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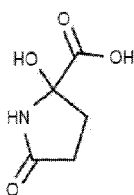
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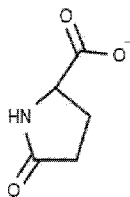
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(54) Title: COMPOSITIONS AND METHODS FOR IMPROVING PLANT PERFORMANCE

FIG. 1



2-hydroxy-5-oxoproline (2HOP)



L-Pyroglutamate (L-PGA)

(57) Abstract: Compositions and methods that increase plant performance in terms of nitrogen uptake, photosynthesis, growth, yield, tolerance to biotic and abiotic stressors, disease resistance, and general plant health are disclosed. The compositions of the present invention may include 2-hydroxy-5-oxoproline or derivatives thereof, L-pyroglutamic acid or derivatives thereof, and combinations thereof are of particular use in agricultural applications and can be applied to a plant, a seed, the soil, or combinations thereof. The methods of the present invention have broad applications in agriculture for crop management, reduction of food pollution, reduction of crop carbon footprints, and the general improvement of food quality and safety.



Declarations under Rule 4.17:

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*
- *of inventorship (Rule 4.17(iv))*

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- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

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INTERNATIONAL SEARCH REPORT

International application No.

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A. CLASSIFICATION OF SUBJECT MATTERIPC: *A01H 5/10* (2024.01); *A01N 25/04* (2024.01); *A01N 25/12* (2024.01); *A01N 25/16* (2024.01); *A01N 43/36* (2024.01); *A01P 21/00* (2024.01)CPC: *A01N 43/36*; *A01N 25/04*; *A01N 25/12*; *A01N 25/16*; *A01P 21/00*; *A01H 5/10*

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.
X	US 6,831,040 B1 (UNKEFER et al.) 14 December 2004 (14.12.2004) entire document	1, 23, 39, 45-48, 52, 64, 433, 454
Y	entire document	43, 44
Y	US 2018/0325105 A1 (VADAKEKUTTU et al.) 15 November 2018 (15.11.2018) entire document	43, 44
A	US 2014/0038824 A1 (LOS ALAMOS NATIONAL SECURITY LLC) 06 February 2014 (06.02.2014) entire document	1, 23, 39, 43-48, 52, 64, 433, 454
P, X	WO 2023/043648 A1 (VERDESIAN LIFE SCIENCES U.S. LLC) 23 March 2023 (23.03.2023) entire document	1, 23, 39, 43-48, 52, 64, 433, 454



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

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2023/034325

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E, X	US 2024/0108003 A1 (ADVANCED CROP CHEMISTRY) 04 April 2024 (04.04.2024) entire document	1, 23, 39, 43-48, 52, 64, 433, 454

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

treatment composition for increasing plant growth characteristics comprising: a. 2HOP, a functional derivative of 2HOP, L-PGA, a functional derivative of LPGA, or a combination thereof (a method of treating seeds prior to planting comprising wetting the seeds directly with a solution of a composition including a mixture of L- and D-pyroglytamate stereoisomers in a ratio of L to D of from about 80:20 to about 97:3, Para. [0011]).

Further, in regards to wherein said composition regulates expression of at least one gene of a plant onto which said composition is applied, a recitation of the intended use of the claimed invention must result in a structural difference between the claimed invention and the prior art in order to distinguish the claimed invention from the prior art. If the prior art is capable of performing the intended use, it meets the claim. In this case, Los Alamos discloses a composition comprising a structurally identical L-PGA, and is therefor capable of performing the intended use of regulating expression of at least one gene of a plant onto which said composition is applied.

The inventions listed in Groups I+, II+, III+, IV+, V+, VI+, VII+, VIII+, and IX+ therefore lack unity under Rule 13 because they do not share a same or corresponding special technical feature.

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.: **1, 23, 39, 43-48, 52, 64, 433, 454**

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.

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:

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees need to be paid.

Group I+: claims 1-67 and 433-459 are drawn to compositions for increasing plant growth characteristics, compositions, and seed treatment compositions for increasing plant growth characteristics.

Group II+: claims 68-118 are drawn to methods of increasing innate tolerance to biotic and abiotic stresses in a plant.

