INCORPORATION OF BIOLOGICAL AGENTS IN FERTILIZERS

Applicant: The Mosaic Company, Plymouth, MN (US)

Inventors: Kathlene Laurie Jacobson, Saskatoon, Saskatchewan (CA); Troy William Hobbs, Plymouth, MN (US); Lauren A. Balaban, Wimauma, FL (US)

Assignee: The Mosaic Company, Plymouth, MN (US)

Appl. No.: 15/224,473

PCT Filed: Jul. 7, 2015

PCT No.: PCT/US2015/039302

§ 371 (c)(1), Date: Jan. 6, 2017

Related U.S. Application Data

Provisional application No. 62/021,552, filed on Jul. 7, 2014.

Publication Classification

Int. Cl. C05G 3/00 (2013.01); C05B 17/00 (2013.01); C05D 1/00 (2013.01); C05D 3/0058 (2013.01)

ABSTRACT

A biological-laden dry fertilizer includes a dry fertilizer granule and a coating inoculated with a biological agent and applied to the dry fertilizer granule. The biological coating is a solution or suspension comprising water or oil and at least one biological agent, or an emulsion of an oil and a solution or suspension comprising water and at least one biological agent. The at least one biological agent is a biological chemical, plant extract, microbial agent, and/or a living organism.
Fig. 1-1

TO ATMOS.

52 SCRUBBER

OVERSIZE (HAND CHARGED)

OVERSIZE BELT FEEDER

36 ROLL MILL

30 DRYING DRUM DISCHARGE CONVEYOR

34 OVERSIZE CONVEYOR

32 SWECO SCREENER

38 RECYCLE CONVEYOR

48 PRODUCT ELEVATOR

46 PRODUCT DIVERTER

44 COOLING DRUM

28 DRYING DRUM
INCORPORATION OF BIOLOGICAL AGENTS IN FERTILIZERS

PRIORITY CLAIM

[0001] The present application claims the benefit of U.S. Provisional Application No. 62/021,552 filed Jul. 7, 2014, which is incorporated herein in its entirety by reference.

FIELD OF THE INVENTION

[0002] Embodiments of the present invention are directed to fertilizers and manufacture thereof, and more particularly incorporation of biological agents into fertilizers.

BACKGROUND OF THE INVENTION

[0003] Agricultural inorganic fertilizers typically include a base comprising at least one of three primary inorganic nutrients—nitrogen (N), phosphate (P), and potassium (K). These fertilizers are identified by their NPK rating in which the N value is the percentage of elemental nitrogen by weight in the fertilizer, and the P and K values represent the amount of oxide in the form of P₂O₅ and K₂O that would be present in the fertilizer if all the elemental phosphorus and potassium were oxidized into these forms. The N-P-K proportions or concentration vary across fertilizer types and user needs.

[0004] For example, the base fertilizer can comprise a phosphate fertilizer (such as monoammonium phosphate (“MAP”), diammonium phosphate (“DAP”), a potash fertilizer (such as muriate of potash (“MOP”)) or other potassium-based fertilizer, or a nitrogen-based fertilizer such as a fertilizer containing area. The fertilizers can also include any combination of secondary nutrients and/or micronutrients. The secondary nutrients can include sulfur compounds, calcium, and/or magnesium, and the micronutrients can include iron, manganese, zinc, copper, boron, molybdenum, and/or chlorine. The micronutrients and/or secondary nutrients can be added to solution in their elemental form, or as compounds, such as a salt.

[0005] Stressed areas, such as those areas where soil conditions are highly saline, experience frequent drought or other stresses, or cannot support agriculture or have materially reduced yield levels. In these conditions, application of fertilizers alone may be insufficient to render the stressed area profitable. Much of the world is covered by such stressed areas, and therefore a solution to make these areas suitable for the profitable cultivation of crops is needed.

