRONEGOCIOS LTDA	

1. ☒ The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.

   Filing of amendments and statement under Article 19:
   The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):

   When? The time limit for filing such amendments is normally two months from the date of transmittal of the international search report.

   How? Directly to the International Bureau preferably through ePCT, or on paper to:
   The International Bureau of WIPO, 34, chemin des Colombettes, 1211 Geneva 20, Switzerland

   For more detailed instructions, see the *PCT Applicant's Guide*, International Phase, paragraphs 9.004 – 9.011.

2. ☐ The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.

3. ☐ **With regard to any protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:
   - ☐ the protest together with the decision thereon has been transmitted to the International Bureau together with any request to forward the texts of both the protest and the decision thereon to the designated Offices.
   - ☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Reminders**

   The applicant may **submit comments on an informal basis on the written opinion of the International Searching Authority** to the International Bureau. These comments will be made available to the public after international publication. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established.

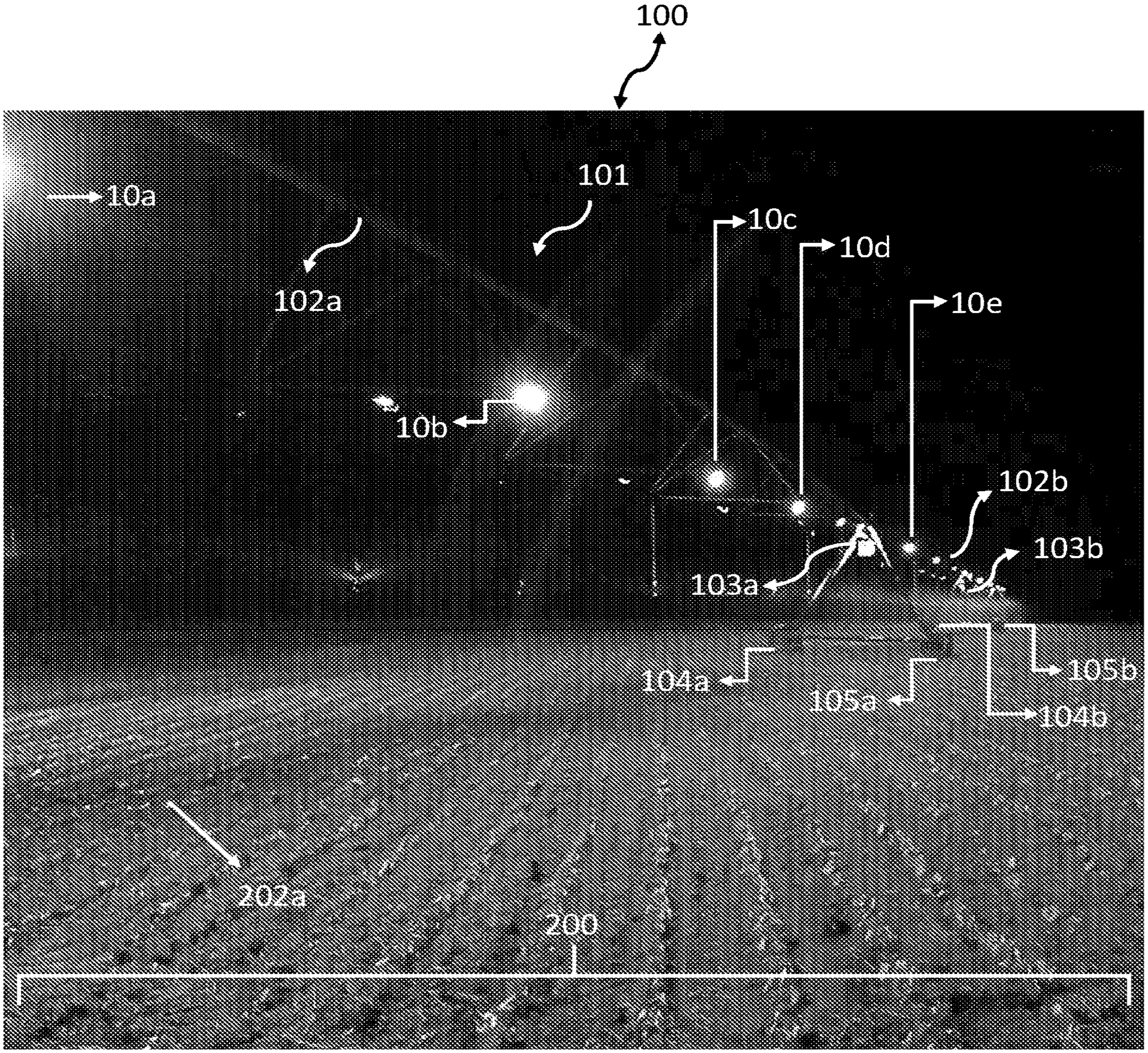
   Shortly after the expiration of **18 months from the priority date, the international application will be published** by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau before the completion of the technical preparations for international publication (Rules 90*bis*.1 and 90*bis*.3).

   Within **19 months** from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase **until 30 months** from the priority date (in some Offices even later); otherwise, the applicant must, **within 20 months** from the priority date, perform the prescribed acts for **entry into the national phase** before those designated Offices. In respect of other designated Offices, the time limit of **30 months** (or later) will apply even if no demand is filed within 19 months. For details about the applicable time limits, Office by Office, see www.wipo.int/pct/en/texts/time_limits.html and the *PCT Applicant's Guide*, National Chapters.

   Within **22 months from the priority date, the applicant may request that a supplementary international search be carried out** by a different International Searching Authority that offers this service (Rule 45*bis*.1). The procedure for requesting supplementary international search is described in the *PCT Applicant's Guide*, International Phase, paragraphs 8.006-8.032.

Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Kari Rodriquez Telephone No. PCT Helpdesk: 571-272-4300

Form PCT/ISA/220 (revised January 2020)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105b
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202a
200

Figure 1

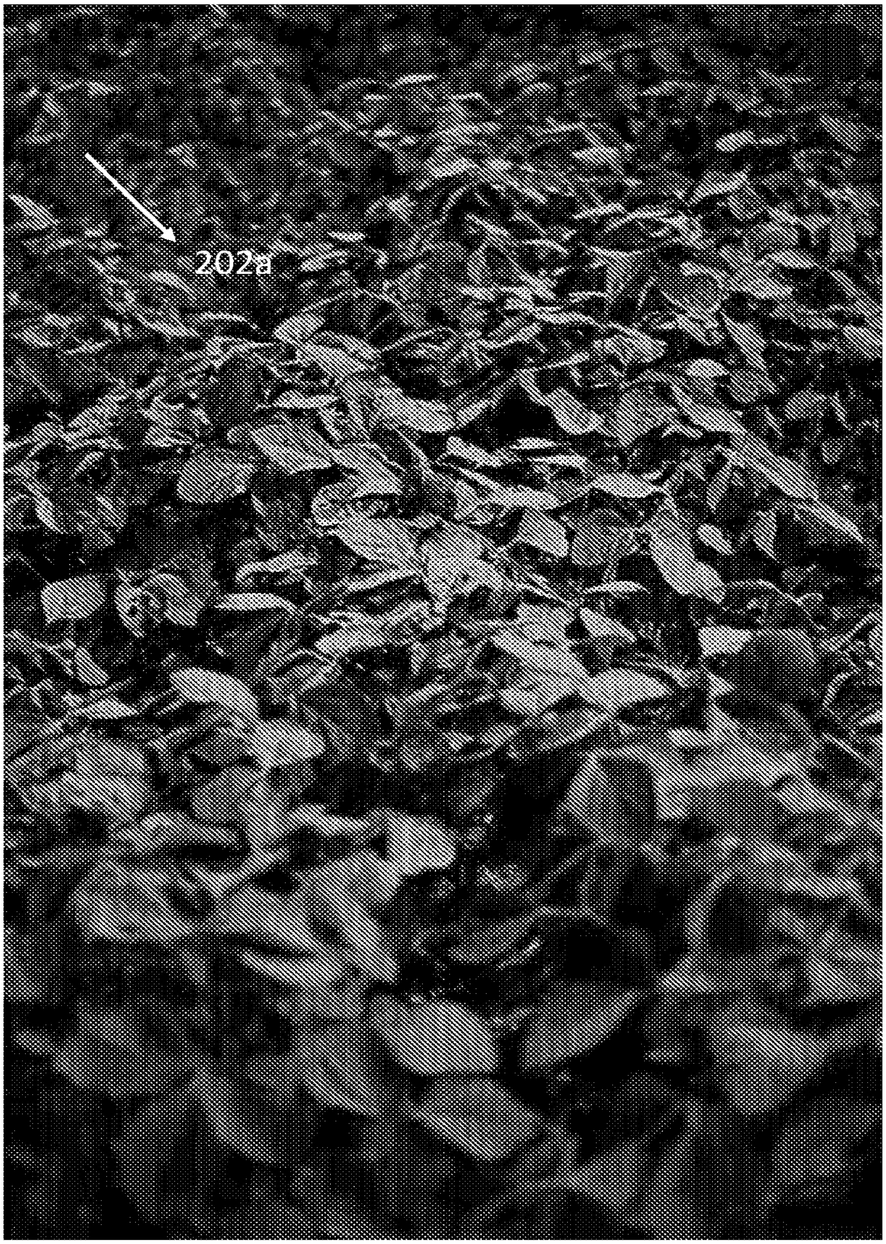


Figure 2

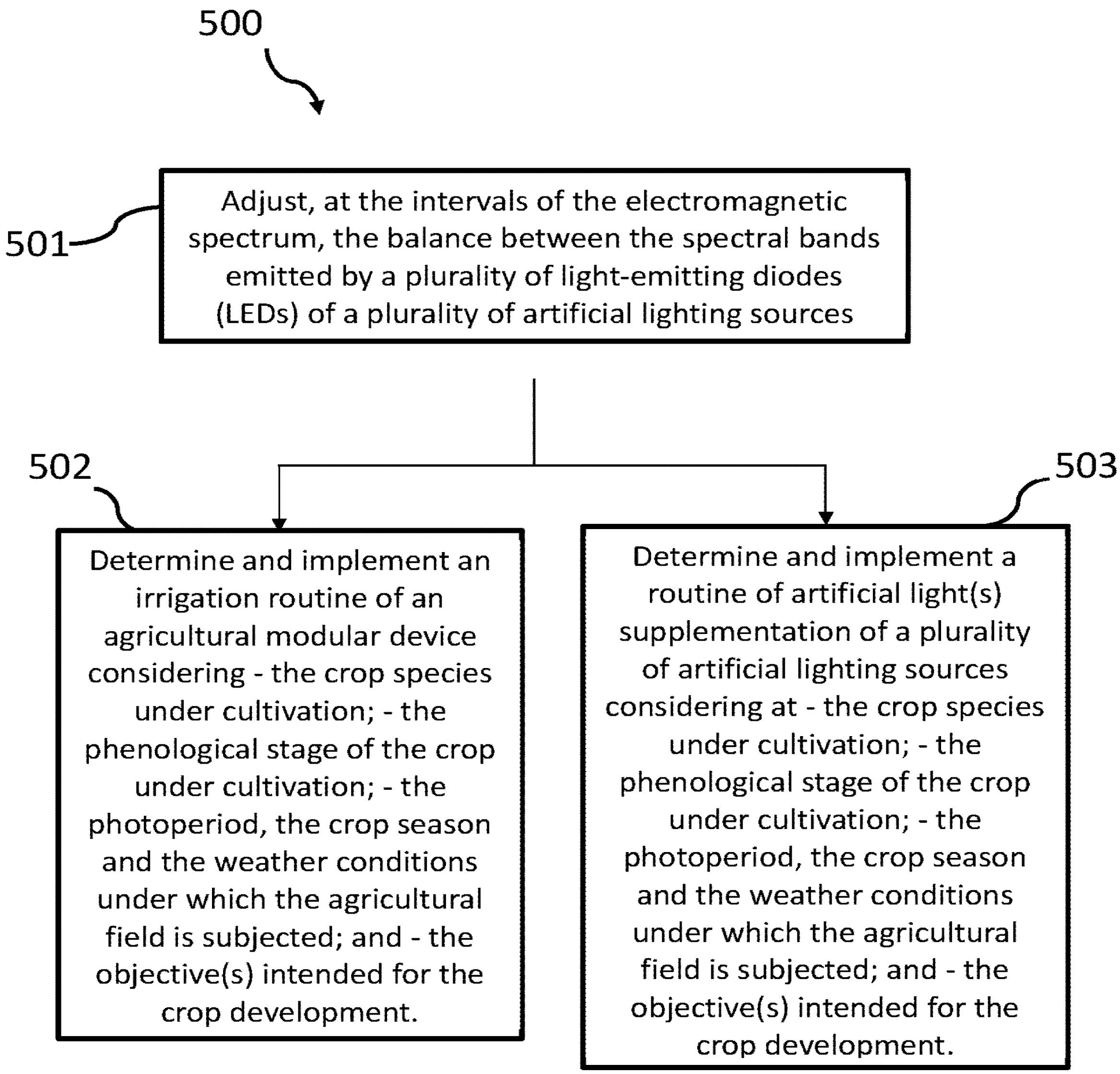
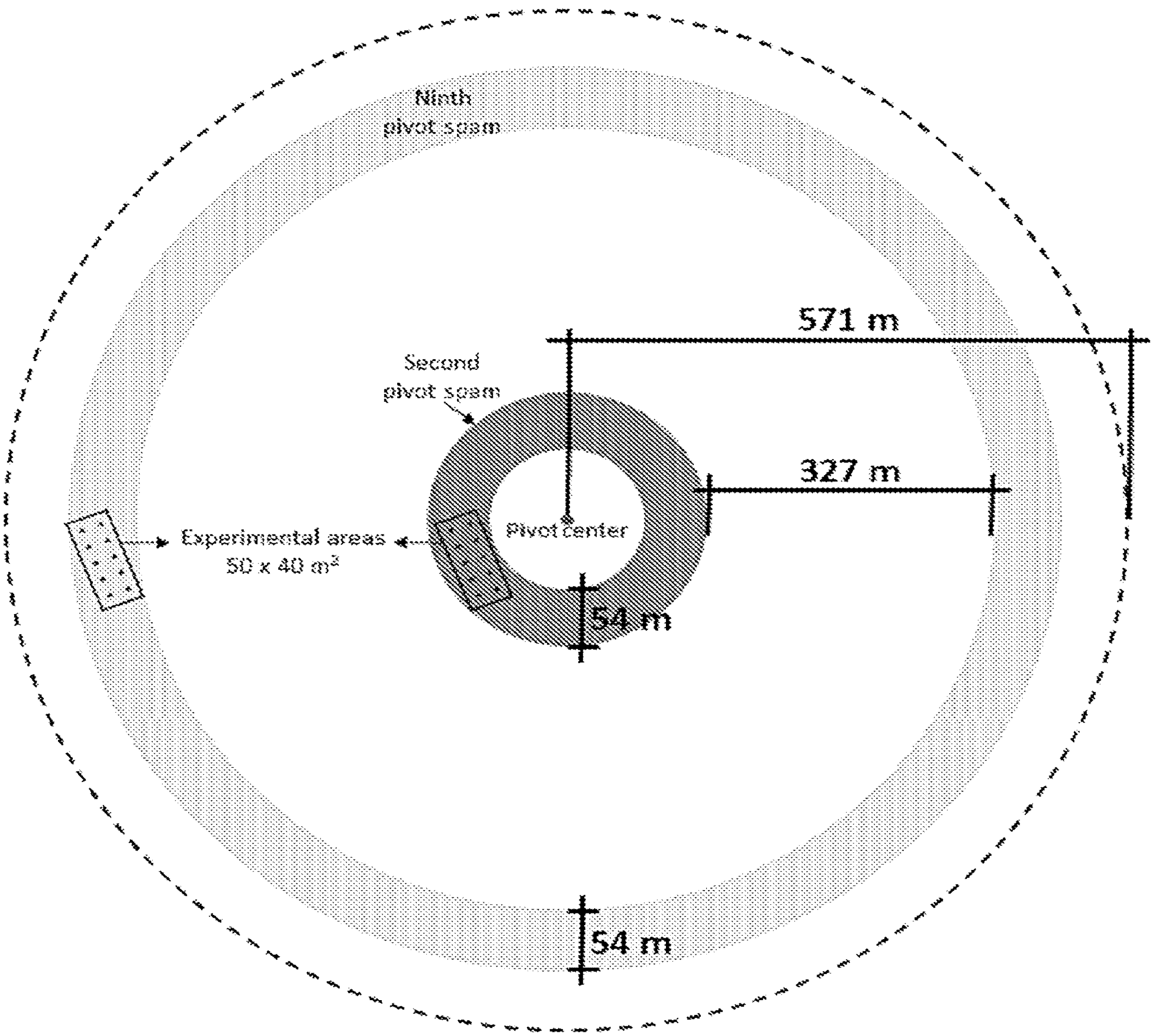

500
501
Adjust, at the intervals of the electromagnetic spectrum, the balance between the spectral bands emitted by a plurality of light-emitting diodes (LEDs) of a plurality of artificial lighting sources
502
Determine and implement an irrigation routine of an agricultural modular device considering - the crop species under cultivation; - the phenological stage of the crop under cultivation; - the photoperiod, the crop season and the weather conditions under which the agricultural field is subjected; and - the objective(s) intended for the crop development.
503
Determine and implement a routine of artificial light(s) supplementation of a plurality of artificial lighting sources considering at - the crop species under cultivation; - the phenological stage of the crop under cultivation; - the photoperiod, the crop season and the weather conditions under which the agricultural field is subjected; and - the objective(s) intended for the crop development.

Figure 3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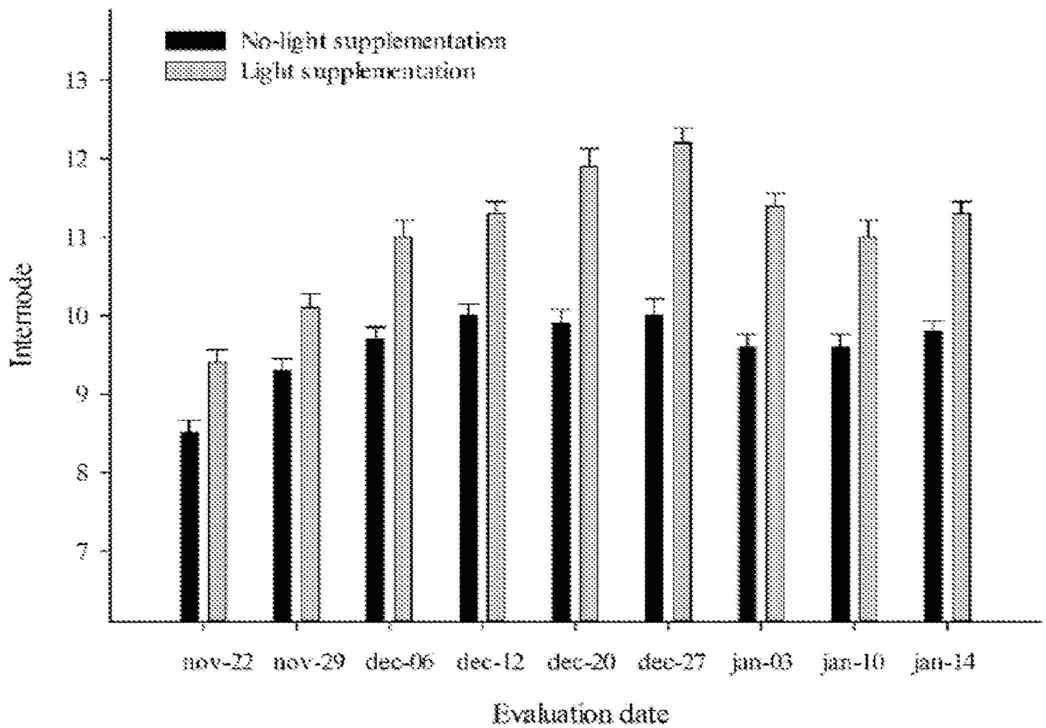
pivot spam
571 m
Second
pivot spam
327 m
Experimental areas
50 x 40 m²
Pivot center
54 m
54 m