Group III+: claims 119-169 are drawn to methods for inhibiting the production of a microbial toxin by a microbe infecting a plant.

Group IV+: claims 170-224 are drawn to methods for reducing a toxin level in a plant.

Group V+: claims 225-273 are drawn to methods of increasing disease resistance in a plant.

Group VI+: claims 274-326 are drawn to methods for improving the resistance of a plant to the glutamine synthetase-targeting herbicide.

Group VII+: claims 327-387 are drawn to methods for improving nutrient use efficiency of a plant.

Group VIII+: claims 388-415 are drawn to methods of improving the growth characteristics of a plant.

Group IX+: claims 416-432 are drawn to methods of improving the carbon sequestration of a plant.

The first invention of Group I+ is restricted to a composition for increasing plant growth characteristics comprising 2HOP, compositions comprising the same, and seed treatment compositions for increasing plant growth characteristics comprising the same. The first named invention has been selected based on the guidance set forth in section 10.54 of the PCT International Search and Preliminary Examination Guidelines. Specifically, the first named invention was selected based on the first listed element for each of the variables presented in the claims (see claim 1). It is believed that claims 1, 23, 39, 43-48, 52, 64, 433, and 454 read on this first named invention and thus these claims will be searched without fee to the extent that they read on the above embodiment.

The first invention of Group II+ is restricted to a composition comprising 2HOP, and methods of increasing innate tolerance to biotic and abiotic stresses in a plant comprising the same.

The first invention of Group III+ is restricted to a composition comprising 2HOP, and methods for inhibiting the production of a microbial toxin by a microbe infecting a plant comprising the same.

The first invention of Group IV+ is restricted to a composition comprising 2HOP, and methods for reducing a toxin level in a plant comprising the same.

The first invention of Group V+ is restricted to a composition comprising 2HOP, and methods of increasing disease resistance in a plant comprising the same.

The first invention of Group VI+ is restricted to a composition comprising 2HOP, and methods for improving the resistance of a plant to the glutamine synthetase-targeting herbicide comprising the same.

The first invention of Group VII+ is restricted to a composition comprising 2HOP, and methods for improving nutrient use efficiency of a plant comprising the same.

The first invention of Group VIII+ is restricted to a composition comprising 2HOP, and methods of improving the growth characteristics of a plant comprising the same.

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

The first invention of Group IX+ is restricted to a composition comprising 2HOP, and methods of improving the carbon sequestration of a plant comprising the same.

Applicant is invited to elect additional compositions for each method to be searched in a specific combination by paying an additional fee for each set of election. An exemplary election would be a composition for increasing plant growth characteristics comprising 2HOP, further comprising a solubilizing agent comprising one organic acid selected to be ethylenediaminetetraacetic acid (EDTA), compositions comprising the same, and seed treatment compositions for increasing plant growth characteristics comprising the same. Additional compositions will be searched upon the payment of additional fees. Applicants must specify the claims that read on any additional elected inventions. Applicants must further indicate, if applicable, the claims which read on the first named invention if different than what was indicated above for this group. Failure to clearly identify how any paid additional invention fees are to be applied to the "+" group(s) will result in only the first claimed invention to be searched/examined.

The inventions listed in Groups I+, II+, III+, IV+, V+, VI+, VII+, VIII+, and IX+ do not relate to a single general inventive concept under PCT Rule 13.1, because under PCT Rule 13.2 they lack the same or corresponding special technical features for the following reasons:

The special technical features of Group I+, compositions for increasing plant growth characteristics, compositions, and seed treatment compositions for increasing plant growth characteristics, are not present in Groups II+, III+, IV+, V+, VI+, VII+, VIII+, and IX+; the special technical features of Group II+, methods of identifying a compound that enhances T cell mediated immunity by HLA binding, are not present in Groups I+, III+, IV+, V+, VI+, VII+, VIII+, and IX+; the special technical features of Group III+, methods for inhibiting the production of a microbial toxin by a microbe infecting a plant, are not present in Groups I+, II+, IV+, V+, VI+, VII+, VIII+, and IX+; the special technical features of Group IV+, methods for reducing a toxin level in a plant, are not present in Groups I+, II+, III+, V+, VI+, VII+, VIII+, and IX+; the special technical features of Group V+, methods of increasing disease resistance in a plant, are not present in Groups I+, II+, III+, IV+, VI+, VII+, VIII+, and IX+; the special technical features of Group VI+, methods for improving the resistance of a plant to the glutamine synthetase-targeting herbicide, are not present in Groups I+, II+, III+, IV+, V+, VII+, VIII+, and IX+; the special technical features of Group VII+, methods for improving nutrient use efficiency of a plant, are not present in Groups I+, II+, III+, IV+, V+, VI+, VIII+, and IX+; the special technical features of Group VIII+, methods of improving the growth characteristics of a plant, are not present in Groups I+, II+, III+, IV+, V+, VI+, VII+, and IX+; and the special technical features of Group IX+, methods of improving the carbon sequestration of a plant, are not present in Groups I+, II+, III+, IV+, V+, VI+, VII+, and VIII+.

Groups I+, II+, III+, IV+, V+, VI+, VII+, VIII+, and IX+ compositions and methods do not share a significant structural element, requiring the selection of alternatives for the HLA binding molecules where "2HOP, a functional derivative of 2HOP, L-PGA, a functional derivative of LPGA, or a combination thereof," where "further comprising a solubilizing agent," where "further comprising an agriculturally acceptable carrier," where "further comprising a surfactant, a humectant, an adjuvant, an antioxidant, and/or a stabilizer," where "further comprising a pH modifier," where "further comprising a physiologically active agent," and where "further comprising a biocide."

Additionally, even if Groups I+, II+, III+, IV+, V+, VI+, VII+, VIII+, and IX+ were considered to share the technical features of a composition for increasing plant growth characteristics comprising: a. 2HOP, a functional derivative of 2HOP, L-PGA, a functional derivative of LPGA, or a combination thereof; a composition comprising 2HOP, a functional derivative of 2HOP, L-PGA, a functional derivative of L-PGA, or a combination thereof, wherein said composition regulates expression of at least one gene of a plant onto which said composition is applied; a method of increasing innate tolerance to biotic and abiotic stresses in a plant comprising applying a composition comprising 2HOP, a functional derivative of 2HOP, LPGA, functional derivative of L-PGA, or a combination thereof to a plant or a growth media therefor; a method for inhibiting the production of a microbial toxin by a microbe infecting a plant, comprising: a. applying to at least one of a plant and a growth medium of said plant an amount of a composition effective to inhibit production of said microbial toxin, said composition comprising at least one of 2HOP, a functional derivative of 2HOP, L-PGA, and functional derivative of L-PGA; a method for reducing a toxin level in a plant, said method comprising; a. applying a composition comprising 2HOP, a functional derivative of 2HOP, LPGA, functional derivative of L-PGA, or a combination thereof to a plant or a growth media therefore; a method of increasing disease resistance

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

in a plant comprising applying a composition comprising 2HOP, a functional derivative of 2HOP, L-PGA, functional derivative of L-PGA, or a combination thereof to a plant or a growth media therefor; a method for improving the resistance of a plant to the glutamine synthetase-targeting herbicide, comprising: a. applying a composition comprising 2HOP, a functional derivative of 2HOP, LPGA, functional derivative of L-PGA, or a combination thereof to a plant or a growth media therefor; a method for improving nutrient use efficiency of a plant, comprising: a. applying a composition comprising 2HOP, a functional derivative of 2HOP, LPGA, functional derivative of L-PGA, or a combination thereof to a plant or a growth media therefor; a method of improving the growth characteristics of a plant, comprising: a. applying a composition comprising 2HOP, a functional derivative of 2HOP, LPGA, functional derivative of L-PGA, or a combination thereof to a plant or a growth media therefor; a method of improving the carbon sequestration of a plant, comprising: a. applying a composition comprising 2HOP, a functional derivative of 2HOP, LPGA, functional derivative of L-PGA, or a combination thereof to a plant or a growth media therefor; a seed treatment composition for increasing plant growth characteristics comprising: a. 2HOP, a functional derivative of 2HOP, L-PGA, a functional derivative of LPGA, or a combination thereof, these shared technical features do not represent a contribution over the prior art as disclosed by US 2014/0038824 A1 to Los Alamos National Security, LLC (hereinafter, "Los Alamos").