SUMMARY OF THE INVENTION

[0006] According to embodiments of the invention, biological-laden or -inoculated fertilizer granules includes a dry fertilizer granule, and particularly an N-P-K based fertilizer (in which each of N, P, and K range from 0 to 100% relative content of each element), and a biological coating containing one or more biological agents or compositions, or “biologicals”, applied to the dry fertilizer granule. Some aspects, the biological agents or compositions, or “biologicals,” can comprise, for example, one or more biological chemicals, plant and other extracts, microbial agents, and/or other organisms. In some embodiments, the biological agent can comprise microorganisms, including, but not limited to, one or more species from a bacterial genus such as, but not limited to, Bacillus, Rhizobium, Azobacter, and Azospirillum, one or more species from a fungal genus or fungi such as Aspergillus, Mycorhizae, Beauveria, Metarhizium, and Trichoderma, and/or one or more species from a yeast genus such as Saccharomyces, Schizosaccharomyces, Sporobolomyces, Candida, Trichosporon, and Rhodosporidium. In other cases, the biological agent can comprise agents that are not microorganisms, including, but not limited to, small molecule and peptide-based compositions such as metabolites, peptides, lipopeptides, hormones, peptide hormones, siderophores, glycopeptides, haptens, surfactants, vitamins, enzymes, amino acids and amino acid derivatives, and/or nucleic acids and nucleic acid derivatives. Optionally, in addition to the biological agent, antimicrobial agents, pesticides, insecticides, fungicides, surfactants, emulsifiers, pigments, dyes, and/or other additives can be combined with the biological agent(s) in a biological composition.

[0007] In some embodiments, the biological coating is formed from a material or composition including an aqueous solution or dispersion and one or more biologicals dispersed throughout. In other embodiments, the biological coating material includes an oil-based carrier and one or more biologicals dispersed throughout. In yet other embodiments, the biological coating material contains a water-in-oil or an oil-in-water emulsion of an oil and a solution of water and one or more biologicals. In other words, the biologicals, and optional other additives, are dispersed in water to form a biological composition, and then the dispersed or solution is emulsified with oil, such that the biologicals are encapsulated by the water phase.

[0008] A biological-laden fertilizer can be made by a process including providing a plurality of granulated pellets comprising a fertilizer, mixing the plurality of granulated pellets, and spraying or otherwise coating the plurality of granulated pellets with such a biological-containing coating material.

[0009] The above summary of embodiments of the invention is not intended to describe each illustrated embodiment or every implementation of the present invention. The figures and the detailed description that follow more particularly exemplify these embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Embodiments of the invention may be more completely understood in consideration of the following detailed description in connection with the accompanying drawings, in which:

[0011] FIG. 1 is a schematic illustration of a process for manufacturing a dry phosphate-based fertilizer, according to an embodiment.

[0012] FIG. 2 is a schematic illustration of a process for manufacturing a dry potash-based fertilizer, according to an embodiment.

[0013] FIG. 3 is a perspective view of a spraying system configured to apply a solution including biologicals to a dry fertilizer, according to an embodiment.

[0014] FIG. 4 is a schematic illustration of a process for manufacturing a biological containing emulsion, according to an embodiment.

[0015] While the invention is amenable to various modifications and alternative forms, specifics thereof have been shown by way of example in the drawings and will be described in detail. It should be understood, however, that the intention is not to limit the invention to the particular embodiments described. On the contrary, the intention is to
cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE DRAWINGS

[0016] Biologicals, such as, but not limited to, biological chemicals, plant and other extracts, microbial agents, and/or other living organisms, such as, for example, endophytes, fungi, yeasts, and bacteria, can be added to dry fertilizers to improve plant health and overall crop yield. The biologicals are added to fertilizer in the form of an emulsion, so that the biological can be suspended in water without undesirably increasing the moisture content of the fertilizer beyond a critical relative humidity at which the fertilizer is more likely to cake. Use of fertilizers containing such biologicals can be sufficient to render stressed areas more profitable.

[0017] FIG. 1 is a schematic illustrating a non-limiting embodiment of a system that uses a process known as granulation to produce dry phosphate fertilizers. In one non-limiting embodiment, the fertilizer granules are formed using the granulation methods described in U.S. Pat. No. 6,544,313 ("313 Patent") entitled "Sulfur-Containing Fertilizer Composition and Method for Preparing Same," incorporated herein by reference in its entirety. In another non-limiting embodiment, the fertilizer granules are formed using the granulation methods described in U.S. Pat. No. 7,497,891 entitled "Method For Producing A Fertilizer With Micronutrients," incorporated herein by reference in its entirety.