Figure 4


No-light supplementation
Light supplementation
Internode
13
12
11
10
9
8
7
nov-22
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dec-06
dec-12
dec-20
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jan-03
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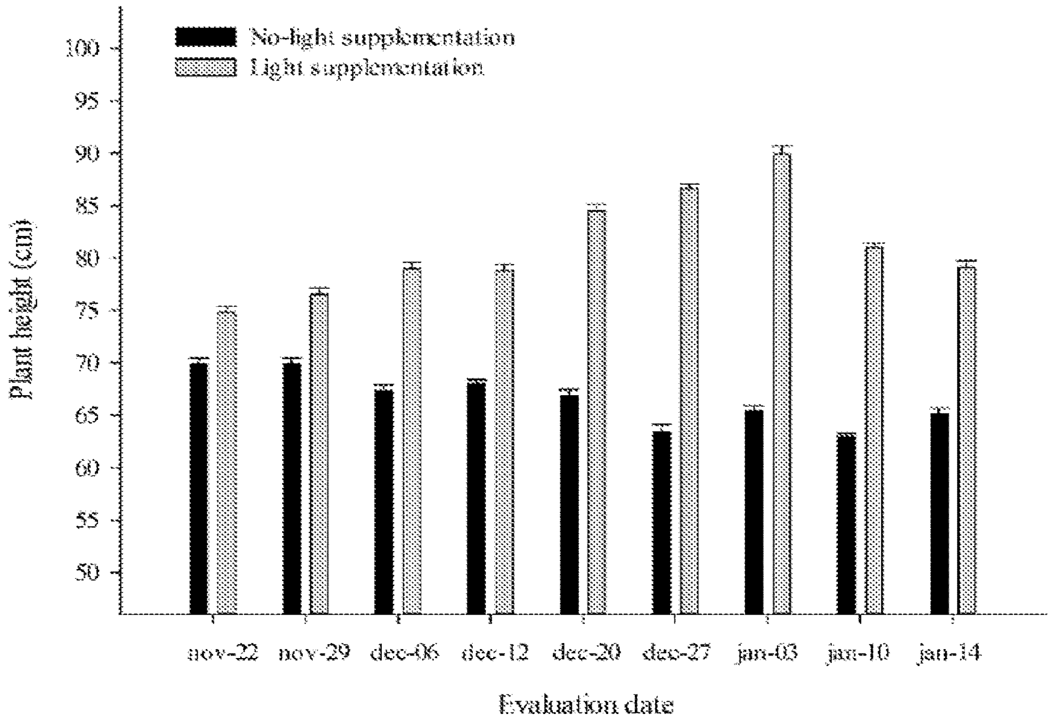
jan-14
Evaluation date

Figure 5


No-light supplementation
Light supplementation
100
95
90
85
80
75
70
65
60
55
50
Plant height (cm)
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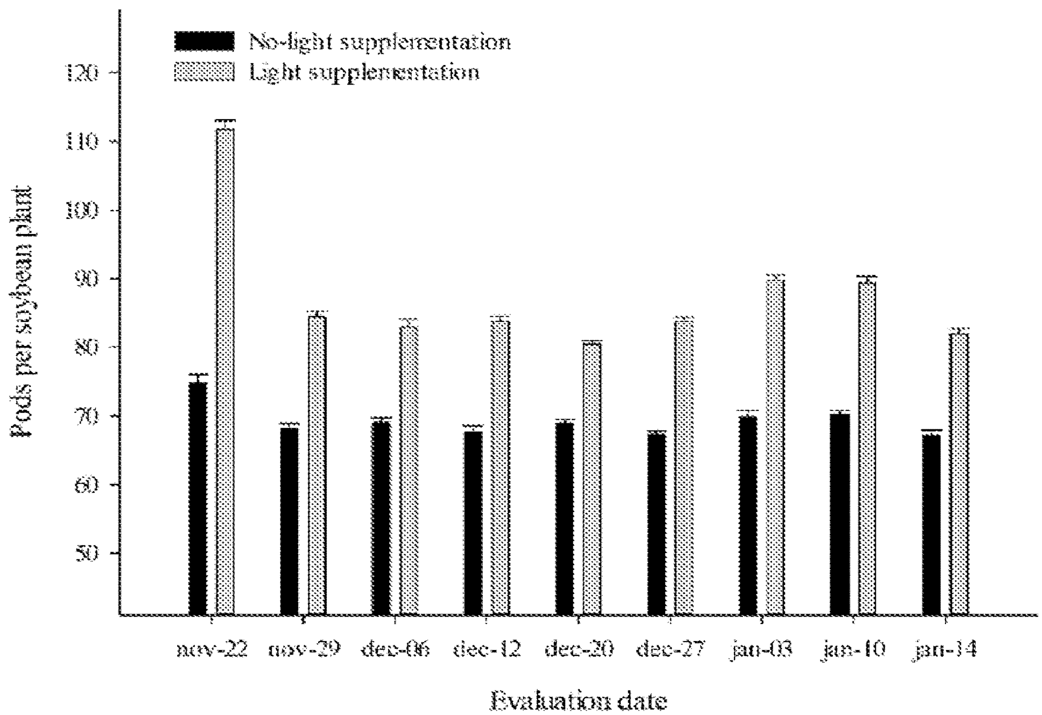
nov-29
dec-06
dec-12
dec-20
dec-27
jan-03
jan-10
jan-14
Evaluation date

Figure 6


No-light supplementation
Light supplementation
Pods per soybean plant
120
110
100
90
80
70
60
50
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Evaluation date

Figure 7

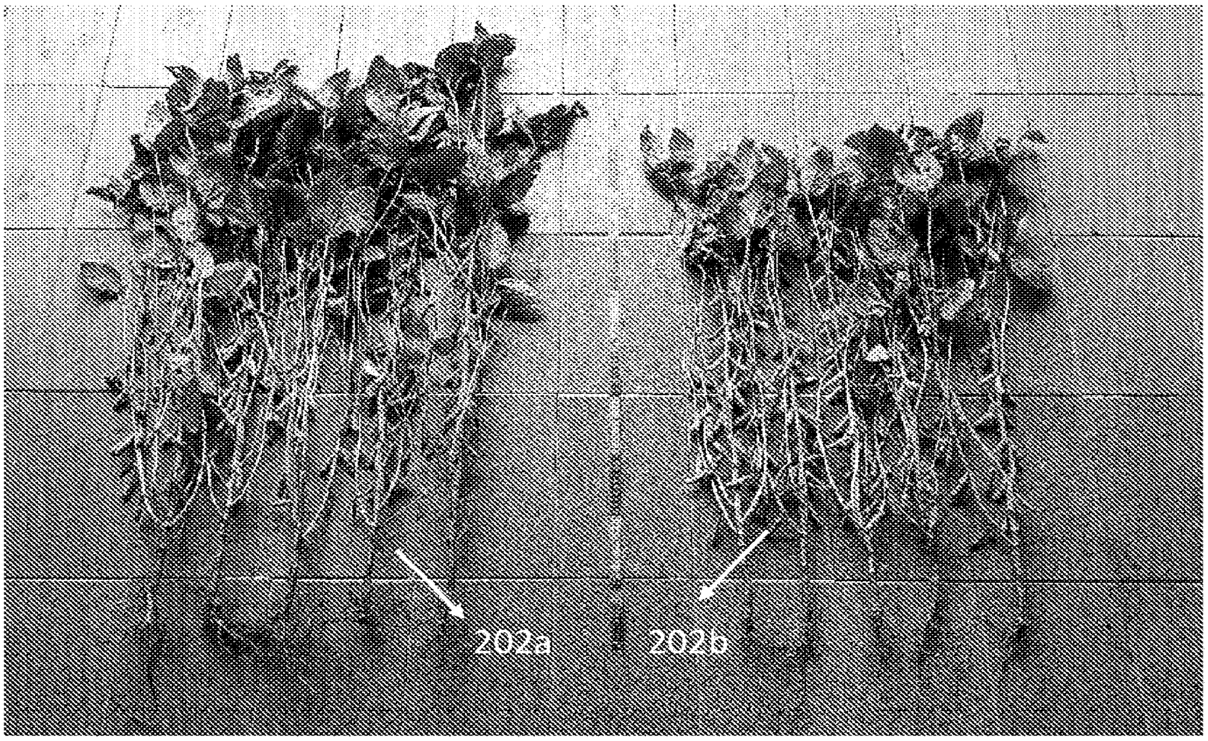

Figure 8

UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC PAYMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
18/292,837	**01/26/2024 06:22:47 PM Z ET**	**092210-786599**

Title of Invention

SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT

Application Information

APPLICATION TYPE	Utility - U.S. National Stage under 35 USC 371	PATENT #	-
CONFIRMATION #	1124	FILED BY	Catalina Paun
PATENT CENTER #	64109241	AUTHORIZED BY	Robert Balls
CUSTOMER #	30678	FILING DATE	-
INTL. APPLICATION #	PCT/BR2022/050461	INTL. FILING DATE	11/24/2022
CORRESPONDENCE ADDRESS	-	FIRST NAMED INVENTOR	Gustavo Alexandre GROSSI

Payment Information

PAYMENT METHOD	PAYMENT TRANSACTION ID	PAYMENT AUTHORIZED BY
DA / 501662	**E20241PI24109502**	**Catalina Paun**

FEE CODE	DESCRIPTION	ITEM PRICE($)	QUANTITY	ITEM TOTAL($)
2617	SEARCH FEE, EXAMINATION FEE OR OATH OR DECLARATION AFTER THE DATE OF COMMENCEMENT OF THE NATIONAL STAGE	64.00	1	64.00
2631	BASIC NATIONAL STAGE FEE	128.00	1	128.00
2633	NATIONAL STAGE EXAMINATION FEE - ALL OTHER SITUATIONS	320.00	1	320.00
2642	NATIONAL STAGE SEARCH FEE - SEARCH REPORT PREPARED AND PROVIDED TO USPTO	216.00	1	216.00
			TOTAL AMOUNT:	**$728.00**

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PATENT COOPERATION TREATY

From the RECEIVING OFFICE

To:
NAKATA, Carolina
AV. BRIGADEIRO FARIA LIMA, 1485 - 11o
ANDAR - TORRE NORTE
01452-002 São Paulo-SP
Brazil

PCT

NOTIFICATION OF THE INTERNATIONAL APPLICATION NUMBER AND OF THE INTERNATIONAL FILING DATE

(PCT Rule 20.2(c))

Date of mailing *(day/month/year)* **25 November 2022**

Applicant's or agent's file reference **3610-0016**

IMPORTANT NOTIFICATION

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/BR2022/050461	**24 November 2022**	**14 April 2022**

Applicant **FIENILE AGRONEGÓCIOS LTDA**

Title of the invention **SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT**

1. The applicant is hereby notified that the international application has been accorded the international application number and the international filing date indicated above.

2. The applicant is further notified that the record copy of the international application:

- [x] was transmitted to the International Bureau on **25 November 2022**
- [ ] has not yet been transmitted to the International Bureau for the reason indicated below and a copy of this notification has been sent to the International Bureau*:
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Telephone No. **55 21 3037-3319**

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PCT REQUERIMENTO

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0	**Reservado para o Organismo receptor**	
0-1	Pedido internacional No.	**PCT/BR2022/050461**
0-2	Data do depósito internacional	**24 Novembro 2022 (24.11.2022)**
0-3	Nome do Organismo receptor e "Pedido internacional PCT"	**RO/BR**

0-4	**Formulário PCT/RO/101 Requerimento PCT**	
0-4-1	Preparado Utilizando	**ePCT-Filing** **Version 4.10.010 MT/FOP 20221109/1.1**
0-5	**Petição** O abaixo assinado solicita que o presente pedido internacional seja processado de acordo com o Tratado de Cooperação em matéria de Patentes	
0-6	**Organismo receptor (especificado pelo requerente)**	**Instituto Nacional da Propriedade Industrial (Brasil) (RO/BR)**
0-7	**Referência do processo do requerente ou do mandatário**	**3610-0016**
I	**Título da invenção**	**SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT**
II	**Requerente**	
II-1	Esta pessoa é:	**Apenas requerente**
II-2	Requerente para	**Todos os Estados designados**
II-4	Nome	**FIENILE AGRONEGÓCIOS LTDA**
II-5	Endereço	**Praça Dom Eduardo, n. 255 - sala 01, Centro** **38700-124 Patos de Minas-MG** **Brasil**
II-6	Nacionalidade (nome do Estado)	**BR**
II-7	Domicílio (nome do Estado)	**BR**
II-8	No. de telefone	**+55 11 2149-4500**
II-10	Endereço de correio electrónico	**internacionalglpi@glpi.com.br**
II-10(a)	Autorização relativa ao correio electrónico O Organismo receptor, a Autoridade responsável pela pesquisa internacional, a Secretaria Internacional e a Autoridade responsável pelo exame preliminar internacional têm autorização para utilizar este endereço de correio electrónico para enviar, se tal desejarem esses organismos, notificações relativas a este pedido internacional:	**exclusivamente sob a forma electrónica (nenhuma notificação será enviada em papel)**

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III-1	**Requerente e/ou inventor**	
III-1-1	Esta pessoa é:	**Apenas inventor**
III-1-3	Inventor para	**Todos os Estados designados**
III-1-4	Nome (APELIDO, nome próprio)	**GROSSI, Gustavo Alexandre**
III-1-5	Endereço	**Fazenda São Matheus - Bairro Zona Rural 38500-000 Monte Carmelo-MG Brasil**
III-1-10	Endereço de correio electrónico	**internacionalglpi@glpi.com.br**
IV-1	**Mandatário ou representante comun; ou endereço para a correspondência** A pessoa abaixo-identificada é/foi, por este meio, designada para actuar em nome do(s) requerente(s) perante as Autoridades Internacionais competentes, na qualidade de:	**Mandatário**
IV-1-1	Nome (APELIDO, nome próprio)	**NAKATA, Carolina**
IV-1-2	Endereço	**AV. BRIGADEIRO FARIA LIMA, 1485 - 11o ANDAR - TORRE NORTE 01452-002 São Paulo-SP Brasil**
IV-1-3	No. de telefone	**55 11 2149-4500**
IV-1-4	No. de fax	**55 11 3819-0455**
IV-1-5	Endereço de correio electrónico	**internacionalglpi@glpi.com.br**
IV-1-5(a)	Autorização relativa ao correio electrónico O Organismo receptor, a Autoridade responsável pela pesquisa internacional, a Secretaria Internacional e a Autoridade responsável pelo exame preliminar internacional têm autorização para utilizar este endereço de correio electrónico para enviar, se tal desejarem esses organismos, notificações relativas a este pedido internacional:	**exclusivamente sob a forma electrónica (nenhuma notificação será enviada em papel)**
IV-1-6	No. do registo do requerente junto do Organismo	**API 1798/SP**
IV-2	**Mandatário(s) adicional**	**agente(s) adicional/ais com o mesmo endereço do primeiro mandatário**
IV-2-1	Nome(s)	**MURAKAMI, Juliano Ryota(API 2187/SP); DE SOUZA, Thiago Arpagaus(OAB/SP 273.398)**
V	**DESIGNAÇÕES**	
V-1	**O depósito deste requerimento constitui, de acordo com a Regra 4.9.a), a designação de todos os Estados Contratantes vinculados pelo PCT na data do depósito internacional, para os fins da concessão de qualquer tipo de protecção disponível e, se for caso disso, para os fins da concessão tanto de patentes regionais como de patentes nacionais.**	
VI-1	**Reivindicação de prioridade de um pedido nacional anterior**	
VI-1-1	Data do depósito	**14 Abril 2022 (14.04.2022)**
VI-1-2	Número	**1020220072728**
VI-1-3	País ou membro da OMC	**BR**

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VI-2	**Incorporação por referência:** quando um elemento do pedido internacional mencionado no Artigo 11.1)iii)d) ou e) ou uma parte da descrição, das reivindicações ou dos desenhos mencionados na Regra 20.5.a) ou um elemento ou parte da descrição, das reivindicações ou dos desenhos mencionados na Regra 20.5bis.a), não estiver de outro modo incluído no pedido internacional mas estiver totalmente incluído no pedido anterior cuja prioridade é reivindicada na data em que um ou mais elementos mencionados no Artigo 11.1)iii) tenham sido recebidos pela primeira vez pelo Organismo receptor, esse elemento ou parte é, sob reserva de confirmação de acordo com a Regra 20.6, incorporada por referência neste pedido internacional para os fins da Regra 20.6.		
VII-1	**Autoridade Responsável pela Pesquisa Internacional Escolhida**	**Instituto de Patentes e Marcas dos Estados Unidos (USPTO) (ISA/US)**	
VIII	**Declarações**	Número de declarações	
VIII-1	Declaração relativa à identidade do inventor	-	
VIII-2	Declaração relativa ao direito do requerente, na data do depósito internacional, de pedir e obter uma patente	-	
VIII-3	Declaração relativa ao direito do requerente, na data do depósito internacional, de reivindicar a prioridade do pedido anterior	-	
VIII-4	Declaração de autoria da invenção (apenas para os fins da designação dos Estados Unidos da América)	-	
VIII-5	Declaração relativa a divulgações não prejudiciais ou excepções à falta de novidade	-	
IX	**Lista de controle**	Número de folhas	Ficheiro(s) electrónico(s) anexado(s)
IX-1	Requerimento (incluindo as folhas de declaração)	**4**	✓
IX-2	Descrição	**33**	✓
IX-3	Reivindicações	**6**	✓
IX-4	Resumo	**1**	✓
IX-5	Desenhos	**8**	✓
IX-6a	Listagem de sequências fazendo parte da descrição	-	-
IX-7	TOTAL	**52**	

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	Itens anexos	Documento(s) em papel anexado(s)	Ficheiro(s) electrónico(s) anexado(s)
IX-8	Folha de cálculo das taxas	-	✓
IX-11	Cópia da procuração geral	-	✓
IX-13	Documento(s) de prioridade	-	**Item/Itens VI-1**
IX-19	Outro	**Direito a redução de taxa**	✓
IX-19	Outro	**Documentos no formato pré-conversão Declaração (Instrução 706): Isto é uma cópia completa e exacta do pedido internacional antes da sua conversão ao formato de documento electrónico no qual o pedido é depositado.**	✓
IX-20	**Figura dos desenhos que deve acompanhar o resumo**	**4**	
IX-21	**Língua do depósito do pedido internacional**	**Inglês**	
X-1	**Assinatura do requerente, do mandatário ou do representante comun**	**/Carolina NAKATA/**	
X-1-1	Nome (APELIDO, nome próprio)	**NAKATA, Carolina**	
X-1-3	Qualidade (se tal qualidade não for evidente para quem ler o requerimento)	**Mandatário**	

RESERVADO PARA O ORGANISMO RECEPTOR

10-1	**Data efectiva de recepção do alegado pedido internacional**	**24 Novembro 2022 (24.11.2022)**
10-2	**Desenhos:**	
10-2-1	Recebida	
10-2-2	Não recebida	
10-3	**Data efectiva de recepção, corrigida devido à recepção ulterior, mas dentro do prazo, de documentos ou desenhos que completam o alegado pedido internacional**	
10-4	**Data da recepção, dentro do prazo, das correcções exigidas de acordo com o Artigo 11.2) do PCT**	
10-5	**Autoridade responsável pela pesquisa internacional**	**ISA/US**
10-6	**Transmissão da cópia de pesquisa diferida até ao pagamento da taxa de pesquisa**	

RESERVADO PARA A SECRETARIA INTERNACIONAL

11-1	**Data da recepção da via original pela Secretaria Internacional**	

Docket No.: 092210-786599
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Gustavo Alexandre GROSSI

Application No.: National Stage of PCT/BR2022/050461

Confirmation No.: N/A

Filed: November 24, 2022

Art Unit: N/A

For: SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT

Examiner: Not Yet Assigned

FIRST PRELIMINARY AMENDMENT

MS Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Prior to examination on the merits, please amend the above-identified U.S. patent application as follows:

Amendments to the Specification begin on page 2 of this paper.

Amendments to the Claims are reflected in the listing of claims which begins on page 3 of this paper.

Remarks begin on page 7 of this paper.

AMENDMENTS TO THE SPECIFICATION

In the Specification at page 1, after the title, please insert the following new heading and paragraph:

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a national stage application (under 35 U.S.C. § 371) of PCT/BR2022/050461, filed November 24, 2022, which claims benefit of Brazilian Application No. 1020220072728, filed April 14, 2022, which are incorporated herein by reference in their entireties.

AMENDMENTS TO THE CLAIMS

This Listing of Claims will replace all prior versions and listings of claims in this application.

Listing of Claims:

1. (Original) AGRICULTURAL MANAGEMENT SYSTEM (100) is characterized by comprising:
   - a modular agricultural irrigation pivot-like device (101) positioned on an agricultural field (200) in the cultivation of a crop (202a) species, the modular agricultural irrigation pivot-like device (101) comprising:
   - a plurality of artificial lighting sources (10a, 10b, 10c, 10d, 10e) arranged along the modular agricultural irrigation pivot-like device (101) at a predetermined distance above the aerial parts of the crop (202a), comprising a plurality of light-emitting diodes; and
   - a plurality of energy sources that feed the plurality of artificial lighting sources (10a, 10b, 10c, 10d, 10e),

     the agricultural management system (100) further comprising:

     a processor in communication with a dimerizer and/or a polarizer of the plurality of artificial lighting sources (10a, 10b, 10c, 10d, 10e) and with the plurality of energy sources, wherein the processor is configured to:

     a) adjust (501), in the intervals of the electromagnetic spectrum, the balance between the spectral bands emitted by the plurality of light-emitting diodes; and
     b) determine and implement:
   - an irrigation routine (502); and/or
   - an artificial light(s) supplementation routine (503);

wherein stages a) and b) are determined by the processor considering at least one among:

- a crop (202a) species under cultivation;
- a phenological stage of the crop (202a) under cultivation;
- a photoperiod, a season and current weather conditions under which the agricultural field (200) is subjected; and
- one or more objective(s) intended for the crop (202a) development.