Los Alamos teaches a composition for increasing plant growth characteristics comprising: a. 2HOP, a functional derivative of 2HOP, L-PGA, a functional derivative of LPGA, or a combination thereof (a composition including a mixture of L- and D-pyroglutamate stereoisomers in a ratio of L to D of from about 80:20 to about 97:3, Para. [0009]); a composition comprising 2HOP, a functional derivative of 2HOP, L-PGA, a functional derivative of L-PGA, or a combination thereof, wherein said composition regulates expression of at least one gene of a plant onto which said composition is applied (a composition including a mixture of L- and D-pyroglutamate stereoisomers in a ratio of L to D of from about 80:20 to about 97:3, Para. [0009]); a method of increasing innate tolerance to biotic and abiotic stresses in a plant comprising applying a composition comprising 2HOP, a functional derivative of 2HOP, LPGA, functional derivative of L-PGA, or a combination thereof to a plant or a growth media therefor (a method... by treating a target plant with a composition including a mixture of L- and D-pyroglutamate stereoisomers in a ratio of L to D of from about 80:20 to about 97:3, Para. [0010]); a method for inhibiting the production of a microbial toxin by a microbe infecting a plant, comprising: a. applying to at least one of a plant and a growth medium of said plant an amount of a composition effective to inhibit production of said microbial toxin, said composition comprising at least one of 2HOP, a functional derivative of 2HOP, L-PGA, and functional derivative of L-PGA (a method... by treating a target plant with a composition including a mixture of L- and D-pyroglutamate stereoisomers in a ratio of L to D of from about 80:20 to about 97:3, Para. [0010]); a method for reducing a toxin level in a plant, said method comprising: a. applying a composition comprising 2HOP, a functional derivative of 2HOP, LPGA, functional derivative of L-PGA, or a combination thereof to a plant or a growth media therefore (a method... by treating a target plant with a composition including a mixture of L- and D-pyroglutamate stereoisomers in a ratio of L to D of from about 80:20 to about 97:3, Para. [0010]); a method of increasing disease resistance in a plant comprising applying a composition comprising 2HOP, a functional derivative of 2HOP, L-PGA, functional derivative of L-PGA, or a combination thereof to a plant or a growth media therefor (a method... by treating a target plant with a composition including a mixture of L- and D-pyroglutamate stereoisomers in a ratio of L to D of from about 80:20 to about 97:3, Para. [0010]); a method for improving the resistance of a plant to the glutamine synthetase-targeting herbicide, comprising: a. applying a composition comprising 2HOP, a functional derivative of 2HOP, LPGA, functional derivative of L-PGA, or a combination thereof to a plant or a growth media therefor (a method... by treating a target plant with a composition including a mixture of L- and D-pyroglutamate stereoisomers in a ratio of L to D of from about 80:20 to about 97:3, Para. [0010]); a method for improving nutrient use efficiency of a plant, comprising: a. applying a composition comprising 2HOP, a functional derivative of 2HOP, LPGA, functional derivative of L-PGA, or a combination thereof to a plant or a growth media therefor (a method... by treating a target plant with a composition including a mixture of L- and D-pyroglutamate stereoisomers in a ratio of L to D of from about 80:20 to about 97:3, Para. [0010]); a method of improving the growth characteristics of a plant, comprising: a. applying a composition comprising 2HOP, a functional derivative of 2HOP, LPGA, functional derivative of L-PGA, or a combination thereof to a plant or a growth media therefor (a method... by treating a target plant with a composition including a mixture of L- and D-pyroglutamate stereoisomers in a ratio of L to D of from about 80:20 to about 97:3, Para. [0010]); a method of improving the carbon sequestration of a plant, comprising: a. applying a composition comprising 2HOP, a functional derivative of 2HOP, LPGA, functional derivative of L-PGA, or a combination thereof to a plant or a growth media therefor (a method... by treating a target plant with a composition including a mixture of L- and D-pyroglutamate stereoisomers in a ratio of L to D of from about 80:20 to about 97:3, Para. [0010]); a seed