[0018] The granulation system illustrated in FIG. 1 is similar to the granulation process shown in FIG. 1 of the '313 patent, and also includes vessel 6 and spray or sparger 8. Vessel 6 is a device or vessel for generating a biological coating material comprising a solution, dispersion, or emulsion containing biologicals. For example, one or more biologicals, in various non-limiting embodiments and combinations as described throughout, can be dissolved or dispersed in oils, in water, in emulsions thereof, or any other suitable carrier medium in vessel 6.

[0019] As discussed above, examples of biologicals include one or more species from a bacterial genus such as, but not limited to, Bacillus, Rhizobium, Azobacter, and Azospirillum, one or more species from a fungal genus or fungi such as Aspergillus, Mycorrhizae, Beauveria, Mortanizium, and Trichoderma, and/or one or more species from a yeast genus such as Saccharomyces, Schizosaccharomyces, Sporabolomyces, Candida, Trichosporon, and Rhodosporidium. Other biologicals are not microorganisms, but rather can be small molecule and peptide-based compositions such as metabolites, peptides, lipopeptides, hormones, peptide hormones, siderophores, glycopeptides, humates, surfactants, vitamins, enzymes, amino acids and acidic amino acid derivatives, and nucleic acids and nucleic acid derivatives. Optionally, in addition to the biological agent, antimicrobial agents, pesticides, insecticides, fungicides, surfactants, emulsifiers, pigments, dyes, and/or other additives can be combined with the biological agent(s) in a biological composition. Non-limiting examples of compositions containing biological agents and other additives can be found in U.S. Patent Application Publication Nos. 2015/0148228 (entitled "Composition Comprising a Biological Control Agent and a Fungicide"); 2015/0141246 (entitled "Compositions Comprising a Biological Control Agent and an Insecticide"); 2015/0141245 (entitled "Compositions Comprising a Biological Control Agent and a Fungicide from the Group Consisting of Inhibitors of the Respiratory Chain at Complex I or II"); and 2015/0141244 (entitled "Compositions Comprising a Biological Control Agent and an Insecticide"), all of which are herein incorporated by reference in their entireties.

[0020] One or more of these biologicals (or others and/or other additives) can be dissolved into or suspended in the carrier medium in vessel 6. In embodiments, vessel 6 can be a shear mixer, emulsifier, roller, or shaker/agitator, for example.

[0021] FIG. 1 is a schematic illustrating a non-limiting embodiment of a system that uses a process known as granulation to produce dry phosphate fertilizers. In one non-limiting embodiment, the fertilizer granules are formed using the granulation methods described in U.S. Pat. No. 6,544,313 ("313 Patent") entitled "Sulfur-Containing Fertilizer Composition and Method for Preparing Same," incorporated herein by reference in its entirety. In another non-limiting embodiment, the fertilizer granules are formed using the granulation methods described in U.S. Pat. No. 7,497,891 entitled "Method For Producing A Fertilizer With Micronutrients," incorporated herein by reference in its entirety.

[0022] One or more spray stations 8 for application of a biological solution in combination with one or more other additives. For example, spray stations 8 can be used to apply a de-dust oil to fertilizer granules in addition to a solution containing biological, either sequentially or simultaneously. Alternatively, as discussed above, the solution can comprises an aqueous based solution, an oil-based solution, or an emulsion, such as an emulsion of water-encapsulated biologicals emulsified with an oil.

[0023] Biologicals applied accordingly have the potential to enhance the growth and development of plants as well as function as a bio-pesticide to treat plant pests, such as, for example, plant diseases. Application rates of the liquid-biological mixture can be in the range of 1-10 L/dry ton of fertilizer, for example. In some embodiments, the biological-inoculated composition can be applied to dry fertilizer in the range of 2-3 L/dry ton of fertilizer. After application, fertilizers can possess various densities of CFUs. In one embodiment, fertilizers can be sprayed with biological spray station 8 until they have a biological concentration of 10^6 CFU/g or more.