2. (Original) SYSTEM (100), according to claim 1, characterized in that stages a) and b) determined by the processor using an artificial intelligence model.

3. (Currently Amended) SYSTEM (100), according to claim 1 ~~any of claims 1 and 2~~, characterized in that the modular agricultural irrigation pivot-like device (101) comprises:

- a drive device for the displacement of the modular agricultural irrigation device (101) over the agricultural field (200); and
- sprinkler devices comprising a plurality of sprinklers,

wherein the processor is in communication with the drive device and with the sprinkler device for the execution of stage b).

4-17. (Cancelled)

18. (Original) AGRICULTURAL MANAGEMENT METHOD (500), for the cultivation of a crop (202a) in an agricultural field (200), characterized by comprising the steps of:

a) adjusting (501), in intervals of the electromagnetic spectrum, the balance between the spectral bands emitted by a plurality of light-emitting diodes of a plurality of artificial lighting sources (10a, 10b, 10c, 10d, 10e); and
b) determining and implementing:

- an irrigation routine (502) of a modular agricultural irrigation device (101); and/or
- a routine of artificial light(s) supplementation (503) of the plurality of artificial lighting sources (10a, 10b, 10c, 10d, 10e);

wherein stages a) and b) are determined considering at least one among:

- a crop (202a) species under cultivation;
- a phenological stage of the crop (202a) under cultivation;
- a season, a photoperiod, and current weather conditions under which the agricultural field (200) is subjected; and
- one or more objective(s) intended for the crop (202) development.

19. (Original) METHOD (500), according to claim 18, characterized in that stages a) and b) are determined by the processor using an artificial intelligence model.

20. (Currently Amended) METHOD (500), according to claim 18 ~~any of the claims 18 to 19~~, is characterized by further comprising a stage c) of determining a routine of soil management in the agricultural field (200) based on soil analyses from the agricultural field (200).

21. (Original) METHOD (500), according to claim 20, characterized in that stage c) of determining through the artificial intelligence model considers at least one of the following:

- the irrigation routine (502);
- the routine of artificial light(s) supplementation (503);
- the crop (202a) species under cultivation;
- the phenological stage of the crop (202a) under cultivation;
- the photoperiod, the season and the current weather conditions under

which the agricultural field (200) is subjected; and

- the one or more objective(s) intended for the crop (202a) development.

22-24. (Cancelled)

REMARKS

Applicant has amended the specification to refer to prior related applications. No new matter has been added into the specification.

Applicant has cancelled claims 4-17 and 22-24. Claims 3, 17, and 20 have been updated to remove multiple dependencies. Remaining claims 1-3 and 18-21 align with the claims the Written Opinion of the International Searching Authority found patentable. Applicant encloses a request to participate in the Patent Prosecution Highway (PPH) based on the allowable subject matter identified in the Written Opinion issued by International Searching Authority (The United States Patent and Trademark Office).

In the event the Examiner believes an interview might serve in any way to advance the prosecution of this application, the undersigned attorney is available at the telephone number noted below.

Applicant believes no fee is due with this response. However, if a fee is due, please charge our Deposit Account No. 50-1662, under Order No. 092210-786599 from which the undersigned is authorized to draw.

Dated: January 25, 2024

Respectfully submitted,

Electronic signature: /R. James Balls/
R. James Balls
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SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT

FIELD OF THE INVENTION

The present invention refers, in general, to an agricultural management system. The present invention also refers to an agricultural management method. In particular, according to the present invention, the system and method of agricultural management include artificial light(s) supplementation and are directed to the cultivation of a crop in an agricultural field.

BACKGROUND OF THE INVENTION

Large-scale agricultural production has always been closely linked to and dependent on multiple variables. Such variables include the nutritional and microbiological factors of the soil, intrinsic characteristics of a given region (e.g., climate, photoperiod, and rainfall distribution), as well as a plurality of stresses that affect crops, such as pathogens (plant diseases), insect infestations (plant predations), invasive plants (weeds), extreme (deficit or excess) of climatic, light irradiation, nutritional and water factors, among others.

In the context of the current agro-industrial scenario, Brazil notably stands out as one of the largest producers and exporters of agricultural commodities, such as soybeans (*Glycine max*) and corn (*Zea mays*), with an annual grain production of over 270 million tons according to CONAB (*Companhia Nacional de Abastecimento*, Brazilian agricultural ministry department) 2022 estimations. Thus, it is evident that developing new techniques and technologies for crop management has a tremendous economic and industrial impact. In addition, agricultural production is pressured by the growing world population and, consequently, by the increased international demand for agricultural commodities.

In this sense, there have been several efforts of new technologies to model and monitor variables such as edaphoclimatic conditions to understand the consequences and interactions between soil and crop. For example, the use of technologies and strategies for soil management and water resources, intelligent use of agrochemicals, efficient application of fertilizers, integration of the Internet of Things (IoT) into agriculture, and climate monitoring practices are essential for high crop performance and yield.

In addition to monitoring and controlling external factors, other technologies can improve agricultural activity. For example, biological technologies, such as genetically modified cultivars, benefit farmers, consumers, the environment,

and the economy; bioactive compounds, such as growth-regulating phytohormones, result in plant changes from germination to senescence and the source-drain relationship of photoassimilates in the plant during its cycle. Such technologies also improve the plant's resistance to adverse conditions during the crop cycle and increase the human nutritional value of crop production.

Over the past few decades, the use of such technologies has become constant to intensify agricultural production around the globe. The frequency of use of such technologies in South America and Asia farms has almost equated to the frequency of use in Europe and North America. However, climate change has recently caused a new demand for intensified agricultural production with more sustainable technological approaches. Additionally, the intensification of agricultural output to meet global demand is driven by the use of costly non-renewable fertilizers.

In this way, recent advances have been made in studies on artificial light(s) supplementation for crop production *outdoor* (large scales), defined as the process of applying artificial light(s) to plants grown in the open field, emphasizing the beneficial effects of the use of light-emitting diodes (LEDs) on plant's metabolism, on the efficiency of light absorption by the leaves, as well as the mitigation of abiotic (e.g., extreme temperatures and drought) and biotic (e.g., insect pests, plant diseases, weeds) stresses, while applying a sustainable management of the available resources.

Document *US 2016/0198640 A1* reveals a mobile irrigation pivot equipped with sprinklers and a plurality of light-emitting diodes configured to emit different frequencies of polarized light in spectral bands from violet to far red spectrum over plants of short, long, or neutral photoperiod response in an agricultural field. The light-emitting diodes are fixed on the irrigation pivot structure, illustrated in Figure 1 of the referred document.

The described irrigation pivot can also comprise a control circuit configured to control the operation of light-emitting diodes, irrigation parameters, and pivot moving.

Light(s) supplementation applied to crops can alter plant responses significantly. However, these responses are affected by several factors, such as plant species, crop management, soil fertility, water availability, and the prevailing climate. Document *US 2016/0198640 A1* fails to reveal artificial light(s) supplementation combined with crop management factors. Instead, when artificial light(s) supplementation is used alone, as indicated in document *US 2016/0198640 A1*, this

may not have the desired effect or may even impair plant development (empirical observation). Artificial light(s) supplementation may, for example, not achieve high yields if the applied fertilization does not adequately meet the desired level of crop production, or artificial light(s) supplementation may favor a condition of intense weeds competition in the crop field if an adequate positioning of herbicides is not made.

Noticeably, the *state of the art* lacks technological improvements regarding integrated crop management strategies. Actions in crop fields are still evaluated independently and not integrally. The sustainable use of energy, fertilizers, water, and adequate artificial light(s) supplementation are essential for sustainable large-scale improved cropping activities. These large-scale cropping activities have a great responsibility in human impact on Earth's environments. Improving the sustainability of large-scale cropping activities is possible with the present invention.

OBJECTIVES AND DESCRIPTION OF THE INVENTION

Therefore, an objective of the present invention is to provide an agricultural management system combined with artificial light(s) supplementation capable of raising agricultural production in a cropping area, increasing its productivity, reducing the negative effects of stresses present in the *outdoor* environment, increasing the efficiency of the applied inputs for crop production and, in this way, reduce the limitations of the currently known cropping techniques.

Another objective of the present invention is to provide an agricultural management system via consultancy combined with adequate artificial light(s) supplementation routine. The light-emitting diodes can be implemented in any new or preexisting irrigation pivot in an agricultural cropping area. The routine of light(s) supplementation is usually independent of the irrigation routine.

Another objective of the present invention is to provide an agricultural management system combined with artificial light(s) supplementation capable of stimulating plant characteristics of any species at a given phenological stage. These responses are regulated by the moment of artificial light(s) supplementation, the predominant color in the artificial light(s) applied, and the interaction among these factors and the environment, crop genetics, crop response to photoperiod, and crop management.

Another objective of the present invention is to provide an agricultural management system combined with artificial light(s) supplementation capable of stimulating plant characteristics of a given species at a given phenological stage.

These stimulated characteristics can improve plant performance against adverse stressful conditions that impair photosynthesis using natural light (sunlight) and reduce the negative effects of low natural luminosity during cloudy days.

Another objective of the present invention is to provide dimerization and/or polarization of the spectral bands in the artificial light(s) supplementation according to the crop species, region, soil physical and chemical conditions, climate, predominant agronomic management and type of agricultural production system in use (e.g., no-tillage cropping system).

Another objective of the present invention is to maintain and adapt the routine of water irrigation and light(s) supplementation at different phenological stages during all crop development stages, improving agricultural production in quantity, quality, and sustainability.

Another objective of the present invention is to protect crops against plant diseases and insect pests by modulating artificial light(s) supplementation. Artificial light(s) can be used to affect plant diseases and insect pest development, cycle, and pressure on crop performance. The improved crop protection advantageously has the potential to reduce the need for the application of phytosanitary products. This potential reduction in use of phytosanitary products (e.g., insecticides and fungicides) consequently reduces the damage caused to the environment by the excessive use of such products.

Another objective of the present invention is to act beyond the mere application of light(s) supplementation, as it must consider soil factors, plant nutrition levels, climate, photoperiod responses, agronomic management, and crop variety selection, among others, to achieve the balance between the demand of the plant stimulated by light(s) supplementation and the technical use of production resources. In other words, according to the present invention, artificial light(s) supplementation is a tool that must be inserted in a set of appropriate technical actions to achieve the best production results and sustainability of large-scale agriculture.

Finally, the present invention aims to increase the efficiency of production resources, such as irrigation, fertilizers, and agrochemicals (insecticides, fungicides, bactericides, fertilizers, stimulants, …), due to the effects caused by artificial light(s) supplementation, such as a great development of the plant root system, allowing improved exploration of the soil profile and reduce the water, nutrients and agrochemicals losses.

One or more objectives of the above-mentioned invention(s), among others, are achieved by means of an agricultural management system combined with artificial light(s) supplementation, comprising:

- a modular agricultural irrigation device positioned on an agricultural field using a plurality of artificial lighting sources arranged along the modular agricultural irrigation device, optionally at equidistant points and at a predetermined distance above the aerial crop parts.

- a plurality of light-emitting diodes capable of emitting a plurality of electromagnetic spectrum bands applied alone or in combinations of different proportions of spectral bands from the limit of ultraviolet C and B (wavelength of 280 nm) to infrared (wavelength > 700 nm); and

a plurality of energy sources that feed a plurality of artificial lighting sources.

The agricultural management system also comprises

- a processor in communication with a dimerizer and/or polarizer of a plurality of artificial lighting sources and a plurality of energy sources, in which a processor is configured to

a) adjust, in the intervals of the electromagnetic spectrum, the balance between the spectral bands emitted by a plurality of light-emitting diodes; and

b) determine and implement - an irrigation routine; and/or - an artificial light(s) supplementation routine; in which stages a) and b) are determined by a processor considering at least one among

- the crop species 202a under cultivation;

- the phenological stage of the crop 202a under cultivation;

- the photoperiod, station and current weather conditions under which the agricultural field 200 is subjected; and

- one or more objective(s) intended for the crop 202a development under light(s) supplementation.

Understand "*objective(s) intended for the crop*" as the main purpose of the cropping of such plant specie; if, for example, the crop is for grain production, then a crop and artificial light(s) management, or protocol, is applied; however, if the crop is only intended for cattle grazing, then another crop and artificial light(s) management, or protocol, is applied.

The objective(s) of the above-mentioned invention, among others, is also achieved by means of adequate agricultural management methods combined with artificial light(s) supplementation for crop cultivation in an agricultural field, comprising the stages

a) adjusting the balance between the spectral bands emitted by a plurality of light-emitting diodes of a plurality of lighting sources artificially capable of emitting a plurality of electromagnetic spectrum bands applied alone, or in combinations of spectral bands from the limit of ultraviolet C and B (wavelength of 280 nm) to infrared (wavelength > 700 nm); and

b) determine and implement - an irrigation routine of a modular agricultural irrigation device; and/or

- a routine of artificial light(s) supplementation of a plurality of artificial lighting sources; in which stages a) and b) are determined considering at least one among

- the crop species under cultivation;

- the phenological stage of the crop under cultivation;

- the crop photoperiod response, crop cropping season and current weather conditions under which the agricultural field is subjected; and

- the objective(s) intended for the crop 202a development under light(s) supplementation.

BRIEF DESCRIPTION OF THE DRAWINGS

The objectives, technical effects and advantages of the present invention will be apparent with the following detailed description that refers to the attached figures, which illustrate, but not limited, embodiments of the objects claimed

- Figure 1 illustrates a 100 agricultural management system combined with light(s) supplementation operating on a modular agricultural irrigation device 101 on an agricultural field 200, according to the present invention;

- Figure 2 shows an expansion of a crop 202a in the agricultural field 200 under the action of the agricultural management system 100 combined with artificial light(s) supplementation, according to the present invention;

- Figure 3 illustrates the stages of the logic operation of the agricultural management method 500 combined with artificial light(s) supplementation, according to an embodiment of the present invention;

- Figure 4 illustrates a superior view of a schematization of an irrigation pivot in which the agricultural management system 100 combined with artificial light(s) supplementation was installed, according to an embodiment of the present invention;

- Figure 5 illustrates a first graph of an analysis of a sovbean plant internode variable of the crop 202a over time, under the performance of the agricultural management system 100 allied to artificial light(s) supplementation, according to the embodiment of the present invention;

- Figure 6 illustrates a second graph of an analysis of soybean plant height variable of the crop 202a over time, under the action of the agricultural management system 100 allied to artificial light(s) supplementation, according to the present invention embodiment;

- Figure 7 illustrates a third graph of an analysis of third plant variable of the crop 202a over time, under the action of the agricultural management system 100 combined with artificial light(s) supplementation, according to the embodiment of the present invention;

- Figure 8 illustrates a comparison between crop 202a plants under the intervention of the agricultural management system 100 combined with artificial light(s) supplementation, and crop 202b plants with no artificial light(s) supplementation and corresponding crop management, according to the embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS OF THE INVENTION

Initially, it should be noted that the system and method of the present invention will be described below according to particular but non-limiting embodiments since it may be executed in different ways and variations and according to the objective(s) intended for the crop 202a development under light(s) supplementation.

In one embodiment, the present invention reveals a 100 agricultural management system combined with artificial light(s) supplementation for the cultivation of a crop 202a in an agricultural field 200.

In another embodiment, the present invention reveals a 500 agricultural management method combined with artificial light(s) supplementation for the cultivation of a crop 202a in an agricultural field 200.

It is emphasized that adjustments in agricultural management and artificial light(s) supplementation should be implemented for each crop 202a and cropping region due to latitude, the height of the area compared to sea level, soil

characteristics, and climate variations. The crop 202a phenological stage, photoperiod, the weather conditions under which the agricultural field 200 is submitted, and the objective with the plant development should also be considered to define the wavelength range applied and its combinations of electromagnetic spectrum bands to meet the specified objective. The luminous flux and the balance between the spectral bands emitted by a plurality of light-emitting diodes are, therefore, variable by means of digital dimerization and/or polarization and controllable by an electronic processor, according to the routine of artificial light(s) supplementation, which in turn takes into account the factors mentioned above.

It should be noted that the expressions “plant”, “cultivate”, or “culture” should be understood as any plant varieties, whether from long-day, such as oats (*Avena sativa*) or potato (*Solanum tuberosum*) or short-day plants, such as soy (*Glycine max*) or coffee (*Coffea* sp.), or neutral plants, which benefit from artificial light(s) supplementation in accordance with the present invention. Crop species evaluated with adequate crop corrections and management combined with artificial light(s) supplementation include soybean (*Glycine max*), bean (*Phaseolus vulgaris*), corn (*Zea mays*), tomato (*Solanum lycopersicum*), carrot (*Daucus carota*), sugarcane (*Saccharum officinarum*), tobacco (*Nicotiana tabacum*), garlic (*Allium sativum*), onion (*Allium cepa*), pea (*Pisum sativum*), sunflower (*Helianthus annuus*), sorghum (*Sorghum bicolor*), cotton (*Gossypium hirsutum*), potato (*Solanum tuberosum*), hops (*Humulus lupulus*), strawberry (*Fragaria × ananassa*), pitaya (*Hylocereus undatus*), lettuce (*Lactuca sativa*), arugula (*Eruca vesicaria* ssp. *sativa*) and agricultural soil cover crops. Each crop species received adjusted in artificial light(s) supplementation for each crop 202a and region of cultivation, as well as other factors such as the phenological stage of the crop 202a under cultivation, the photoperiod, and the meteorological conditions under which the agricultural field 200 is submitted and the objective(s) intended for the crop 202a development. All these crop species 202a showed positive results with adequate agricultural management and artificial light(s) supplementation, according to the present invention, compared to control (no artificial light(s) supplementation). The positive results are discussed below.

Furthermore, this descriptive report means “corrections” as any practice carried out by the producer in the agricultural area to improve the conditions available for plant development. In this sense, all practices that affect soil management (chemical and physical structure) and plant nutrition management (fertilizers) can be

considered “corrections”. Examples of corrections are the application of limestone (soil acidity correcting, calcium and magnesium source), the application of gypsum (reducing potential acidity in depth in the soil, source of calcium and sulfur), and the cultivation of cover crops (soil compaction management, nutrient recycling, pest control such as phytonematodes).

As can be seen in figures 1 and 2, the agricultural management system 100 combined with artificial light(s) supplementation, according to the application of the present invention, can be adapted to an irrigation new pivot or already existing in an agricultural field 200, such as a central irrigation pivot, whether towed or non-towable, or even a linear irrigation pivot. In this descriptive report, the pivot is generally described as “agricultural irrigation modular device 101”.

This modular agricultural irrigation device 101 is positioned on the agricultural field 200 on which the cultivation of a crop 202a occurs, and the modular device 101 comprises an irrigation line 102a with wheeled towers and many spans (irrigation space between towers presenting oblong arms). The distal end of the first irrigation span 102a is supported by a wheeled tower 103a, and mechanically associated with a drive device, such as an engine or equivalent, and wheels 104a; 105a; the proximal end of the first irrigation span 102a is mechanically connected in a circular rotating way to the center of the pivot. The drive device triggers the tower 103a displacement.

The modular agricultural irrigation device 101 may have one or many wheeled towers and spans.

The span(s) of the modular device 101 presents a plurality of water sprinklers connected to a hydraulic pressure line in water communication with a reservoir which may be arranged, for example, at a central pivot, in the hydraulic line extending along the pivot spans 102a; 102b, which are equipped with water sprinklers in order to promote the irrigation of the agricultural field 200.

The agricultural management system 100, combined with artificial light(s) supplementation, incorporates a plurality of artificial lighting sources 10a, 10b, 10c, 10d, 10e arranged, for example, along the irrigation spans 102a; 102b of the agricultural irrigation modular device 101 and may be located at specific points and at a predetermined distance above the aerial part (canopy, plant shoot) of the crops 202a, the distance from the ground and other sources of artificial lighting 10a, 10b, 10c, 10d, 10e can also be adjusted as necessary, depending on the type of modular device 101

that will receive the artificial lighting sources and the crop 202a species under cultivation.

In addition, a plurality of artificial lighting sources 10a, 10b, 10c, 10d, 10e comprise a plurality of light-emitting diodes. In a preferred embodiment, light-emitting diodes are full-spectrum with wavelengths ranging from 280 nm, at the limit of the UV-C spectrum with UV-B, up to 1200 nm, in the near-infrared spectrum, over agricultural crop 202as (whether short, long or neutral-day plants) which are directly associated with biomass production, plant morphology, plant resistance to stresses, and crop development 202a. In one embodiment, the wavelength interval applied may be the same during the day or night but with variable luminous flux intensities.

The system 100 also comprises a plurality of energy sources, feed a plurality of artificial lighting sources 10a, 10b, 10c, 10d, 10e, as well as a processor in communication with the water sprinkles, the pivot drive device, and a dimerizer or polarizer of a plurality of artificial lighting sources 10a, 10b, 10c, 10d, 10e The referred processor is configured to adjust 501 the light spectral bands, the balance between these spectral bands emitted by a plurality of light-emitting diodes, and determine an irrigation routine 502 and an artificial light(s) supplementation 503 routine. The irrigation routines and artificial light(s) supplementation are independent. In other words, according to the established routine, a processor can command the action of the drive device, water sprinkle device, and the light dimerizer or polarizer. A processor determines this routine, preferably using an artificial intelligence model, considering the crop 202a species under cultivation; the phenological stage of the crop 202a under cultivation; the photoperiod and weather conditions under which the agricultural field 200 is/was subjected; the objectives intended for the crop 202a development, and information provided by users (farmers) through a user interface, which will be commented on below.

In an embodiment of the artificial light(s) supplementation routine, the crop 202a plant development can be stimulated or inhibit the production of leaves, branches, flowers, and roots; stimulate or inhibit the production of grains, fibers, fruits, and essences; stimulate or inhibit vegetative and reproductive growth, and stimulate plant photosynthesis.

In an embodiment of the artificial light(s) supplementation routine, a processor may be in communication with a plurality of photoresponsive sensors to determine a threshold of sunlight incidence, which controls the performance of a

plurality of light-emitting diodes and routines of application, reducing the negative effects of weather adversities under which the agricultural field 200 is subjected, such as cloudy days with a low sunlight incidence.

It is also noteworthy that the threshold of light incidence may additionally depend on other factors, such as the crop 202 species under cultivation, current crop 202a phenological stage, the region (e.g., information regarding soil, climate, history of the cropping area), and crop 202a management applied.

A light dimerizer or polarizer adjusts the luminous flux and the balance between the spectral bands emitted by a plurality of light-emitting diodes. The light dimerization or polarization is controllable by the interaction between photoresponsive cells and a processor to define a routine of light artificial supplementation. The definition of such routine takes into account the factors mentioned above. For example, for crops 202a in general, the basic phenological stages are vegetative (V) (crop cycle period before flowering and where pre-flowering occurs) and reproductive (R) (begins with the first reproductive structure, usually flowers), in which specific artificial light(s) supplementation with specific spectral band composition is applied. This balance of spectral bands can be the same applied during the day or night or may diverge between these periods, varying the intensity of the luminous flux and spectral band composition. In nocturnal applications, the luminous flux can be adjusted to be lower, for example, than the luminous flux in daytime applications, intending only to cause stimuli in crop 202a plants, which will be commented on below. Especially in daytime applications, the luminous flux can be adjusted to be higher in cloudy periods, intending to mitigate the effects of photosynthetic reduction due to low natural light availability.

This is especially advantageous, as cloudiness can reduce the photosynthetic capacity of the crop 202a plants by more than 50%, causing the crop 202a to produce fewer sugars (assimilated organic carbon via photosynthesis) and consequently grow less and produce less biomass (e.g., grains, fruits, fibers). This reduction in photosynthetic activity also results in smaller amounts of root exudates released to the soil (decreasing the soil aggregating effect) and lower symbiont microorganisms (due to decreased root exudate supply), which in turn have the function of obtaining nutrients from the environment to the crop 202a, making them more resistant to pathogens and agricultural pests. Thus, it is evident that compensation for the low incidence of natural sunlight is a decisive factor for soil structuring and plant protection against pathogens and agricultural pests.

In another embodiment, a plurality of energy sources can be generated by wind, sunlight, thermal, or combustion generators in order to feed a plurality of artificial lighting sources 10a, 10b, 10c, 10d, 10e. In any of these embodiments, a processor may be in communication with a machine-readable memory, which stores database information comprising real-time updates on the geolocation of agricultural field 200 and climate indicators to suggest to the user, through a user interface, the crop 202a variety to be cultivated.

The user interface is in communication with a processor, and in turn, the user feeds other information to a processor, through the interface, such as

- the history of cultivation of the agricultural field 200 in order to identify successful plants species and crop varieties previously cultivated in the agricultural field 200;

- the history of agricultural inputs used in the agricultural field 200, such as fertilizations and corrections made;

- the occurrence of stresses in plants, such as the emergence of plant diseases and insect pest infestation, nutritional deficiencies, extreme of temperatures and rainfall distribution;

- the occurrence, intensity and determination of the principal weeds;

- results of productivity from previous harvests;

- the characteristics of the irrigation pivot 101, such as irrigated area, irrigation flow, working speeds and the height of the structure wherein a plurality of artificial lighting sources 10a, 10b, 10c, 10d, 10e are fixed in order to adjust the illumination of the light-emitting diodes as a function of the distance of a plurality of artificial lighting sources 10a, 10b, 10c, 10d, 10e

- the current crop season weather conditions and weather indicators of the crop field area.

The user interfaces in an embodiment implemented on a panel, mobile phone, tablet, or similar mobile devices with a direct connection to a center of information where the reported data will be processed, and the artificial intelligence will be fed.

In another embodiment, a plurality of energy sources uses information such as the sunlight duration, cloudiness, sunlight brightness as well as the insolation index (ratio between the actual number and the maximum possible number of hours of sunlight brightness) to determine the threshold of sunlight incidence in the agricultural

field 200. Below the calculated threshold and depending on a certain routine of artificial light(s) supplementation, a processor interacts with the dimerizer or polarizer to command the performance of a plurality of light-emitting diodes and project artificial light(s) with specific spectral band composition, reducing the negative impact of meteorological adversities (e.g., cloudy days) under which the agricultural field 200 is subjected.

In one embodiment, data on the crop 202a species, crop 202a phenological stage, photoperiod, meteorological conditions under which the agricultural field 200 is submitted, objective(s) intended for the crop 202a development, as well as the technologies implemented in the agricultural field (fertilizers, agrochemicals, and soil management techniques) are stored in a machine-readable memory and accessed by a processor, in order to properly apply light(s) supplementation, according to parameters provided by the machine-readable memory.

Such previous information on the agricultural field 200 and the routine of artificial light(s) supplementation is important because they help

- in understanding and predict the consequences and interactions potentially present in the agricultural field 200;

- indicate improvements and corrections to be implemented in the agricultural field 200 for the optimization of the results of artificial light(s) supplementation;

- assist in the use of technologies and strategies for soil and water resources management;

- assist in the intelligent use of agrochemicals and in the efficient application of fertilizers; - assist in the integration of internet of things (IOT) to monitor crop (satellite), climate and agricultural practices; and

- help to improve the application format of the routine of artificial light(s) supplementation, such as the type of artificial lighting source 10a, 10b, 10C, 10D, 10e to be used, such as light-emitting diode panels (LEDs), led strips (LED), lamps in general, and their respective power, frequency and wavelength.

In addition, pedological, edaphological, mineralogical, textural, phytopathological, and nutritional analyses are essential before the agricultural field 200 receives adequate agricultural management and artificial light(s) supplementation routine. It is impossible to define the best inputs management for crop production without knowing such mentioned information. How many, how much, and when to

apply fertilizers for high crop performance under artificial light supplementation? Soil, irrigation, and phytosanitary management, what is the best routine? It is necessary to know the soil conditions before implementing adequate agricultural and artificial light(s) supplementation management to understand how soil will behave after the referred implementation.

The 100 system of the present invention comprises a plurality of soil sensors under the agricultural field 200 to capture nutritional data from the soil of the agricultural field 200. A processor uses the data to determine and suggest routines for soil treatment/corrections of the agricultural field 200. The respective recommendation made by a processor, using an artificial intelligence model fed with specific parameters and users information, considering the crop parameters, adjusts the balance between the spectral bands 501, and determines the irrigation routine 502 and artificial light(s) supplementation 503.

Short-day crops, such as soybean (*Glycine max*), are largely influenced by abiotic factors such as photoperiod and temperature. Soybean flowering and reproductive cycle occur under short photoperiodisms, that is, on days when the absence of light (night period) is longer than the presence of light (day period). While the opposite, extended day periods can delay or inhibit flowering and the beginning of the reproductive cycle. This condition of dependence on the photoperiod allows light(s) supplementation to influence the extension of the crop 202a cycle. Consequently, plant height, number of internodes, pods, seeds per pod, and distribution of pods in the aerial parts of soybean are affected by extended photoperiods through adequate agricultural and artificial light(s) supplementation management.

It is also important to mention that for a positive balance for photosynthesis, the luminous flux is usually between 200 and 600 μmol m^{-2} s^{-1}. However, artificial light(s) supplementation acts on other physiological aspects that directly and indirectly affect photosynthesis in the plant, and not necessarily artificial light(s) supplementation is applied to be the light source that momentarily causes photosynthesis. This light source may have a luminous flux of less than 200 μmol m^{-2} s^{-1}.

In general, artificial lighting sources 10a, 10b, 10c, 10d, 10e with luminous flux less than 200 μmol m^{-2} s^{-1} are not able to cause considerable amounts of positive photosynthesis on most plants. However, even smaller luminous fluxes can cause stimuli in crop 202a that can directly or indirectly positively affect photosynthesis

to be performed the following day after the night of application of artificial light(s) supplementation. Therefore, a low luminosity, capable only of causing other responses but unable to directly cause considerable amounts of positive photosynthesis; a higher luminosity, will consequently have specific and useful applications according to the present invention.

Artificial light(s) supplementation, according to the present invention, is, therefore, a tool within a broad technical project that interacts both with the agricultural management of soil aspects, such as soil fertility and texture, and plant nutrition, as well as with the pathological and beneficial microbiological aspects, environmental aspects, such as temperature and rain in the agricultural region, and economic aspects, such as the cost of production and marketing of agricultural commodities that receive agricultural management combined with artificial light(s) supplementation according to the present invention.

The increase in agricultural production, according to the present invention, is the result of the interaction among stimulated crop 202a physiological processes by light(s) supplementation, the time defined for sowing, irrigation volume, time of application, formulation, frequency, and dosage of fertilizers, climate variation, management of insect pests and plant diseases and their impacts on the relationships with the environment. Agricultural cultivation with this integration of adequate technical knowledge (agricultural management) and artificial light(s) supplementation, according to the present invention, increases the resilience and stability of crop production, which increases regional and global food security.

It is noteworthy here that artificial light(s) supplementation improves the result of good management but does not correct poor management. In other words, according to the present invention, artificial light(s) supplementation enhances the development of plants that are well nourished, with good water distribution throughout the crop cycle, and that present soil physical and chemical structure suitable for high yields. Under these conditions, supplement artificial light(s) will generate the best results. However, if light(s) supplementation is not combined with adequate agricultural management, then light(s) supplementation alone cannot fix preexisting limitations for the full development of plants, such as nutritional deficiencies, lack of water, insect infestations, or the presence of agricultural pathogens.

The application of agricultural management and artificial light(s) supplementation, according to the present invention, does not present

contraindications regarding - crop 202a species (any cultivated plant specie would benefit from adequate agricultural management and artificial light(s) supplementation); - phenological stage during crop 202a cycle (vegetative or flowering/reproductive); - joint application, or not, with water irrigation.

In addition, the application of agricultural management and artificial light(s) supplementation, according to the present invention - can be handled to raise the levels of specific substances in the final product (e.g., grains, fruits, and fibers); - recommend the dimerization/polarization of the light spectrum to be applied with the development of the crop 202a (e.g., modification of the bluish spectrum in the vegetative to the reddish spectrum in the reproductive stage); and - recommend the application of artificial light(s) supplementation at specific periods of the crop 202a cycle, and not applied throughout the crop cycle, from sowing to harvest.

Without getting in the light of any specific theory, it was observed that light dimerization/polarization effects are beneficial, including changes in plant morphology, crop cycle extension, physiological responses, and plant productivity.

For example, it was observed that the bluish spectrum (spectral band of approximately 400 to 500 nm) is a stimulant of vegetative growth, which is appropriate for plants before flowering. After flowering, plants paralyze growth investments and start investing in grain, fiber, fruit, or essence production.

In turn, it was observed that the reddish spectrum (spectral band of approximately 600 to 750 nm) is a stimulant of reproductive growth, with beneficial effects for flowering, the rate of photosynthesis, and fruit formation. In this post-flowering period, the photosynthetic activity for biomass accumulation and the translocation of these reserves produced to “fill” production is essential. Therefore, avoiding the blue spectrum, or having less blue, is important in the reproductive phenological stage because blue is a stimulant of the vegetative stage, which would cause nutrient reserves to be consumed and not destined to fill the production. On the other hand, having the red spectrum, or having redder to stimulate photosynthesis and the distribution of reserves, is essential for the best results in the reproductive stage.

In a preferred embodiment, the balance between red-green-blue spectral bands presents at least 40% blue color for vegetative phenological stages and about 60% or at least 40% red color for the reproductive phenological stage of the crop 202a under cultivation. More than 40% red color in the artificial light(s) supplementation is recommended for any plant phenological stage.

Figure 3 illustrates the agricultural management method 500 combined with artificial light(s) supplementation for the cultivation of a crop 202a in an agricultural field 200, which comprises the stages a) adjusting 501, in the intervals of the electromagnetic spectrum, the balance between the spectral bands emitted by a plurality of light-emitting diodes of a plurality of artificial lighting sources 10a, 10b, 10c, 10d, 10e; and b) determine and implement an irrigation routine 502 of a modular agricultural irrigation device 101; and/or a routine of artificial light(s) supplementation 503 of a plurality of artificial lighting sources 10a, 10b, 10c, 10d, 10e in which the irrigation routine 502 and the supplementation routine are independent of each other, and in which stages a) and b) are determined through an artificial intelligence model considering at least one of the type of crop 202a under cultivation; the phenological stage of the crop 202a under cultivation; the photoperiod, station and current weather conditions under which the agricultural field 200 is subjected; and the objective(s) intended for the crop 202a development.

Method 500 also comprises stage c) determining and suggesting a soil treatment routine based on soil nutritional data from the agricultural field 200, stage c) being defined through the artificial intelligence model considering at least one of the same parameters considered for stages a) and b), in addition to considering the irrigation routine 502 and/or the routine of artificial light(s) supplementation 503.

In a preferred embodiment, the objective(s) with crop 202a development is to stimulate or inhibit the production of leaves, branches, roots, grains, fibers, fruits, and essences and, also, to stimulate or inhibit vegetative and reproductive growth and photosynthesis.

In a preferred embodiment, the routine of artificial light(s) supplementation 503 occurs, preferably, between the phenological stages V3-V4 to R5-R6 of the crop 202a under cultivation, and the balance between the spectral bands is adjusted 501, the balance between red-green-blue spectral bands presents at least 40% blue color for vegetative phenological stages and about 60% or at least 40% red color for the reproductive phenological stage of the crop 202a under cultivation. More than 40% red color in the artificial light(s) supplementation is recommended for any plant phenological stage.

EXAMPLE 1

Reference is made to an example (technically adequate and representative study) in which the present invention was carefully implemented in order

to verify its effectiveness. According to the present invention, this example evaluated the soybean 202a plant responses related to plant development and crop productivity in an open commercial area 200 (field scale) cultivated under agricultural management conditions and artificial light(s) supplementation. An irrigation pivot 101, irrigating a commercial cropping area 200, received an artificial lighting source 10a, 10b, 10c, 10d, 10e, according to the present invention, in internal pivot 101 spans for artificial light(s) supplementation of the soybean plants 202a.

According to the example, about 40 hours of artificial light(s) supplementation was applied to soybean plants 202a during the soybean crop 202a cycle. The number of plant internodes, soybean plant height, and the number of pods per soybean plant were evaluated weekly to calculate the area below the variable progression curve. Grain yield at harvest was also evaluated. Later, the area below the progression curve of the number of internodes, soybean plants height, and pods per soybean plant was positively affected by the system and method of adequate agricultural management combined with artificial light(s) supplementation 100, 500, according to the present invention.

The regular soybean 202a cycle, without artificial light(s) supplementation, is about 15 to 17 weeks; however, soybean harvesting occurred two weeks later when no artificial light(s) supplementation was applied. The artificial light(s) supplementation increased soybean grain yield by 57.3% and profitability by 180% when compared to soybean cropping without artificial light(s) supplementation.

METHODOLOGY EXPERIMENTAL AREA AND SOYBEAN CULTIVATION

The experiment with light(s) supplementation on soybean was carried out in an irrigation pivot 101, on a commercial farm in Monte Carmelo, Minas Gerais state, Brazil. Located at a latitude and longitude of 18º 57” South, 47° 25” West, at 980 m above sea level. The most common and representative biome of the region is the Cerrado (savannah-like biome). The climate of the region is humid tropical, with rainy summers and dry winters.

Physical analyses of the soil in the agricultural area 200, from 0 to 0.4 m deep, indicated 450, 100, and 450 g kg^{-1} of sand, silt, and clay, respectively. The chemical analyses of the soil up to the depth of 0.4 m did not indicate the acute deficiency of any nutrient necessary for the crops to complete their cultivation cycle fully. The soil analyses are presented in Table 1.

TABLE 1

pH H_2O	Ca	Mg	Al	H+Al	CEC	V	P	K	S.O.M
1-2.5	----------cmol$_c$ dm^{-3}----------					%	------mg dm^{-3}------		g kg^{-1}
----------0-0.2 m soil depth----------									
6.9	6.03	2.87	0	1.26	10.44	88	188	96	2.9
----------0.2-0.4 m soil depth----------									
6.8	5.70	2.78	0	1.08	9.77	89	158	82	2.3

B	Co	Cu	Fe	Mn	Mo	Si	Zn
----------mg dm^{-3}----------							
----------0-0.2 m soil depth----------							
0.19	1.7	9.0	14.0	1.9	2.9	12.4	12.8
----------0.2-0.4 m soil depth----------							
0.14	1.3	7.7	17.0	3.5	2.3	11.4	11.1

Despite the large soil clay proportion and high soil fertility, 3,000 kg ha^{-1} of soil remineralizer (rock powder) (FMX® Tratto. Aparecida from Goiânia, Brazil) was applied throughout the experimental area 200, 30 days before the soybean sowing 202a; 400 kg ha^{-1} of organomineral 6-30-05 (% of N, P_2O_5, K_2O) (Valoriza Agro Ltda. Patos de Minas, Brazil) and 150 kg ha^{-1} of KCl was applied at the time of sowing, and 2 L ha^{-1} of Mn was sprayed on the aerial parts of the soybean plants 202a, 40 days after the crop 202a seed germination.

The soybean cultivar 202a evaluated in this example was Desafio 8473 RSF (Brasmax® GDM. Cambé, Brazil), which is a soybean variety with indeterminate growth and 7.4 maturity group. Fourteen seeds per linear meter (280,000 plants per hectare) were sowed in lines spaced by 0.5 m; plants 202a were harvested approximately 4 months later. The soybean plants cultivated with no artificial light(s) supplementation were harvested first. The average daily air temperature during the experimental period ranged from 24 to 34 °C.

In the experimental area, insects, pests, plant diseases, and weeds were controlled with products registered for soybeans as indicated by the manufacturer. All areas were monitored before and after the first application, and the products were reapplied as needed. The management of crop plants 202a and water irrigation were similar between the areas that received the artificial light(s) supplementation and the control [area with no without artificial light(s) supplementation].

EXPERIMENTAL TREATMENTS AND RESEARCH

The central irrigation pivot 101 that was implemented with the artificial light(s) supplementation light source had ten spans and an irrigation radius of about 571 m. In the four internal spans of the referred irrigation pivot 101, which corresponds to an area of 33.5 ha, the artificial light source 10a, 10b, 10c, 10d, 10e was installed, but the six external spans of irrigation pivot 101, corresponding to an area of 69.5 ha, did not receive artificial light(s) supplementation (control). The main composition of the red-green-blue (RGB) light delivered to the soybean plants presented about 59% red, 33% green, and 8% blue. A continuous light band of approximately 40 m wide by 230 m long was projected below the arm extension of the four internal spans of the irrigation pivot 101.

Each light-emitting diode has a power ranging from 50 to 200 W. About 600 W h^{-1} ha^{-1} were consumed during the artificial light(s) supplementation process. The light-emitting diode module were positioned about 3 meters above the aerial parts of the crop 202a plants and distributed to ensure an equally distributed light power in each span of the circular pivot. The luminous flux per unit area at the level of the aerial parts of soybean 202a plants was about 30 lx.

The artificial light(s) supplementation system 100, according to the present invention, was turned on every night after the full sunset and on very cloudy days. Approximately 480 hours of artificial light(s) supplementation was applied throughout the area during the soybean crop 202a cycle. As irrigation pivot 101 completes a turnover the cultivation area 200 in 12.8 hours in a circular routine, each crop 202a plant received about 40 hours of artificial light(s) supplementation during its cycle. During the soybean cycle, foliar fertilizers containing micronutrients, such as boron and manganese, were applied throughout the area [with and without artificial light(s) supplementation] to compensate for the intense development of plants stimulated by artificial light(s) supplementation.