[0024] Once the fertilizer has been treated with biologicals, it can be applied to soil via broadcasting, banding or other potential means. The fertilizer acts as the delivery method for introducing biologicals to the soil. Once in the soil, the biological targets the plant rhizosphere and reduces the plant stress in one or more of several ways such as in the following descriptions. For example, biologicals can compete with pathogens for nutrients at the root surface. Further, biologicals can produce toxins that inhibit growth and reproduction of pathogens. Biologicals can produce stimu-
latory compounds absorbed by the roots of plants, and can also parasitize fungal pathogens, insects, or nematodes.

**[0025]** FIG. 2 is a schematic illustrating a system that uses a process known as compaction to produce dry potash fertilizers. Similarly to the granulation process shown in FIG. 1, biologicals may be added at various points in a compaction process. As such, potash fertilizer can act as a carrier for the biologicals that are added in an emulsion.

**[0026]** One example of potash fertilizer manufacturing process shown in FIG. 2 includes the steps of providing a raw fertilizer material feed, shown here as muriate of potash (MOP) feed 110 for exemplary purposes only. One of ordinary skill in the art would recognize that other potash sources can also be contemplated. Optionally, a binder can be added at step 112. The fertilizer is blended in bulk at step 114. Steps 116-124 are a loop for properly sizing the finished fertilizer pellets. At step 116, compaction takes place and, at step 118 the compacted MOP (and any additives) are crushed. At step 120, the crushed MOP is screened for size. Undersized MOP pellets are returned, via step 122, to be re-compact. Oversized MOP pellets are returned, via step 124, to be re-crushed. Those pellets that fit within some desired size parameters exit the sizing loop and make up the final product, at step 126.

**[0027]** In the embodiment shown in FIG. 2, and similar to the process of FIG. 1, a biological coating solution is formed in vessel 106, that is then applied via the biological application or spray station 108, which can be applied to a potash fertilizer at any of several steps in the process of making the fertilizer. Vessel 106 and biological spray station 108 are substantially similar to vessel 6 and biological spray station 8 of FIG. 1, respectively. The biological coating solution can be applied to the MOP fertilizer pellets at one or more steps, as shown. For example, the biological coating solution can be sparged onto the MOP feed at step 110. Alternatively, the biological coating solution can be added at the bulk blending 114 step. Additionally or alternatively, the biological coating solution can be added to the product 126.

**[0028]** FIG. 3 is a perspective view of a mixing system 200 by which the biologicals described with respect to FIGS. 1 and 2 can be added to dry fertilizer, according to an embodiment.

**[0029]** Mixing system 200 includes pipe 206, which is the outlet of a vessel. Pipe 206 is connected to sprayers 207. Sprayers 207 deliver biological coating solution 208 which can comprise, as discussed above, an aqueous-based solution or dispersion, an oil-based solution or dispersion, or an emulsion of oil and water or biological-laden water (e.g. inoculated water-in-oil or in-water, or inoculated water-in-oil-in-water), onto fertilizer 210. While sprayers 207 are spraying biological spray 208, mixer 212 agitates fertilizer 210, to promote even distribution of biological coating solution 208 onto the pellets of fertilizer 210.

**[0030]** FIG. 4 is a flow chart depicting an emulsion process, according to one non-limiting embodiment. Water 300 and biologicals 302 (and optional additives not shown) are combined into solution or suspension 304. Solution 304 is combined with oil 306 in a shear mixer 308 to form emulsion 310. In some embodiments, shear mixer 305 generates emulsion 310 that contains pockets of solution 304, such that biologicals 302 are dispersed only in water 300. This facilitates the use of biologicals 302 that are more stable in water 300 than oil 306, as well as allowing subsequent coating of fertilizer in such a way that the relative humidity or moisture content of the fertilizer is not substantially increased. This can be important because significant increase in the water content of fertilizers can cause clumping or sintering.