Artificial light(s) supplementation began in V3-V4 (third to fourth fully expanded trifoliated leaf) soybean phenological stage and ended in the R5-R6 soybean phenological stage (full grain stage). The choice of vegetative phenological stage V3-V4 for the beginning of artificial light(s) supplementation allows crop 202a to close the space between lines in the agricultural field 200 and begin cultivation area covering (a situation where the plant's growth is enough to shelter all exposed soil from an up-sight perspective). If artificial light(s) supplementation is applied before soybean plants cover the cropping area, weed plants start to compete for resources with crop

202a. The plant competition for resources such as water, nutrients, and light, impairs crop performance and yield and increases herbicide costs. In turn, the choice of the end of artificial light(s) supplementation in the reproductive phenological stage R5-R6 is due to the fact that at this stage, the soybean crop 202a reached its final development. However, it should be noted that artificial light(s) supplementation could continue after R5-R6 stage, favoring some extra crop 202a production; however, the benefits would not be higher than the energy costs related to artificial light(s) supplementation beyond this plant stage.

Between the first and second pivot span towers 103a; 103b, a homogeneous area of 50 by 40 m was delimited, corresponding to an area of 2,000 m^2 to be evaluated as the treatment “supplemented by artificial light(s)”. The schematization of irrigation pivot 101 according to the experiment can be seen in figure 4, in which the crop 202as under the green span of irrigation pivot 101 received artificial light(s) supplementation, while the rectangles indicate the position of both treatments, with and without artificial light(s) supplementation, and the dots in each rectangle indicate the sampling points.

SOYBEAN EVALUATIONS

The evaluations of plant internode number, plant height from the soil level to the highest node, and pods per plant 202a were assessed weekly from the R3 soybean phenological stage (beginning of the pod formation) to R7 (beginning of soybean maturity). During nine weeks, evaluations were performed weekly; no further evaluation was possible after R7 because the plants in the treatment without artificial light(s) supplementation reached physiological maturity earlier than the plants in the treatment of artificial light(s) supplementation.

In this sense, it is important to highlight the delay of physiological maturity induced by the treatment with artificial light(s) supplementation. This extension of the crop 202a cycle stimulated by artificial light supplementation depends on factors such as the crop 202a species, the geographic region of the cropping area, prevailing climate, crop phenological stage, period of suspension of artificial light(s) supplementation, and the crop management.

The soybean crop 202a, for example, extended its cycle between 5 and 20 days, depending on the cultivar, light management, and cropping region. However, this extension was not prominent in grass crops tested, such as corn, sorghum, and wheat, being only a few days longer than where artificial light(s) supplementation was

not applied. Avoiding any specific theory, this crop cycle extension as affected by artificial light(s) supplementation may be a consequence of a series of metabolic and morphological reactions, such as photomorphogenesis (morphological modification of the 202a culture stimulated by light, which could favor photosynthesis during the day), alteration of the crop 202a predominant photoperiod and crop 202a circadian cycle (modification of the crop 202a routine compared to the period of natural light), regulation of crop 202a secondary metabolism (regulation of natural defenses of crop 202a to stresses), and crop 202a phytochrome activities (photoresponsive substances and response modulators in culture 202a).

Amazingly, it was concluded that through these reactions or stimuli (and other possible causes or joint action of these responses) caused by artificial light(s) supplementation, as well as the correct management of soil and water resources, the crop 202a ends up producing more biomass through a more efficient photosynthesis process. Even after the study, it was observed that the plant stand (quantity of plants per area) could be reduced by about 20%, considering this greater amount of biomass produced (larger canopy and larger root systems). Overall, good productive results were observed, even with smaller stands, which reduces investment in seeds and their agrochemical treatment for sowing, in addition to increasing the sustainability of agricultural activity by producing more food using precise resources and technologies.

The mean measurement of each evaluated variable was estimated from a representative evaluation of the plants 202a in 10 sampling points in each area (2,000 m^2). Each sample point evaluated was considered a replication.

The influence of artificial light(s) supplementation or no artificial light(s) supplementation in each variable was evaluated using the area below the progression curve of each specific variable to interpret the results of the evaluations in various times. The area below the progression curve was calculated by trapezoidal integration area below the progression curve= (dti × ((Yi + Yi+d)/ 2))

Where *dti* is the time interval between every two observations, *Yi* and *Yi + d*. The area below the variable progression curve was calculated based on nine evaluations. Correlations between the area below the progression curve of the evaluated variables were computed to determine whether there was, or not, a linear relationship between them.

The agricultural areas used for each treatment (2,000 m^2) were harvested at 115 and 136 days after sowing without and with artificial light(s) supplementation,

respectively. Grain yield in each area was expressed in kilograms per hectare (kg ha^{-1}).

STATISTICAL ANALYSIS

Extreme values (outliers) in the area below the progression curve of each variable were identified using boxplot graphs of the data residuals. When outliers' values were identified, these were replaced by an average dataset value that does not include the outlier(s). The boxplots were generated in the Software SPSS Statistics®, which was also used to calculate Pearson's correlation coefficients and the basic premises for analysis of variance (ANOVA), normality of residue distribution by Shapiro-Wilk, and homogeneity of variances by Levene, both at $p > 0.01$.

Variance analysis (ANOVA, F test) was performed after confirmation of its assumptions and considering a completely randomized experimental design. When significant differences were observed ($p < 0.05$) in ANOVA, the area below the progression curve of the variables was compared using the Tukey test of averages ($p < 0.05$) to distinguish treatments with artificial light(s) supplementation and without artificial light(s) supplementation. The ANOVA and Tukey test were performed using SISVAR® statistical program. Sigma Plot® v.12 software was used to generate the graphics.

RESULTS

The weekly evaluation data of all variables (number of soybean internodes, plant height, and number of pods per soybean plant) for both treatments with artificial light(s) supplementation and without artificial light(s) supplementation did not include extreme values. This observation indicates that the responses were grouped around an average with low standard error. The soybean variables and their respective standard errors during the nine weeks are presented in Figures 5, 6, and 7, where the lines on the bars indicate the data standard error.

The number of internodes per soybean plant, plant height, and the number of pods per plant treated with artificial light(s) supplementation 202a were higher when compared to the sample without artificial light(s) supplementation 202b. These superior responses can also be observed in Figure 8, where on the left side are represented soybean plants treated with artificial light(s) supplementation 202a at 80 days after sowing, while on the right are represented soybean plants without artificial light(s) supplementation 202b. Each segment on the measuring tape illustrates 0.1 m.

The ANOVA of the area below the progression curve and the assumptions (normality and homogeneity) are presented in Table 2.

TABLE 2

SV	DF	Internodes	Height	Pods per plant
Light supplementation	1	375**	1,590**	2,649**
Error	18			
CV (%)		1.67	1.17	0.98
KS	20	0.935^{+}	0.985^{+}	0.964^{+}
L	1+18	1.139^{+}	0.106^{+}	0.262^{+}

Table 2. Analysis of variance (F test) and statistics of the ANOVA presumptions of the area below the progression curve of the variables number of soybean internodes, plant height, and the number of pods per soybean plant. ** significant differences at 0.01. CV (%) coefficient of variation. KS Kolmogorov-Smirnov statistics for normality of waste distribution ($p > 0.01$). L Levene statistics for homogeneity of data variances ($p > 0.01$). + normality of the residues (KS) or homogeneity of the variances (L) fulfilled.

All the area data below the progression curve of the soybean variables (number of internodes, plant height, and pods per plant) met the assumptions of ANOVA (normality of residue distribution and homogeneity of variances). In addition, the coefficients of variation, CV (%), were very low (< 2%). Thus, it was appropriate to proceed with ANOVA, which indicated significant differences ($p < 0.01$) between treatments [with artificial light(s) supplementation and without artificial light(s) supplementation].

The area below the progression curve of the number of internodes per soybean plant, plant height, and the number of pods per plant in the treatment with light(s) supplementation were 15.6, 23.3, and 25.3% higher than the treatment without artificial light(s) supplementation.

Pearson's calculation and interpretation of correlation require that data be normally distributed and without outliers. These requirements were met, as presented in Table 1. All correlations observed in Table 3 were strong ($r > 0.9$) and obtained statistical significance ($p < 0.01$).

TABLE 3

	Internodes	Plant height	Pods per plant
Internodes	1	0.962**	0.970**
Plant height		1	0.990**
Pods per plant			1

Table 3. Pearson correlation (r) between the area below the progression curve of the variables studied. Internodes number of soybean internodes; Plant height soybean plant height; Pods per plant number of pods per soybean plant. ** significant differences at 0.01.

The evaluated soybean cultivar has a cycle of approximately 17 weeks. On day 115 after sowing, soybean plants from the area without artificial light(s) supplementation 202b (2,000 m^2) were harvested; however, the harvest of soybean plants in the area with artificial light(s) supplementation occurred three weeks later, representing a 17.6% longer crop 202a cycle.

The estimated productivity of the area without artificial light(s) supplementation was about 4,500 kg ha^{-1} (75 bags ha^{-1}; 1 bag = 60 kg), while treatment with artificial light(s) supplementation was about 7,080 kg ha^{-1} (118 bags ha^{-1}). Grain yield under artificial light(s) supplementation was 57.3% higher and 109.5% above the average Brazilian soybean yield (3,379 kg ha^{-1}).

The average cost to produce soybean from soil management to harvesting is about 55 bags of soybean per hectare. The average cost required by artificial light(s) supplementation was about 7 bags ha^{-1}. Thus, the profitability of soybean traditionally produced (without artificial light(s) supplementation) and soybean produced with artificial light(s) supplementation was about 20 and 56 bags ha^{-1}, respectively.

The extension of the soybean crop 202a cycle by three weeks due to artificial light(s) supplementation also increased the period of plant 202a photosynthetic activity. This prolonged cycle also contributes to increasing biomass accumulation via natural daily photosynthesis, an absent process in the regular soybean cultivar cycle (17 weeks) where no artificial light(s) supplementation 202b was applied. This combination of factors resulted in taller soybean plants, with more internodes, more pods, and, consequently, more than 57% extra grain yield.

In the exposed example, the extra yield generated by the application of adequate crop management and artificial light(s) supplementation cannot be attributed only to the hours of artificial light(s) supplementation provided to each soybean crop

202a (about 40 hours). As mentioned above, in addition to the extension of the soybean cycle through artificial light(s) supplementation, other factors should be taken into account, such as photomorphogenesis, alteration of the plant photoperiod and circadian cycle of culture 202a, upper or lower regulation of phytohormones and phytochromes, as well as changes in secondary metabolism of the crop 202a plant, which are factors responsive to artificial light(s) supplementation.

Agricultural inputs such as fertilizers, plant inoculants, and plant protection products, applied during crop 202a cycle 202b, are intended to maximize agricultural production and economic returns. Although such agricultural inputs have adverse effects on soil dynamics and these effects are often overlooked. However, according to the present invention, artificial light(s) supplementation 200 to field crops can potentially reduce the proportional need for such inputs, mainly fertilizers.

The efficiency of fertilization in this exemplified study probably resulted from a significant increase in shoot biomass followed by artificial light(s) supplementation. The increase in the biomass of the shoots, in turn, causes a proportional increase in the biomass of the roots. This improved root development increases the efficiency of absorption of nutrients by the roots, thus increasing fertilizer efficiency.

The present invention is used as a response model to reproducibly understand and apply the consequences and interactions of nutritional, microbiological, environmental, and economic aspects around agricultural production by integrating valuable information on physiological processes, sowing time, irrigation frequency, and time, fertilizer doses, management of insects and plant diseases, and soil relations with the environment. The inclusion of climate information may clarify the relationship between agricultural production and weather fluctuations. This integrated approach increases the resilience of the global food production system and food security against unexpected climate shocks.

Currently, there is a rapid continuous increase in the integration of technologies and digitization in agriculture. This movement is also aligned with the sustainability of the ecosystems explored for agricultural activities. In this sense, before starting cropping, other factors must be considered for a productive and sustainable agricultural activity. Such other factors include crop management strategies and their consequences, the level of technologies implemented, and soil water and nutrient

availability. Although the use of artificial light(s) supplementation on a field scale 200 is a challenge to control, the present invention makes it possible.

The present invention also has great potential to reduce deforestation of new native areas for agricultural production purposes since more food can be produced in the same agricultural area. Although crop 202a productivity can be increased with adequate implementation of artificial light(s) supplementation throughout the crop 202a cycle, the *state of the art* does not reveal the interactions between the different factors. For example, soil, plant, climate, agronomic management, crop 202a performance, yield formation, and cost-benefit ratio indicate its inherent complexity. In addition, the present invention has the potential to reduce the use of agrochemicals, fertilizers, and water since the plant becomes more efficient in soil exploration through an improved root system stimulated by artificial light(s) supplementation and other technologies implemented.

According to the present invention, the production costs of crops 202a cultivated by the artificial light(s) supplementation system 100 depend on several factors. These factors include the efficiency of the available cropping structure, for example, machinery and farm administration; the technology implemented, for example, genetic materials and fertilizers; and the use of precise agricultural systems. Other factors include the characteristics of the irrigation system, for example, the irrigated area and the height of the irrigation pivot 101 that affects light dissipation, artificial light(s) supplementation in areas of static irrigation, soil structuring, for example without physical or chemical limitation, and with healthy microbiota; electricity supply, for example, source, spinning, constancy, and stability, in addition to the internet of things and agronomic management of agricultural crops 202a. Thus, the cost and profitability in this example reflect a specific scenario of soybean production that may vary on a case-by-case basis. Despite this observation, according to the present invention, artificial light(s) supplementation presents an opportunity to improve crop 202a production.

In conclusion, in the exemplified study, the present invention was implemented and delivered approximately 40 hours of artificial light(s) supplementation to each soybean plant were required during the crop 202a cycle to positively affect the number of internodes, pods, plant height, and crop 202a cycle.

Artificial light(s) supplementation, according to the present invention, increased soybean yield by 57.3% and its profitability by 180% in relation to cultivation

processes without artificial light(s) supplementation and proved to be a viable and promising technique to improve sustainably of crop production in the same agricultural field.

Due to the youth of *outdoor* artificial light(s) supplementation technology and due to its success being associated with its application integrated with technically adequate and balanced agriculture, preliminary studies were conducted for other crops besides soybeans (*Glycine max*). However, the results obtained have been positive for biomass production by plants were light(s) supplementation was(were) present. The responses observed for other crops and perceptions of the application of artificial light(s) supplementation integrated with appropriate agronomic technologies and management will be briefly discussed below.

Beans (*Phaseolus Vulgaris*)

The common bean was cultivated in the winter crop season and received artificial light(s) supplementation from post-sowing until pre-harvest. Soil remineralizers and biological products were applied before sowing. The plant stand was reduced by 15% compared to the regular stand recommendation for traditional crop cultivation without artificial light(s) supplementation.

A lower number of fungicide applications and 36% more grain yield were observed in the area that received artificial light(s) supplementation. Other studies with beans were conducted in different regions and confirmed the positive response of this crop when artificial light(s) supplementation is applied according to the present invention.

Corn (*Zea Mays*)

Corn was grown in spring/summer and received artificial light(s) supplementation from post-sowing until pre-harvest, as well as soil remineralizers, organominerals, and biological products that were applied to the soil before sowing. In this study, the plant stand (plant number per hectare) was 60% higher than the stand regularly used in traditional cultivation without artificial light(s) supplementation.

Differences were observed among the studied varieties (hybrids), such as plants generally higher (> 4 m), higher average ear number per plant, and greater crop health. Healthier plants in the area that received artificial light(s) supplementation allowed crop cultivation with fewer fungicide applications. Grain yield was 183% higher than the regional grain yield average for the same year.

Tomato (*Solanum Lycopersicum*)

Different varieties of tomato for pulp were evaluated, and the area that received artificial light(s) supplementation presented plants with superior development of the aerial plant part compared to the area without artificial light(s) supplementation. This further development of the aerial part allowed the early plant cover of the space between planting lines and doubled the production of tomato fruits.

Only the area that did not receive artificial light(s) supplementation had problems with calcium deficiency, causing the "*blossom end rot*" symptom in the fruits. In the area that received artificial light(s) supplementation, no such stress was observed that would impair the development of the plants and their respective productions.

Both areas received soil remineralizers and foliar nutrients. Artificial light(s) supplementation occurred throughout the crop cycle in the respective area, and the light color combination used in soybean (59% red, 33% green, and 8% blue) showed excellent results in tomato plant development.

COTTON (*GOSSYPIUM HIRSUTUM*)

Cotton was tested in different regions and different varieties. As observed for the other crops, the aerial part of the cotton plants that received the artificial light(s) supplementation project was significantly higher than the plants that did not receive artificial light(s) supplementation.

The cotton tree that received the artificial light(s) supplementation project produced 20 to 40% more "apples" (structure containing the plume, the cotton fiber) per plant and about 12% more final fiber production. The artificial light(s) supplementation positively impacted the final production and quality of the cotton fiber. The presence of insects in the area that received artificial light(s) supplementation was reduced compared to traditional cotton cultivation without artificial light(s) supplementation.

SUGARCANE (*SACCHARUM OFFICINARUM*)

Artificial light(s) supplementation in sugarcane has brought many beneficial effects. The area received the application of soil remineralizer and was cultivated without any fungicide application. Initially, sugarcane with artificial light(s) supplementation showed a higher number of tillers (seedlings) per clump, which increased the production of crop biomass.

Stem height, total soluble solids content, apparent sucrose, and recovered total sugars were higher in sugarcanes grown with artificial light(s)

supplementation. The “*brown spot*” was a foliar fungal disease that occurred only in the area that did not receive artificial light(s) supplementation, indicating how the present invention promotes not only increases in yield, but also increases the plant resistance to stresses and reduces the cost and environmental impacts with lower frequencies of fungicide application.

TOBACCO (*NICOTIANA TABACUM*)

More vigorous tobacco plants, larger leaves, and higher leaf production were commonly observed in the area that received artificial light(s) supplementation. The tobacco cropping area received the application of soil remineralizer and was cultivated without any application of insecticide or fungicide. Light supplementation with the predominance of blue collors favored the development of tobacco plants.

GARLIC (*ALLIUM SATIVUM*) AND ONION (*ALLIUM CEPA*)

Areas that received the application of soil remineralizer and organominerals were cultivated without any insecticide application and with a reduced amount of fungicide applications. The yields were higher than 80% in the areas that received artificial light(s) supplementation all night during specific periods, both for garlic and onion.

The application of foliar fertilizers was similar between the areas [with or without light(s) supplementation]; however, the excellent plant development caused by artificial light(s) supplementation turned the plant more sensitive to the lack of essential nutrients, especially those required in smaller amounts (micronutrients).

PEA (*PISUM SATIVUM*)

Pea is a crop that responds satisfactorily well to artificial light(s) supplementation. Depending on its application (grain production or cover crop), it should be changed the color composition of artificial light(s) supplementation.

The high pea biomass production, which increased the crop residues added to the soil surface, was produced with a predominance of blue coloration in the artificial light(s) supplementation; however, for exclusive grain production, the composition of artificial light(s) supplementation in soybean (59% red, 33% green and 8% blue) was more adequate.

SUNFLOWER (*HELIANTHUS ANNUUS*)

Artificial light(s) supplementation increased the size of the sunflowers, increasing the production of larger seeds with improved quality parameters such as

size and integrity. Sunflower areas cultivated with artificial light(s) supplementation showed high vegetative-productive development and plant sanity.

In areas where artificial light(s) supplementation was applied, insecticides or fungicides were not applied to the crop plants. The production of sunflower seeds was 44% higher in the area that received the artificial light(s) supplementation compared to the traditional cultivation area without artificial light(s) supplementation.

POTATO (*SOLANUM TUBEROSUM*)

Different varieties and planting stands were studied for potatoes that received artificial light(s) supplementation. Artificial light(s) supplementation in this crop can be used from emergence until about ten days before harvest desiccation. The production occurred with lower use of fungicides compared to the area without artificial light(s) supplementation and the commercial cropping area adjacent to the experimental area 200.

There was a large production of root tubers, and production was about 38% higher than in traditional cultivation without artificial light(s) supplementation. Soil and organomineral remineralizers were used in both areas to complement the basic fertilization and support higher root tuber productions.

HOPS (*HUMULUS LUPULUS*)

The artificial light(s) supplementation applied to hop plants generated promising results. It was possible to develop and harvest the second crop of hops in the same agricultural year, which was not observed in the area without artificial light(s) supplementation. The number of floral cones (structures used as raw material for beer) was much higher, and their dimensions were larger in plants that received artificial light(s) supplementation.

The beer produced using the hops produced with artificial light(s) supplementation did not present any harm in relation to traditional cultivation. Therefore, artificial light(s) supplementation allowed more than doubling the productive capacity of hops in an area, besides not negatively affecting beer production and quality.

STRAWBERRY (*FRAGARIA × ANANASSA*)

Production, fruit sanity, and shelf time were superior for strawberries produced with artificial light(s) supplementation applied throughout the crop cycle. Some strawberry varieties respond better to artificial light(s) supplementation. In

general, reddish artificial light(s) supplementation provides better results in fruit production and seedlings of plant development.

PITAYA (*HYLOCEREUS UNDATUS*)

The number of crops and fruits was positively affected by artificial light(s) supplementation. The harvests became continuous with adequate crop management and artificial light(s) supplementation. About 4 to 6 hours of artificial light(s) supplementation per night were enough to maintain this fruit harvest constancy and increase the number of fruits per plant. With increased harvests per year and fruits per plant, the required amounts of fertilizers, soil pH correctors and conditioners, soil remineralizers, and organominerals were necessary to support the production.

This situation of great fertilizer need to compensate for a higher total production is further indication that the full functioning of artificial light(s) supplementation, according to the present invention, is dependent on other factors that need to be available so that plant responses are not limited by factors whose deficiency may compromise crop full development and yield.

LETTUCE (*LACTUCA SATIVA*) AND ARUGULA (*ERUCA VESICARIA SSP. SATIVA*)

All experiments with horticultural crops with artificial light(s) supplementation showed more accelerated plant development from seedlings to adult plants, allowing for more year-round harvests. In addition, they presented more intense colors and more pleasant flavors.

The use of more bluish artificial light(s) supplementation allowed better results; however, there are significant differences in responses between the varieties studied in each plant species. This observation indicates that each region should be studied for adequate crop varieties to select those with better responses to artificial light(s) supplementation.

COVER CROPS

Different cover crops were responsive to artificial light(s) supplementation, and all responses were positive. The higher the plant biomass (e.g., leaves, stems, and roots) growth, the faster the covering of the cropping area, which improves soil protection and reduces crop competition with invasive plants (weeds). The cropping of solitary crop species (only one predominant species) or mixtures of different species presented improved results under artificial light(s) supplementation.

The use of more bluish artificial light(s) supplementation also allowed better results. However, it was clear how each cover crop (such as Sudan grass, fodder

turnip, millet, crotalaria, wheat, and buckwheat) in different regions presented differentiated responses to the same spectral signature of artificial light(s) supplementation, indicating that different crop species would have distinct and unique spectral band composition for each plant species and edaphoclimatic condition.

The achievements exposed above indicated that the present invention accomplishes significant advances in the application and development of artificial light(s) supplementation, highlighting the beneficial effects of the use of artificial lighting sources 10a, 10b, 10c, 10d, 10e in the metabolism and agronomic management of plants, in the efficiency of light absorption and photosynthesis in their respective aerial parts, as well as in the mitigation of stresses such as insect pests and plant pathogens that can be repelled or controlled in the areas that receive a light(s) supplementation. These effects benefit the agricultural production process by extending the plant resistance to adverse conditions during crop development, improving qualitative and nutritional aspects of the final crop product, and elevating the sustainability of the agricultural activity.

Despite the description of crop yield achievements to specific accomplishments, the present invention may present modifications in its implementation so that the scope of protection of the invention is limited to the content of the attached claims, including possible equivalent variations.

SET OFCLAIMS

1. AGRICULTURAL MANAGEMENT SYSTEM (100) is characterized by comprising:

- a modular agricultural irrigation pivot-like device (101) positioned on an agricultural field (200) in the cultivation of a crop (202a) species, the modular agricultural irrigation pivot-like device (101) comprising:

- a plurality of artificial lighting sources (10a, 10b, 10c, 10d, 10e) arranged along the modular agricultural irrigation pivot-like device (101) at a predetermined distance above the aerial parts of the crop (202a), comprising a plurality of light-emitting diodes; and

- a plurality of energy sources that feed the plurality of artificial lighting sources (10a, 10b, 10c, 10d, 10e),

the agricultural management system (100) further comprising:

a processor in communication with a dimerizer and/or a polarizer of the plurality of artificial lighting sources (10a, 10b, 10c, 10d, 10e) and with the plurality of energy sources, wherein the processor is configured to:

a) adjust (501), in the intervals of the electromagnetic spectrum, the balance between the spectral bands emitted by the plurality of light-emitting diodes; and

b) determine and implement:

- an irrigation routine (502); and/or

- an artificial light(s) supplementation routine (503);

wherein stages a) and b) are determined by the processor considering at least one among:

- a crop (202a) species under cultivation;

- a phenological stage of the crop (202a) under cultivation;

- a photoperiod, a season and current weather conditions under which the agricultural field (200) is subjected; and

- one or more objective(s) intended for the crop (202a) development.

2. SYSTEM (100), according to claim 1, characterized in that stages a) and b) determined by the processor using an artificial intelligence model.

3. SYSTEM (100), according to any of claims 1 and 2, characterized in that the modular agricultural irrigation pivot-like device (101) comprises:

- a drive device for the displacement of the modular agricultural irrigation device (101) over the agricultural field (200); and

- sprinkler devices comprising a plurality of sprinklers,

wherein the processor is in communication with the drive device and with the sprinkler device for the execution of stage b).

4. SYSTEM (100), according to any of claims 1 to 3, characterized by in that a plurality of soil sensors under the agricultural field (200) captures nutritional data of the soil of the agricultural field (200).

5. SYSTEM (100), according to claim 4, characterized in that the processor using all data available from the agricultural field (200):

c) determines and suggests the routines for crop and artificial light(s) supplementation management.

6. SYSTEM (100), according to claim 5, characterized in that stage c) determined by the processor using the artificial intelligence model, considers one of the following:

- the irrigation routine (502);

- the routine of artificial light(s) supplementation (503);

- the crop (202a) species under cultivation;

- the phenological stage of the crop (202a) under cultivation;

- the photoperiod responses, the season and the current weather conditions under which the agricultural field (200) is subjected; and

- the one or more objective(s) intended for the crop (202a) development.

7. SYSTEM (100), according to any of claims 1 to 6, characterized in that the one or more objectives intended for the crop (202a) development under cultivation is/are:

- stimulating or inhibiting a production of leaves, branches, and roots;

- stimulating or inhibiting a production of grains, fibers, fruits, and essences

- stimulating or inhibiting vegetative growth; and

- stimulating photosynthesis.

8. SYSTEM (100), according to any of the claims 1 to 7, characterized in that the routine of artificial light(s) supplementation (503), majorly occurs, but not exclusively, between phenological stages V3-V4 to R5-R6 of the crop (202a) under cultivation.

9. SYSTEM (100), according to any of claims 7 to 8, characterized in that the balance between spectral bands being adjusted (501) to understand compositions of red-green-blue spectral bands presenting at least 40% blue color for vegetative phenological stages and about 60% or at least 40% red color for the reproductive phenological stage of the crop 202a under cultivation, more than 40% red color in the artificial light(s) supplementation is recommended for any plant phenological stage.

10. SYSTEM (100), according to any of the claims 1 to 9, characterized in that the processor further considers:

- the geolocation of the agricultural field (200) and climatic indicators for the determination of agricultural zoning of climatic risk (ZARC) to suggest a crop (202a) to be cultivated, if regional information regarding the most adapted crop varieties is unavailable.

11. SYSTEM (100), according to any of claims 5 to 10, characterized in that an user interface is in communication with the processor, wherein an user feeds the following information to the processor:

- history of crops previously cultivated in the agricultural field (200);

- history of agricultural inputs used in the agricultural field (200);

- occurrence of stresses during the crop (202a) cycle, such as at least one of the following: the occurrence of phytopathology; the occurrence of pests and the occurrence of weeds;

- productivity results from previous harvests; and

- characteristics of the modular agricultural irrigation device (101), among irrigated area, irrigation flow, pivot working speed and height of the agricultural irrigation modular device (101);

wherein stages a), b) and c) are determined by the processor using the artificial intelligence model, considering at least one of the following:

- the crop (202a) species under cultivation;

- the phenological stage of the crop (202a) under cultivation;

- the photoperiod, the season and the current weather conditions under which the agricultural field (200) is subjected;

- the one or more objective(s) for crop (202a) development and responses; and

- the user-fed information through the user interface.

12. SYSTEM (100), according to claim 11, characterized in that the processor using information on the height of the modular agricultural irrigation device (101) to adjust (501) the illumination emitted by the LEDs as a function of the distance of the plurality of artificial lighting sources (10a, 10b, 10c, 10d, 10e) for the crop (202a) under cultivation.

13. SYSTEM (100), according to claims 1 to 12, characterized in that the plurality of energy sources being a plurality of photovoltaic and wind cells for energy production to support the energy needed for the artificial light(s) supplementation working during nights (majorly).

14. SYSTEM (100), according to claim 13, characterized in that the processor, in communication with a plurality of photosensor cells, determines a threshold of incidence of sunlight in the photovoltaic cells, for which below this, and depending on a certain routine of artificial light(s) supplementation (503), a processor commands the performance of the plurality of light-emitting diodes.

15. SYSTEM (100), according to any of claims 1 to 12, characterized in that the plurality of energy sources being at least one of the following: wind, thermal, or combustion generators.

16. SYSTEM (100), according to claim 15, characterized in that the processor using information of insolation index and cloudiness to determine a threshold of incidence of sunlight in the agricultural field (200) for which below this, and depending on a certain routine of artificial light(s) supplementation (503), the processor commands the performance of the plurality of light-emitting diodes.

17. SYSTEM (100), according to any of claims 1 to 16, characterized in that the crop under cultivation being at least one of: soybean, beans, corn, tomato, carrot, cotton, sugar cane, tobacco, garlic, onion, pea, sunflower, sorghum, potato, hops, strawberry, pitaya, lettuce, arugula, oats, coffee, and soil cover crops and grasses.

18. AGRICULTURAL MANAGEMENT METHOD (500), for the cultivation of a crop (202a) in an agricultural field (200), characterized by comprising the steps of:

a) adjusting (501), in intervals of the electromagnetic spectrum, the balance between the spectral bands emitted by a plurality of light-emitting diodes of a plurality of artificial lighting sources (10a, 10b, 10c, 10d, 10e); and

b) determining and implementing:

- an irrigation routine (502) of a modular agricultural irrigation device (101); and/or

- a routine of artificial light(s) supplementation (503) of the plurality of artificial lighting sources (10a, 10b, 10c, 10d, 10e);

wherein stages a) and b) are determined considering at least one among:

- a crop (202a) species under cultivation;

- a phenological stage of the crop (202a) under cultivation;

- a season, a photoperiod, and current weather conditions under which the agricultural field (200) is subjected; and

- one or more objective(s) intended for the crop (202) development.

19. METHOD (500), according to claim 18, characterized in that stages a) and b) are determined by the processor using an artificial intelligence model.

20. METHOD (500), according to any of the claims 18 to 19, is characterized by further comprising a stage c) of determining a routine of soil management in the agricultural field (200) based on soil analyses from the agricultural field (200).

21. METHOD (500), according to claim 20, characterized in that stage c) of determining through the artificial intelligence model considers at least one of the following:

- the irrigation routine (502);

- the routine of artificial light(s) supplementation (503);

- the crop (202a) species under cultivation;

- the phenological stage of the crop (202a) under cultivation;

- the photoperiod, the season and the current weather conditions under which the agricultural field (200) is subjected; and

- the one or more objective(s) intended for the crop (202a) development.

22. METHOD (500), according to any of the claims 18 to 21, characterized in that the one or more objectives intended for the crop (202a) development to:

- stimulate or inhibit the production of leaves, branches, and roots;

- stimulate or inhibit the production of grains, fibers, fruits, and essences - stimulate or inhibit vegetative growth; and - stimulate photosynthesis.

23. METHOD (500), according to any of the claims 18 to 22, characterized in that the routine of artificial light(s) supplementation (503) that majorly,

but not always, occurs between phenological stages V3-V4 to R5-R6 of the crop (202a) under cultivation.

24. METHOD (500), according to any of the claims 22 to 23, characterized in that the balance between the spectral bands being adjusted (501) to understand compositions of red-green-blue spectral bands that should present at least 40% blue color for vegetative phenological stages and about 60% or at least 40% red color for the reproductive phenological stage of the crop 202a under cultivation, more than 40% red color in the artificial light(s) supplementation is recommended for any plant phenological stage.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/292,837		Gustavo Alexandre GROSSI	092210-786599	1124

30678 7590 02/29/2024
POLSINELLI PC
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EXAMINER	

ART UNIT	PAPER NUMBER

NOTIFICATION DATE	DELIVERY MODE
02/29/2024	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

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Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

patentdocketing@polsinelli.com

PTOL-90A (Rev. 04/07)

Commissioner for Patents
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450
www.uspto.gov

In re Application of	:	
FIENILE AGRONEGÃ“ CIOS LTDA	:	
Application No. 18/292,837	:	DECISION ON PETITION
Filed: 26 January 2024	:	
For: SYSTEM AND METHOD OF	:	
AGRICULTURAL MANAGEMENT	:	

This is a decision on the request to participate in the Patent Prosecution Highway (PPH) program and the petition under 37 CFR 1.102(a), filed 26 January 2024, to make the above-identified application special.

There is no indication that the petition is signed by a registered patent attorney or patent agent of record. However, in accordance with 37 CFR 1.34, the signature of R. James Balls appearing on the correspondence shall constitute a representation to the United States Patent and Trademark Office that he/she is authorized to represent the particular party in whose behalf he/she acts.

The request and petition under 37 CFR 1.102(a) are **GRANTED**.

DISCUSSION

A grantable request to participate in the PPH pilot program and petition to make special require:

1. The U.S. application for which participation in the Global/IP5 PPH pilot program is requested must have the same earliest date, whether this is the priority date or filing date, as that of a corresponding national or regional application filed with another Global/IP5 PPH participating office or a corresponding PCT international application for which one of the Global/IP5 PPH participating offices was the International Searching Authority (ISA) or the International Preliminary Examining Authority (IPEA);

2. Applicant must:
   a. Ensure all the claims in the U.S. application must sufficiently correspond or be amended to sufficiently correspond to the allowable/patentable claim(s) in the corresponding Office of Earlier Examination (OEE) application and
   b. Submit a claims correspondence table in English;

3. Examination on the merits of the U.S. application has not begun;

4. Applicant must submit:
   a. Documentation of prior office action:
      i. a copy of the office action(s) just prior to the "Decision to Grant a Patent" from each of the Global/IP5 PPH participating office application(s) containing the allowable/patentable claim(s) or
      ii. if the allowable/patentable claims(s) are from a "Notification of Reasons for Refusal" then the Notification of Reasons for Refusal or
      iii. if the Global/IP5 PPH participating office application is a first action allowance then no office action from the Global/IP5 PPH participating office is necessary should be indicated on the request/petition form or
      iv. the latest work product in the international phase of the OEE PCT application;
   b. An English language translation of the Global/IP5 PPH participating office action or work product from (4)(a)(i)-(ii) or (iv) above; and

5. Applicant must submit:
   a. An IDS listing the documents cited by the Global/IP5 PPH participating office examiner in the Global/IP5 PPH participating office action or work product (unless already submitted in this application) and
   b. Copies of the documents except U.S. patents or U.S. patent application publications (unless already submitted in this application).

The request to participate in the PPH pilot program and petition comply with the above requirements. Accordingly, the above-identified application has been accorded "special" status.

Telephone inquiries concerning this decision should be directed to the undersigned whose telephone number is (571) 272-7141.

All other inquiries concerning the examination or status of the application are accessible in the PAIR system at http://portal.uspto.gov/.

/LASHAWN MARKS/
Paralegal Specialist, OPET

PATENT ASSIGNMENT COVER SHEET

Electronic Version v1.1
Stylesheet Version v1.2

Assignment ID: PATI81818

SUBMISSION TYPE:	NEW ASSIGNMENT
NATURE OF CONVEYANCE:	ASSIGNMENT

CONVEYING PARTY DATA

Name	Execution Date
Gustavo Alexandre GROSSI	03/01/2024

RECEIVING PARTY DATA

Company Name:	FIENILE AGRONEGÓCIOS LTDA
Street Address:	Praça Dom Eduardo, nº 255 - sala 01
City:	Centro – Patos de Minas – MG
State/Country:	BRAZIL
Postal Code:	38700-124

PROPERTY NUMBERS Total: 1

Property Type	Number
Application Number:	18292837

CORRESPONDENCE DATA

Fax Number: 2027833535

Correspondence will be sent to the e-mail address first; if that is unsuccessful, it will be sent using a fax number, if provided; if that is unsuccessful, it will be sent via US Mail.

Phone: 2027833300
Email: PatentDocketing@Polsinelli.com,cpaun@polsinelli.com
Correspondent Name: Mr. R. James Balls Balls
Address Line 1: POLSINELLI PC
Address Line 2: PO Box 140310
Address Line 4: KANSAS CITY, MISSOURI 64114-0310

ATTORNEY DOCKET NUMBER:	092210-786599
NAME OF SUBMITTER:	Catalina Paun
SIGNATURE:	Catalina Paun
DATE SIGNED:	03/08/2024
	This document serves as an Oath/Declaration (37 CFR 1.63).

Total Attachments: 3
source=Assignment#page1.tif
source=Assignment#page2.tif
source=Assignment#page3.tif

COMBINED ASSIGNMENT & DECLARATION
FOR UTILITY OR DESIGN PATENT APPLICATIONS

ASSIGNMENT

THIS ASSIGNMENT, made by **Gustavo Alexandre GROSSI**, residing at Fazenda São Matheus - Bairro Zona Rural – Monte Carmelo – MG, 38500-000, BR; (hereinafter referred to as Assignors);

WHEREAS, Assignors have invented certain new and useful improvements in SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT, set forth in a Patent application for Letters Patent of the United States, filed on January 26, 2024, as Application No. 18/292,837, and

WHEREAS, FIENILE AGRONEGÓCIOS LTDA, a corporation organized under and pursuant to the laws of Brazil having its principal place of business at Praça Dom Eduardo, n° 255 - sala 01, Centro – Patos de Minas – MG, 38700-124, Brazil, (hereinafter referred to as Assignee), is desirous of acquiring the entire right, title and interest in and to said inventions and said Application for Letters Patent of the United States, and in and to any Letters Patent of the United States to be obtained therefore and thereon.

NOW, THEREFORE, in consideration of One Dollar ($1.00) and other good and sufficient consideration, the receipt of which is hereby acknowledged, Assignors have sold, assigned, transferred and set over, and by these presents do sell, assign, transfer and set over, unto Assignee, its successors, legal representatives and assigns, the entire right, title and interest in and to the above-mentioned inventions and application for Letters Patent, and in and to any and all direct and indirect divisions, continuations and continuations-in-part of said application, and any and all Letters Patent in the United States and all foreign countries which may be granted therefore and thereon, and reissues, reexaminations and extensions of said Letters Patent, and all rights under the International Convention for the Protection of Industrial Property, the same to be held and enjoyed by Assignee, for its own use and benefit and the use and benefit of its successors, legal representatives and assigns, to the full end of the term or terms for which Letters Patent may be granted and/or extended, as fully and entirely as the same would have been held and enjoyed by Assignors, had this sale and assignment not been made.

02/03/2024

AND for the same consideration, Assignors hereby represent and warrant to Assignee, its successors, legal representatives and assigns, that, at the time of execution and delivery of these presents, except for any rights, titles and/or interests that have arisen to Assignee under law or that have already been transferred to Assignee, Assignors are the sole and lawful owners of the entire right, title and interest in and to the said inventions and application for Letters Patent above-mentioned, and that the same are unencumbered and that Assignors have good and full right and lawful authority to sell and convey the same in the manner herein set forth.

AND for the same consideration, Assignors hereby covenant and agree to and with Assignee, its successors, legal representatives and assigns, that Assignors will sign all papers and documents, take all lawful oaths and do all acts necessary or required to be done for the procurement, maintenance, enforcement and defense of any Letters Patent and applications for Letters Patent for said inventions, without charge to Assignee, its successors, legal representatives and assigns, whenever counsel of Assignee, or counsel of its successors, legal representatives and assigns, shall advise: that any proceeding in connection with said inventions, or said Patent application for Letters Patent, or any proceeding in connection with any Letters Patent or applications for Letters Patent for said inventions in any country, including but not limited to interference proceedings, is lawful and desirable; or, that any division, continuation or continuation-in-part of any application for Letters Patent, or any reissue, reexamination or extension of any Letters Patent, to be obtained thereon, is lawful and desirable.

AND Assignors hereby request the Commissioner for Patents and Trademarks to issue said Letters Patent of the United States to Assignee, as Assignee of said inventions and the Letters Patent to be issued thereon, for the sole use and benefit of Assignee, its successors, legal representatives and assigns.

AND Assignors acknowledge an obligation of assignment of this invention to Assignee at the time the invention was made.

01/03/2024

DECLARATION

As a below named inventor, I hereby declare that:

This declaration is directed to the patent application entitled:

SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT

the specification of which was filed on January 26, 2024, as Application No. 18/292,837.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I have reviewed and understand the contents of the above-identified application.

I am aware of the duty to disclose to the Office all information known to me to be material to patentability as defined in 37 C.F.R. 1.56.

I hereby acknowledge that any willful false statement made in this Declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

In the event that the filing date and/or Application No. are not entered above at the time I execute this document, and if such information is deemed necessary, I hereby authorize and request the attorneys/agent(s) at POLSINELLI PC, 1401 Eye Street, N.W., Suite 800, Washington, DC 20005, to insert the filing date and/ or Application No. of said application into this document.

Date: 01/03/2024 Signature: ____________________

Gustavo Alexandre GROSSI

UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
18/292,837	**03/08/2024 03:53:49 PM Z ET**	**092210-786599**

Title of Invention

SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT

Application Information

APPLICATION TYPE	Utility - U.S. National Stage under 35 USC 371	PATENT #	-
CONFIRMATION #	1124	FILED BY	Catalina Paun
PATENT CENTER #	64613224	FILING DATE	-
CUSTOMER #	30678	FIRST NAMED INVENTOR	Gustavo Alexandre GROSSI
INTL. APPLICATION #	-	INTL. FILING DATE	-
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	Robert Balls

Documents

TOTAL DOCUMENTS: 1

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
Declaration.pdf	3	Oath or Declaration filed	6459 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
Declaration.pdf	609E0040251EC7896FF61EC8B409DE14F2A9E2D1D65C76379 5ACA03B5A3E4638513581359D568326C4CC92C45C34A1DFF DCDFFE11130D5D61CAB54F2CB2B1DD4

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

COMBINED ASSIGNMENT & DECLARATION
FOR UTILITY OR DESIGN PATENT APPLICATIONS

ASSIGNMENT

THIS ASSIGNMENT, made by **Gustavo Alexandre GROSSI**, residing at Fazenda São Matheus - Bairro Zona Rural – Monte Carmelo – MG, 38500-000, BR; (hereinafter referred to as Assignors);

WHEREAS, Assignors have invented certain new and useful improvements in SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT, set forth in a Patent application for Letters Patent of the United States, filed on January 26, 2024, as Application No. 18/292,837, and

WHEREAS, FIENILE AGRONEGÓCIOS LTDA, a corporation organized under and pursuant to the laws of Brazil having its principal place of business at Praça Dom Eduardo, nº 255 - sala 01, Centro – Patos de Minas – MG, 38700-124, Brazil, (hereinafter referred to as Assignee), is desirous of acquiring the entire right, title and interest in and to said inventions and said Application for Letters Patent of the United States, and in and to any Letters Patent of the United States to be obtained therefore and thereon.

NOW, THEREFORE, in consideration of One Dollar ($1.00) and other good and sufficient consideration, the receipt of which is hereby acknowledged, Assignors have sold, assigned, transferred and set over, and by these presents do sell, assign, transfer and set over, unto Assignee, its successors, legal representatives and assigns, the entire right, title and interest in and to the above-mentioned inventions and application for Letters Patent, and in and to any and all direct and indirect divisions, continuations and continuations-in-part of said application, and any and all Letters Patent in the United States and all foreign countries which may be granted therefore and thereon, and reissues, reexaminations and extensions of said Letters Patent, and all rights under the International Convention for the Protection of Industrial Property, the same to be held and enjoyed by Assignee, for its own use and benefit and the use and benefit of its successors, legal representatives and assigns, to the full end of the term or terms for which Letters Patent may be granted and/or extended, as fully and entirely as the same would have been held and enjoyed by Assignors, had this sale and assignment not been made.

02/03/2024

AND for the same consideration, Assignors hereby represent and warrant to Assignee, its successors, legal representatives and assigns, that, at the time of execution and delivery of these presents, except for any rights, titles and/or interests that have arisen to Assignee under law or that have already been transferred to Assignee, Assignors are the sole and lawful owners of the entire right, title and interest in and to the said inventions and application for Letters Patent above-mentioned, and that the same are unencumbered and that Assignors have good and full right and lawful authority to sell and convey the same in the manner herein set forth.

AND for the same consideration, Assignors hereby covenant and agree to and with Assignee, its successors, legal representatives and assigns, that Assignors will sign all papers and documents, take all lawful oaths and do all acts necessary or required to be done for the procurement, maintenance, enforcement and defense of any Letters Patent and applications for Letters Patent for said inventions, without charge to Assignee, its successors, legal representatives and assigns, whenever counsel of Assignee, or counsel of its successors, legal representatives and assigns, shall advise: that any proceeding in connection with said inventions, or said Patent application for Letters Patent, or any proceeding in connection with any Letters Patent or applications for Letters Patent for said inventions in any country, including but not limited to interference proceedings, is lawful and desirable; or, that any division, continuation or continuation-in-part of any application for Letters Patent, or any reissue, reexamination or extension of any Letters Patent, to be obtained thereon, is lawful and desirable.

AND Assignors hereby request the Commissioner for Patents and Trademarks to issue said Letters Patent of the United States to Assignee, as Assignee of said inventions and the Letters Patent to be issued thereon, for the sole use and benefit of Assignee, its successors, legal representatives and assigns.

AND Assignors acknowledge an obligation of assignment of this invention to Assignee at the time the invention was made.

01/03/2024

DECLARATION

As a below named inventor, I hereby declare that:

This declaration is directed to the patent application entitled:

SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT

the specification of which was filed on January 26, 2024, as Application No. 18/292,837.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I have reviewed and understand the contents of the above-identified application.

I am aware of the duty to disclose to the Office all information known to me to be material to patentability as defined in 37 C.F.R. 1.56.

I hereby acknowledge that any willful false statement made in this Declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

In the event that the filing date and/or Application No. are not entered above at the time I execute this document, and if such information is deemed necessary, I hereby authorize and request the attorneys/agent(s) at POLSINELLI PC, 1401 Eye Street, N.W., Suite 800, Washington, DC 20005, to insert the filing date and/ or Application No. of said application into this document.

Date: 01/03/2024 Signature: ____________________

Gustavo Alexandre GROSSI

UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
18/292,837	**03/11/2024 02:59:25 PM Z ET**	**092210-786599**

Title of Invention

SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT

Application Information

APPLICATION TYPE	Utility - U.S. National Stage under 35 USC 371	PATENT #	-
CONFIRMATION #	1124	FILED BY	Catalina Paun
PATENT CENTER #	64633359	FILING DATE	-
CUSTOMER #	30678	FIRST NAMED INVENTOR	Gustavo Alexandre GROSSI
INTL. APPLICATION #	-	INTL. FILING DATE	-
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	Robert Balls

Documents

TOTAL DOCUMENTS: 3

DOCUMENT		PAGES	DESCRIPTION	SIZE (KB)
Power_of_Attorney.pdf		5	-	8031 KB
Power_of_Attorney-TRAN.LET.pdf	(1-1)	1	Transmittal Letter	331 KB
Power_of_Attorney-PA...pdf	(2-2)	1	Power of Attorney	7634 KB
Power_of_Attorney-R3.73.pdf	(3-5)	3	Assignee showing of ownership per 37 CFR 3.73	76 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)

Power_of_Attorney.pdf	51CC0904509551B8BE1FAB6389C0CD65E6C339926635F264E7D275CED3179471BC9CF9E6AB97F97DBAD48CEDAD0C3A2DB1B630D62F5E547EBD84DC89D6F59E6C
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New International Application Filed with the USPTO as a Receiving Office

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PTO/AIA/82A (07-13)
Approved for use through 03/31/2021. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

Application Number	18/292,837
Filing Date	January 26, 2024
First Named Inventor	Gustavo Alexandre GROSSI
Title	SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT
Art Unit	Not Yet Assigned
Examiner Name	Not Yet Assigned
Attorney Docket Number	092210-786599

SIGNATURE of Applicant or Patent Practitioner

Signature	/R. James Balls/	Date (Optional)	March 11, 2024
Name	R. James Balls	Registration Number	57703
Title (if Applicant is a juristic entity)			
Applicant Name (if Applicant is a juristic entity)	FIENILE AGRONEGÓCIOS LTDA		

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.

☑ *Total of 1 forms are submitted.

PTO/AIA/82B (07-13)
Approved for use through 03/31/2021. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number

POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

Application Number	Filing Date

(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)

☑ I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above: 30678

OR

☐ I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:

☑ The address associated with the above-mentioned Customer Number

OR

☐ The address associated with Customer Number:

OR

☐ Firm or Individual Name					
Address					
City		State		Zip	
Country					
Telephone		Email			

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

FIENILE AGRONEGÓCIOS LTDA

☐ Inventor or Joint Inventor (title not required below)

☐ Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)

☑ Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)

☐ Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

SIGNATURE of Applicant for Patent

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

Signature		Date (Optional)	
Name	Gustavo Alexandre Cozza		
Title			

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

☑ Total of 1 forms are submitted.

STATEMENT UNDER 37 CFR 3.73(c)

Applicant/Patent Owner: FIENILE AGRONEGÓCIOS LTDA

Application No./Patent No.: 18/292,837 Filed/Issue Date: January 26, 2024

Titled: SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT

FIENILE AGRONEGÓCIOS LTDA, a corporation

(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose **one** of options 1, 2, 3 or 4 below):

1. ☑ The assignee of the entire right, title, and interest.

2. ☐ An assignee of less than the entire right, title, and interest (check applicable box):

   ☐ The extent (by percentage) of its ownership interest is ____________%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.

   ☐ There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. ☐ The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. ☐ The recipient, via a court proceeding or the like (*e.g.*, bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose **one** of options A or B below):

A. ☑ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel 066704, Frame 0189, or for which a copy thereof is attached.

B. ☐ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: ____________ To: ____________

   The document was recorded in the United States Patent and Trademark Office at

   Reel ____________, Frame ____________, or for which a copy thereof is attached.

2. From: ____________ To: ____________

   The document was recorded in the United States Patent and Trademark Office at

   Reel ____________, Frame ____________, or for which a copy thereof is attached.

STATEMENT UNDER 37 CFR 3.73(c)

3. From: ______________________ To: ______________________

The document was recorded in the United States Patent and Trademark Office at

Reel __________, Frame __________, or for which a copy thereof is attached.

4. From: ______________________ To: ______________________

The document was recorded in the United States Patent and Trademark Office at

Reel __________, Frame __________, or for which a copy thereof is attached.

5. From: ______________________ To: ______________________

The document was recorded in the United States Patent and Trademark Office at

Reel __________, Frame __________, or for which a copy thereof is attached.

6. From: ______________________ To: ______________________

The document was recorded in the United States Patent and Trademark Office at

Reel __________, Frame __________, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☑ As required by 37 CFR 3.73(c)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/R. James Balls/	March 11, 2024
Signature	Date
R. James Balls	57703
Printed or Typed Name	Title or Registration Number

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

APPLICATION NO./ CONTROL NO.	FILING DATE	FIRST NAMED INVENTOR/ PATENT IN REEXAMINATION	ATTORNEY DOCKET NO.
18/292,837		GROSSI, Gustavo Alexandre	092210-786599

	EXAMINER	
POLSINELLI PC (DC OFFICE) PO Box 140310 Kansas City, MO 64114-0310	--	
	ART UNIT	PAPER
	--	20240427-KgGUdA

DATE MAILED: 27 April 2024

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner for Patents

PTO-90C (Rev.04-03)

Notice of Potential Erroneous Release of Patent Application Titles

On February 5, 2024, the United States Patent and Trademark Office (USPTO), replaced the Electronic Patent Assignment System (EPAS) and Electronic Trademark Assignment System (ETAS) with Assignment Center.

Between February 5, 2024 and March 29, 2024, the USPTO, unintentionally, through a computer programming error, permitted bibliographic information to be viewed by unauthorized individuals with access to registered Assignment Center accounts. This bibliographic information was limited to the application number (the two-digit series code plus the six-digit serial number) and title of the invention.

You are receiving this notification because your application's patent title may have been viewed during that time frame by individual(s) who lacked permission to do so. The software error was first reproduced by USPTO on March 28, 2024, and was corrected on March 29, 2024. Only application numbers and titles were disclosed; it is important to note that your specification and claims were not part of the information made available and were not accessed.

Any improper access of the application information between the dates of February 5, 2024 and March 29, 2024, is not considered a publication of such applications under 35 U.S.C. 122(b). No rights in United States patents are threatened by the access to unpublished applications. It is extremely unlikely that the title could disclose the invention in a way that would constitute patent-defeating prior art in any jurisdiction. To the extent any issue is raised, the USPTO will assist applicants by confirming that the disclosure was erroneous and inadvertent.

We're committed to data security and are taking enhanced steps to prevent incidents such as this from happening in the future. The USPTO sincerely regrets this error and is instituting more testing controls, both manual and automated testing, to prevent similar processing errors in the future.

Inquiries regarding this matter may be directed to Mark Polutta, Senior Legal Advisor, at (571) 272-7709 or Andrew Stclair, Legal Advisor, at (571) 270-0238, both of the Office of Patent Legal Administration or via email addressed to Patent.Practice@uspto.gov.

Henry "Jamie" Holcombe
Chief Information Officer
US Patent and Trademark Office
Office +1 (571) 272-9400

uspto

Dated: April 27th, 2024

UNITED STATES DEPARTMENT OF COMMERCE
U.S. Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450

APPLICATION NO./ CONTROL NO.	FILING DATE	FIRST NAMED INVENTOR/ PATENT IN REEXAMINATION	ATTORNEY DOCKET NO.
18/292,837		GROSSI, Gustavo Alexandre	092210-786599

		EXAMINER	
POLSINELLI PC (DC OFFICE) PO Box 140310 Kansas City, MO 64114-0310		--	
		ART UNIT	PAPER
		--	20240427-fjuOAC

DATE MAILED: 27 April 2024

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner for Patents

PTO-90C (Rev.04-03)

Notice of Potential Erroneous Release of Patent Application Titles

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We're committed to data security and are taking enhanced steps to prevent incidents such as this from happening in the future. The USPTO sincerely regrets this error and is instituting more testing controls, both manual and automated testing, to prevent similar processing errors in the future.

Inquiries regarding this matter may be directed to Mark Polutta, Senior Legal Advisor, at (571) 272-7709 or Andrew Stclair, Legal Advisor, at (571) 270-0238, both of the Office of Patent Legal Administration or via email addressed to Patent.Practice@uspto.gov.

Henry "Jamie" Holcombe
Chief Information Officer
US Patent and Trademark Office
Office +1 (571) 272-9400

Dated: April 27th, 2024

United States Patent and Trademark Office

Office of the Chief Financial Officer

Document Code:WFEE

User :India Evans

Refund Accounting Date:05/01/2024

Effective Date	Sale Item Reference Number	Refund Total
05/01/2024	18292837	$216.00

Document Number	Fee Code	Fee Code Description	Amount Paid	Payment Method	Account Number
I202451D33459340	2642	NATL STAGE SEARCH FEE - REPORT PROVIDED	$216.00	DA	501662

United States Patent and Trademark Office

Office of the Chief Financial Officer

Document Code:WFEE

User :India Evans

Sale Adjustment Accounting Date:05/01/2024

Effective Date	Sale Accounting Date	Sale Item Reference Number
05/01/2024	05/01/2024	18292837

Document Number	Fee Code	Fee Code Description	Amount Paid	Payment Method
I202451D33459340	2642	NATL STAGE SEARCH FEE - REPORT PROVIDED	$216.00	DA

United States Patent and Trademark Office

Office of the Chief Financial Officer

Document Code:WFEE

User :India Evans

Sale Accounting Date:05/01/2024

Sale Item Reference Number	Effective Date
18292837	01/26/2024

Document Number	Fee Code	Fee Code Description	Amount Paid	Payment Method
I202451D37539366	2641	NATL STAGE SEARCH FEE - U.S. WAS THE ISA	$56.00	Deposit Account

PATENT APPLICATION FEE DETERMINATION RECORD
Substitute for Form PTO-875

Application or Docket Number
18/292,837

APPLICATION AS FILED - PART I

FOR	NUMBER FILED (Column 1)		NUMBER EXTRA (Column 2)	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A		N/A	N/A	128		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A		N/A	N/A	56		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A		N/A	N/A	320		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	7	minus 20 =	* 0	x =	0	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	2	minus 3 =	*	x =	0			
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				0			
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					0			
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	504		TOTAL	

APPLICATION AS AMENDED - PART II

AMENDMENT A

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

AMENDMENT B

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

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UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
18/292,837	01/26/2024		568	092210-786599	7	2

CONFIRMATION NO. 1124

FILING RECEIPT

OC000000072044347

30678
POLSINELLI PC
(DC OFFICE)
PO Box 140310
Kansas City, MO 64114-0310

Date Mailed: 05/03/2024

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

Inventor(s)

Gustavo Alexandre GROSSI, Monte Carmelo MG, BRAZIL;

Applicant(s)

FIENILE AGRONEGÓCIOS LTDA, Centro Patos de Minas MG, BRAZIL;

Assignment For Published Patent Application

FIENILE AGRONEGÓCIOS LTDA, Centro Patos de Minas MG, BRAZIL

Power of Attorney: The patent practitioners associated with Customer Number 30678

Domestic Priority data as claimed by applicant

This application is a 371 of PCT/BR2022/050461 11/24/2022

Foreign Applications (You may be eligible to benefit from the Patent Prosecution Highway program at the USPTO. Please see http://www.uspto.gov for more information.)
BRAZIL 1020220072728 04/14/2022 No Access Code Provided

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 05/01/2024

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 18/292,837**

Projected Publication Date: 08/08/2024

Non-Publication Request: No

Early Publication Request: No
**** SMALL ENTITY ****
Title

SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT

Preliminary Class

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

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NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

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United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

U.S. APPLICATION NO.	FIRST NAMED INVENTOR	ATTY. DOCKET NO.
18/292,837	Gustavo Alexandre GROSSI	092210-786599

30678
POLSINELLI PC
(DC OFFICE)
PO Box 140310
Kansas City, MO 64114-0310

INTERNATIONAL APPLICATION NO.	
PCT/BR2022/050461	
I.A. FILING DATE	PRIORITY DATE
11/24/2022	04/14/2022

CONFIRMATION NO. 1124
371 ACCEPTANCE LETTER

OC000000072044349

Date Mailed: 05/03/2024

NOTICE OF ACCEPTANCE OF APPLICATION UNDER 35 U.S.C 371 AND 37 CFR 1.495

The applicant is hereby advised that the United States Patent and Trademark Office, in its capacity as a Designated / Elected Office (37 CFR 1.495), has ACCEPTED the above identified international application for national patentability examination in the United States Patent and Trademark Office.

The United States Application Number assigned to the application is shown above. A Filing Receipt will be issued for the present application in due course. **THE DATE APPEARING ON THE FILING RECEIPT AS THE "FILING DATE or 371(c) DATE" IS THE DATE ON WHICH THE LAST OF THE 35 U.S.C. 371 (c)(1) and (c)(2) REQUIREMENTS HAS BEEN RECEIVED IN THE OFFICE. THIS DATE IS SHOWN BELOW.** The filing date of the above identified application is the international filing date of the international application (Article 11(3) and 35 U.S.C. 363)

01/26/2024
DATE OF RECEIPT OF 35 U.S.C.
371(c)(1) and (c)(2) REQUIREMENTS

The following items have been received:

- Indication of Small Entity Status
- Drawings filed on 01/26/2024
- Assignee Statement for PGPUB filed on 01/26/2024
- Copy of the International Application filed on 01/26/2024
- Priority Documents filed on 01/26/2024
- Information Disclosure Statements filed on 01/26/2024
- Inventor's Oath or Declaration filed on 03/08/2024
- Assignment filed on 03/08/2024
- Application Data Sheet (37 CFR 1.76) filed on 01/26/2024
- Authorization to Permit Access filed on 01/26/2024
- Authorize Access to Search Results filed on 01/26/2024
- Preliminary Amendments filed on 01/26/2024
- Copy of the International Search Report filed on 01/26/2024
- Power of Attorney filed on 03/11/2024
- U.S. Basic National Fees filed on 01/26/2024

Applicant is reminded that any communications to the United States Patent and Trademark Office must be mailed to the address given in the heading and include the U.S. application no. shown above (37 CFR 1.5)

INDIA L EVANS

Telephone: (571) 272-9085

MULTIPLE DEPENDENT CLAIM
FEE CALCULATION SHEET

Substitute for Form PTO-1360
(For use with Form PTO/SB/06)

Application Number: 18/292,837

Filing Date:

Applicant(s) Gustavo Alexandre GROSSI

* May be used for additional claims or amendments

CLAIMS	AS FILED		AFTER FIRST AMENDMENT		AFTER SECOND AMENDMENT	
	Indep	Depend	Indep	Depend	Indep	Depend
1	1		1			
2		1		1		
3		2		1		
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17		(1)	---	---		
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19		1		1		
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Total Indep	2		2			
Total Depend	25		5			
Total Claims	27		7		0	

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United States Patent and Trademark Office

Under Secretary of Commerce for Intellectual Property and Director of the United States Patent and Trademark Office

WELCOME TO THE UNITED STATES PATENT AND TRADEMARK OFFICE (USPTO)

*Congratulations on taking the first step to protect your invention. You can now advertise or mark any products covered by this application for your invention as **"Patent Pending"** for as long as this application is pending!*

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Under Secretary of Commerce for Intellectual Property and Director of the United States Patent and Trademark Office

Derrick Brent
Deputy Under Secretary of Commerce for Intellectual Property and Deputy Director of the United States Patent and Trademark Office

Notice of References Cited	Application/Control No. 18/292,837	Applicant(s)/Patent Under Reexamination GROSSI, Gustavo Alexandre	
	Examiner EBONY E EVANS	Art Unit 3647	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date YYYY-MM-DD	Name	CPC Classification	US Classification
*	A	US-20020107586-A1	2002-08-08	Kreikemeier, Bruce	G05B19/0423	700/65
*	B	US-20130026259-A1	2013-01-31	Korus; Thomas J.	A01G25/092	239/729
*	C	US-20130090766-A1	2013-04-11	Pfrenger; Jochen	A01G25/092	239/731
*	D	US-20130139437-A1	2013-06-06	Maxik; Fredric S.	A01G7/045	47/58.1LS
*	E	US-9974246-B2	2018-05-22	Frager; James R.	A01G25/097	1/1
	F					
	G					
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	I					
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	K					
	L					
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	N					
	O					
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Search Notes	Application/Control No. 18/292,837	Applicant(s)/Patent Under Reexamination GROSSI, Gustavo Alexandre
	Examiner EBONY E EVANS	Art Unit 3647

CPC - Searched*		
Symbol	**Date**	**Examiner**
A01G 7/045, 9/20, 9/245, 25/09, 25/092, 25/167	06/15/2024	ee

CPC Combination Sets - Searched*		
Symbol	**Date**	**Examiner**

US Classification - Searched*			
Class	**Subclass**	**Date**	**Examiner**
47	48.5	06/15/2024	ee

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	**Date**	**Examiner**
PE2E search	06/15/2024	ee
Inventor search		
Text search		
Forward/back search		

Interference Search			
US Class/CPC Symbol	**US Subclass/CPC Group**	**Date**	**Examiner**
A01G	7/045, 25/092, 25/167	06/15/2024	ee

/EBONY E EVANS/ Primary Examiner, Art Unit 3647	

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	18/292,837	GROSSI, Gustavo Alexandre
	Examiner	**Art Unit**
	EBONY E EVANS	3647

CPC						
Symbol					**Type**	**Version**
A01G	/	25	/	092	F	2013-01-01
A01G	/	25	/	167	I	2013-01-01
A01G	/	7	/	045	I	2013-01-01

CPC Combination Sets								
Symbol					**Type**	**Set**	**Ranking**	**Version**
	/		/					

NONE (Assistant Examiner) (Date)	**Total Claims Allowed:** 7	
/EBONY E EVANS/ , Art Unit 3647 15 June 2024 (Primary Examiner) (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 3

Issue Classification	Application/Control No. 18/292,837	Applicant(s)/Patent Under Reexamination GROSSI, Gustavo Alexandre
	Examiner EBONY E EVANS	Art Unit 3647

INTERNATIONAL CLASSIFICATION				
CLAIMED				
A01G	/	25	/	09

NON-CLAIMED				
	/		/	

US ORIGINAL CLASSIFICATION	
CLASS	**SUBCLASS**

CROSS REFERENCES(S)						
CLASS	**SUBCLASS (ONE SUBCLASS PER BLOCK)**					

NONE (Assistant Examiner) (Date)		**Total Claims Allowed:** 7	
/EBONY E EVANS/ , Art Unit 3647 (Primary Examiner)	15 June 2024 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 3

Issue Classification	Application/Control No. 18/292,837	Applicant(s)/Patent Under Reexamination GROSSI, Gustavo Alexandre
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☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIMS

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1		10	5	19										
2	2		11	6	20										
3	3		12	7	21										
	4		13		22										
	5		14		23										
	6		15		24										
	7		16												
	8		17												
	9	4	18												

NONE (Assistant Examiner)	(Date)	Total Claims Allowed: 7	
/EBONY E EVANS/ , Art Unit 3647 (Primary Examiner)	15 June 2024 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 3

Index of Claims	**Application/Control No.** 18/292,837	**Applicant(s)/Patent Under Reexamination** GROSSI, Gustavo Alexandre
	Examiner EBONY E EVANS	**Art Unit** 3647

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

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CLAIM		DATE								
Final	Original	06/15/2024								
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3	3	=								
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7	21	=								
	22	-								
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	24	-								

PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L1	0	((("GROSSI") near3 ("Gustavo") near3 ("Alexandre"))).INV.	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2024/06/15 10:33 PM
L2	6105	A01G7/045.cpc.	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2024/06/15 10:33 PM
L3	22669	A01G7/045.cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, CA, CH, CN, DD, DE, EA, EP, ES, FR, GB, JP, KR, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/06/15 10:33 PM
L4	4994	A01G9/20.cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, CA, CH, CN, DD, DE, EA, EP, ES, FR, GB, JP, KR, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/06/15 10:33 PM
L5	9268	A01G9/249.cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, CA, CH, CN, DD, DE, EA, EP, ES, FR, GB, JP, KR, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/06/15 10:33 PM
L6	10832	A01G25/09.cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, CA, CH, CN, DD, DE, EA, EP, ES, FR, GB, JP, KR, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/06/15 10:34 PM
L7	3687	A01G25/092.cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, CA, CH, CN, DD, DE, EA, EP, ES, FR, GB, JP, KR, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/06/15 10:34 PM
L8	10190	A01G25/167.cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, CA, CH, CN, DD, DE, EA, EP, ES, FR,	OR	ON	ON	2024/06/15 10:34 PM

			GB, JP, KR, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L9	5119	agricultural$3 WITH (irrigation WITH (light$3 OR diode))	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, CA, CH, CN, DD, DE, EA, EP, ES, FR, GB, JP, KR, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/06/15 10:35 PM
L10	160	L9 AND pivot	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, CA, CH, CN, DD, DE, EA, EP, ES, FR, GB, JP, KR, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/06/15 10:36 PM
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L13	4	"9974246"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, CA, CH, CN, DD, DE, EA, EP, ES, FR, GB, JP, KR, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/06/15 10:40 PM
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L18	19	"20120038281"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, CA, CH, CN, DD, DE, EA, EP, ES, FR, GB, JP, KR, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/06/15 10:56 PM
L19	2	"20020154504"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, CA, CH, CN, DD, DE, EA, EP, ES, FR, GB, JP, KR, OA, RU, SU, WO); FPRS; EPO;	OR	ON	ON	2024/06/15 10:57 PM

			JPO; DERWENT; IBM_TDB)				
L20	34403	H05B47/10.cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, CA, CH, CN, DD, DE, EA, EP, ES, FR, GB, JP, KR, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/06/15 11:00 PM
L21	258	L20 AND A01G$.cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, CA, CH, CN, DD, DE, EA, EP, ES, FR, GB, JP, KR, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/06/15 11:00 PM
L22	5	("20020154504" OR "20120038281" OR "20130263503" OR "20160262313" OR "20200359550").pn.	(US-PGPUB; USPAT)	OR	ON	ON	2024/06/15 11:29 PM
L23	0	47/4805.ccls.	(US-PGPUB; USPAT)	OR	ON	ON	2024/06/15 11:34 PM
L24	926	47/48.5.ccls.	(US-PGPUB; USPAT)	OR	ON	ON	2024/06/15 11:34 PM
L25	0	L24 AND (agricultural$3 WITH (irrigation WITH (light$3 OR diode)))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, CA, CH, CN, DD, DE, EA, EP, ES, FR, GB, JP, KR, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/06/15 11:35 PM

PE2E SEARCH - Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
N1	1495	A01G7/045.cpc.	(US-PGPUB)	OR	ON	ON	2024/06/15 10:48 PM
N2	751	A01G25/167.cpc.	(US-PGPUB)	OR	ON	ON	2024/06/15 10:48 PM
N3	377	A01G25/092.cpc.	(US-PGPUB)	OR	ON	ON	2024/06/15 10:48 PM
N4	309	agricultural$3 WITH (irrigation WITH (light$3 OR diode))	(US-PGPUB)	OR	ON	ON	2024/06/15 10:49 PM
N5	12	N4 AND (N3 OR N2 OR N1)	(US-PGPUB)	OR	ON	ON	2024/06/15 10:49 PM

Bibliographic Data

Application No: 18/292,837

Foreign Priority claimed: ◉ Yes ○ No

35 USC 119 (a-d) conditions met: ☑ Yes ☐ No | ☐ Met After Allowance

Verified and Acknowledged: /EBONY E EVANS/ |

Examiner's Signature | Initials

Title: SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
01/26/2024	047	3647	092210-786599
RULE			

APPLICANTS

FIENILE AGRONEGÓCIOS LTDA, Centro Patos de Minas MG, BRAZIL

INVENTORS

Gustavo Alexandre GROSSI, Monte Carmelo MG, BRAZIL

CONTINUING DATA

This application is a 371 of PCT/BR2022/050461 11/24/2022

FOREIGN APPLICATIONS

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99**)		
	Application Number	
	Filing Date	2024-01-26
	First Named Inventor	Gustavo Alexandre GROSSI
	Art Unit	
	Examiner Name	
	Attorney Docket Number	092210-786599

U.S.PATENTS

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Examiner Initial*	Cite No	Publication Number	Kind Code1	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20200359550	A1	2020-11-19	Tran et al.	
	2	20130263503	A1	2013-10-10	Bostdorff	
	3	20160262313	A1	2016-09-15	Szeto et al.	
	4	20120038281	A1	2012-02-16	Verfuerth	
	5	20020154504	A1	2002-10-24	Fang et al.	

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	Filing Date	2024-01-26
	First Named Inventor	Gustavo Alexandre GROSSI
	Art Unit	
	Examiner Name	
	Attorney Docket Number	092210-786599

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	1	International Search Report and Written Opinion issued on April 24, 2023 for corresponding PCT Application No. PCT/ BR2022/050461	☐

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2024-01-26
	First Named Inventor	Gustavo Alexandre GROSSI
	Art Unit	
	Examiner Name	
	Attorney Docket Number	092210-786599

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

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OR

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☐ See attached certification statement.

☐ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/R. James Balls/	Date (YYYY-MM-DD)	2024-01-26
Name/Print	R. James Balls	Registration Number	57703

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7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/ her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

30678 7590 07/01/2024

POLSINELLI PC
(DC OFFICE)
PO Box 140310
Kansas City, MO 64114-0310

EXAMINER	
EVANS, EBONY E	
ART UNIT	PAPER NUMBER
3647	

DATE MAILED: 07/01/2024

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/292,837	01/26/2024	Gustavo Alexandre GROSSI	092210-786599	1124

TITLE OF INVENTION: SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$480	$0.00	$0.00	$480	10/01/2024

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 40% the amount of undiscounted fees, and micro entity fees are 20% the amount of undiscounted fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via the USPTO patent electronic filing system.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications. **Because electronic patent issuance may occur shortly after issue fee payment, any desired continuing application should preferably be filed prior to payment of this issue fee in order not to jeopardize copendency.**

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

30678 7590 07/01/2024

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PO Box 140310
Kansas City, MO 64114-0310

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via the USPTO patent electronic filing system or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)

(Signature)

(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/292,837	01/26/2024	Gustavo Alexandre GROSSI	092210-786599	1124

TITLE OF INVENTION: SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$480	$0.00	$0.00	$480	10/01/2024

EXAMINER	ART UNIT	CLASS-SUBCLASS
EVANS, EBONY E	3647	047-048500

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/AIA/122 or PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/AIA/47 or PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 ____________________

2 ____________________

3 ____________________

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. Fees submitted: ❑Issue Fee ❑Publication Fee (if required)

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

❑ Electronic Payment via the USPTO patent electronic filing system ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. __________

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

❑ Applicant asserting small entity status. See 37 CFR 1.27

NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

❑ Applicant changing to regular undiscounted fee status.

NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature ______________________ Date ______________________

Typed or printed name ______________________ Registration No. ______________________

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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30678 7590 07/01/2024

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Kansas City, MO 64114-0310

EXAMINER	
EVANS, EBONY E	
ART UNIT	**PAPER NUMBER**
3647	

DATE MAILED: 07/01/2024

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)

(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. The United States Patent and Trademark Office (USPTO) collects the information in this record under authority of 35 U.S.C. 2. The USPTO's system of records is used to manage all applicant and owner information including name, citizenship, residence, post office address, and other information with respect to inventors and their legal representatives pertaining to the applicant's/ owner's activities in connection with the invention for which a patent is sought or has been granted. The applicable Privacy Act System of Records Notice for the information collected in this form is COMMERCE/PAT-TM-7 Patent Application Files, available in the Federal Register at 78 FR 19243 (March 29, 2013).
https://www.govinfo.gov/content/pkg/FR-2013-03-29/pdf/2013-07341.pdf

Routine uses of the information in this record may include disclosure to:

1) law enforcement, in the event that the system of records indicates a violation or potential violation of law;
2) a federal, state, local, or international agency, in response to its request;
3) a contractor of the USPTO having need for the information in order to perform a contract;
4) the Department of Justice for determination of whether the Freedom of Information Act (FOIA) requires disclosure of the record;
5) a Member of Congress submitting a request involving an individual to whom the record pertains, when the individual has requested the Member's assistance with respect to the subject matter of the record;
6) a court, magistrate, or administrative tribunal, in the course of presenting evidence, including disclosures to opposing counsel in the course of settlement negotiations;
7) the Administrator, General Services Administration (GSA), or their designee, during an inspection of records conducted by GSA under authority of 44 U.S.C. 2904 and 2906, in accordance with the GSA regulations and any other relevant (i.e., GSA or Commerce) directive, where such disclosure shall not be used to make determinations about individuals;
8) another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c));
9) the Office of Personnel Management (OPM) for personnel research purposes; and
10) the Office of Management and Budget (OMB) for legislative coordination and clearance.

If you do not furnish the information requested on this form, the USPTO may not be able to process and/or examine your submission, which may result in termination of proceedings, abandonment of the application, and/or expiration of the patent.

Notice of Allowability	**Application No.** 18/292,837	**Applicant(s)** GROSSI, Gustavo Alexandre	
	Examiner EBONY E EVANS	**Art Unit** 3647	**AIA (FITF) Status** Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1.☑ This communication is responsive to 1/26/2024.
☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on ______.

2.☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on ______; the restriction requirement and election have been incorporated into this action.

3.☑ The allowed claim(s) is/are 1-3 and 18-21 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information , please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4.☑ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a) ☑All b) ☐ Some* c) ☐ None of the:

1. ☑ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. ______ .
3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

* Certified copies not received: ______ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5.☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date ______ .

Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6.☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1.☑ Notice of References Cited (PTO-892)
2.☑ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date ______.
3.☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material ______.
4.☐ Interview Summary (PTO-413), Paper No./Mail Date. ______.
5. ☐ Examiner's Amendment/Comment
6. ☑ Examiner's Statement of Reasons for Allowance
7. ☐ Other ______.

/EBONY E EVANS/
Primary Examiner, Art Unit 3647

REASONS FOR ALLOWANCE

The following is an examiner's statement of reasons for allowance: The limitation of a modular agricultural irrigation pivot-like device comprising: a plurality of artificial lighting sources; and a plurality of energy sources that feed the artificial lighting sources; a processor in communication with a dimerizer and/or a polarizer of the artificial lighting sources and with the energy sources, wherein the processor is configured to: a) adjust the plurality of light-emitting diodes; and b) determine and implement: an irrigation routine; and/or an artificial lights supplementation routine; wherein stages a) and b) are determined by the processor considering at least one among: a crop species under cultivation; a phenological stage of the crop under cultivation; a photoperiod, a season and current weather conditions under which the agricultural field is subjected; and one or more objectives intended for the crop development as claimed in claim 1 is not anticipated or made obvious by the prior art of record, in the examiner's opinion. Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Any inquiry concerning this communication or earlier communications from the examiner should be directed to EBONY EVANS whose telephone number is (571)270-1157. The examiner can normally be reached on M-F10-6pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Tien Dinh can be reached on 571-272-6899. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/EBONY E EVANS/
Primary Examiner, Art Unit 3647

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via the USPTO patent electronic filing system.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications. **Because electronic patent issuance may occur shortly after issue fee payment, any desired continuing application should preferably be filed prior to payment of this issue fee in order not to jeopardize copendency.**

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

30678 7590 07/01/2024
POLSINELLI PC
(DC OFFICE)
PO Box 140310
Kansas City, MO 64114-0310

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via the USPTO patent electronic filing system or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/292,837	01/26/2024	Gustavo Alexandre GROSSI	092210-786599	1124

TITLE OF INVENTION: SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$480	$0.00	$0.00	$480	10/01/2024

EXAMINER	ART UNIT	CLASS-SUBCLASS
EVANS, EBONY E	3647	047-048500

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/AIA/122 or PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/AIA/47 or PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 POLSINELLI PC
2 ____
3 ____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE
FIENILE AGRONEGÓCIOS LTDA

(B) RESIDENCE: (CITY and STATE OR COUNTRY)
Centro Patos de Minas MG, BRAZIL

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. Fees submitted: ☒ Issue Fee ☐ Publication Fee (if required)

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

☒ Electronic Payment via the USPTO patent electronic filing system ☐ Enclosed check ☐ Non-electronic payment by credit card (Attach form PTO-2038)

☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. 50-1662

5. **Change in Entity Status** (from status indicated above)

☐ Applicant certifying micro entity status. See 37 CFR 1.29

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

☐ Applicant asserting small entity status. See 37 CFR 1.27

NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

☐ Applicant changing to regular undiscounted fee status.

NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /R. James Balls/ Date July 5, 2024

Typed or printed name R. James Balls Registration No. 57703

UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC PAYMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
18/292,837	07/05/2024 06:08:16 PM Z ET	092210-786599

Title of Invention

SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT

Application Information

APPLICATION TYPE	Utility - U.S. National Stage under 35 USC 371	PATENT #	-
CONFIRMATION #	1124	FILED BY	Catalina Paun
PATENT CENTER #	66253856	AUTHORIZED BY	Robert Balls
CUSTOMER #	30678	FILING DATE	01/26/2024
INTL. APPLICATION #	-	INTL. FILING DATE	-
CORRESPONDENCE ADDRESS	-	FIRST NAMED INVENTOR	Gustavo Alexandre GROSSI

Payment Information

PAYMENT METHOD	PAYMENT TRANSACTION ID	PAYMENT AUTHORIZED BY
DA / 501662	E202475I09026718	Catalina Paun

FEE CODE	DESCRIPTION	ITEM PRICE($)	QUANTITY	ITEM TOTAL($)
2501	UTILITY ISSUE FEE	480.00	1	480.00
			TOTAL AMOUNT:	$480.00

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
18/292,837	**07/05/2024 06:08:16 PM Z ET**	**092210-786599**

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APPLICATION TYPE	Utility - U.S. National Stage under 35 USC 371	PATENT #	-
CONFIRMATION #	1124	FILED BY	Catalina Paun
PATENT CENTER #	66253856	FILING DATE	01/26/2024
CUSTOMER #	30678	FIRST NAMED INVENTOR	Gustavo Alexandre GROSSI
INTL. APPLICATION #	-	INTL. FILING DATE	-
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	Robert Balls

Documents

TOTAL DOCUMENTS: 1

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
Issue_Fee_Transmittal.pdf	1	Issue Fee Payment (PTO-85B)	130 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
Issue_Fee_Transmittal.pdf	FE3EDBD2C9A6A30ECF428EDFBF42D995BB184FCD3F63DE0B0B93D86D97443F7DA6422EA0FA0638003E09FE4CD4C753C4D947D57E6B590E6F5E42314F9AC47BD8

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
18/292,837	01/26/2024	Gustavo Alexandre GROSSI	092210-786599

CONFIRMATION NO. 1124

30678
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PUBLICATION NOTICE

OC000000076245123

Date Mailed: 08/08/2024

Title:SYSTEM AND METHOD OF AGRICULTURAL MANAGEMENT

Publication No.US-2024-0260518-A1
Publication Date:08/08/2024

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be viewed using the USPTO's publicly available Searchable Databases via the Patent Public Search tool at www.uspto.gov. The direct link to access the Patent Public Search tool is currently https://ppubs.uspto.gov/pubwebapp/static/pages/ppubsbasic.html.

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In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through Patent Center, the USPTO’s electronic patent application filing and management system. The direct link to access this status information is currently https://patentcenter.uspto.gov/. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of Patent Center.

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Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/292,837	09/17/2024	12089543	092210-786599	1124

30678 7590 08/28/2024

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ISSUE NOTIFICATION

The projected patent number and issue date are specified above. The patent will issue electronically. The electronically issued patent is the official patent grant pursuant to 35 U.S.C. § 153. The patent may be accessed on or after the issue date through Patent Center at https://patentcenter.uspto.gov/. The patent will be available in both the public and the private sides of Patent Center. Further assistance in electronically accessing the patent, or about Patent Center, is available by calling the Patent Electronic Business Center at 1-888-217-9197.

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Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Center (https://patentcenter.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Patents Stakeholder Experience (OPSE), Stakeholder Support Division (SSD) at (571)-272-4200.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/292,837	01/26/2024	Gustavo Alexandre GROSSI	092210-786599	1124

30678 7590 09/17/2024
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EXAMINER	
EVANS, EBONY E	
ART UNIT	**PAPER NUMBER**
3647	
NOTIFICATION DATE	**DELIVERY MODE**
09/17/2024	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

patentdocketing@polsinelli.com

PTOL-90A (Rev. 04/07)

APPLICATION NO.	ISSUE DATE	PATENT NO.
18/292,837	17-Sep-2024	12089543

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