**[0031]** In some embodiments, oil 306 can be a dedusting oil, such as those described in WIPO Publication No. WO 2015/026806, entitled SYSTEM AND METHODS FOR ADDITION OF BENEFICIAL AGRICULTURAL, BIOLOGICAL, AND/OR DEDUSTING ADDITIVES TO GRANULAR FERTILIZERS, incorporated herein by reference in its entirety, and/or can comprise oil having the trade name Dustrol, Dustrol Plus, VM160, N100, N150, N300 etc., mineral oils, vegetable oils, optionally inoculated with biologicals.

**[0032]** In embodiments, the biological-inoculated liquid or aqueous portion of the emulsion can have a biological concentration equal to or greater than 10^6 CFU/g. For example, the biologicals 302 are present in the emulsion 310 at a final concentration of about 10^4 to about 10^5 CFU (colony forming units)/g, and more particularly about 10^4 to about 10^5 CFU/g. The coating is then added to the fertilizer, such as, for example 4.1 mls of an aqueous solution comprising biologicals can be added to every 1 lb of fertilizer, or alternatively, about 10^5 to about 10^6 CFU/L can be added to liquid fertilizer to achieve the above final target concentration.

**[0033]** According to this embodiment, water 300 is inoculated with biologicals 302. Optional other additives, such as those described above, can also be dispersed within water 300. An oil, such as mineral oil, load-out oil, and/or another oil source, is obtained and used as oil 306 such that the inoculated water solution 304 is mixed with the oil 306 using a high-shear mixer or blender to create water particles or pockets (containing biological and optional other additives) inside the oil. In an embodiment, the water particles can comprise 30-80% of the total emulsion. In this way, the critical relative humidity of the fertilizer is no changed or increased, thereby reducing the probability of caking. Because inoculating oils 306 with biologicals 302 directly can hinder the viability of the biological, suspending the biological in water in an oil-in-water or water-in-oil emulsion can provide increased stability and/or efficacy. As such, it is often desirable to use water to protect the health of the biological 302, but reduce the volume of water 300 on the fertilizer that is subsequently coated by emulsion 310 by suspending the biological-laden water solution 304 in oil.

**[0034]** Various embodiments of systems, devices and methods have been described herein. These embodiments are given only by way of example and are not intended to limit the scope of the invention. It should be appreciated, moreover, that the various features of the embodiments that have been described may be combined in various ways to produce numerous additional embodiments. Moreover, while various materials, dimensions, shapes, configurations and locations, etc. have been described for use with disclosed embodiments, others besides those disclosed may be utilized without exceeding the scope of the invention.

**[0035]** Persons of ordinary skill in the relevant arts will recognize that the invention may comprise fewer features than illustrated in any individual embodiment described above. The embodiments described herein are not meant to be an exhaustive presentation of the ways in which the various features of the invention may be combined. Accordingly, the embodiments are not mutually exclusive combi-
nations of features; rather, the invention may comprise a combination of different individual features selected from different individual embodiments, as understood by persons of ordinary skill in the art.

[0036] Any incorporation by reference of documents above is limited such that no subject matter is incorporated that is contrary to the explicit disclosure herein. Any incorporation by reference of documents above is further limited such that no claims included in the documents are incorporated by reference herein. Any incorporation by reference of documents above is yet further limited such that any definitions provided in the documents are not incorporated by reference herein unless expressly included herein.

1. A biologically coated dry fertilizer comprising:
   a dry fertilizer granule; and
   a biological coating applied to the dry fertilizer granule,
   the biological coating comprising a solution or suspension comprising water or oil and at least one biological agent, or an emulsion of an oil and a solution or suspension comprising water and at least one biological agent
   wherein the at least one biological agent is a biological chemical, plant extract, microbial agent, and/or a living organism.

2. The biological-laden dry fertilizer of claim 1, wherein the at least one biological agent is a bacteria selected from the group consisting of Bacillus, Rhizobium, Azobacter, Azospirillum, and combinations thereof.

3. The biological-laden dry fertilizer of claim 1, wherein the at least one biological agent is a fungus selected from the group consisting of Aspergillus, Mycorhiza, Beauveria, Mucor, and Trichoderma, Saccharomyces, Schizosaccharomyces, Sporobolomyces, Candida, Trichosporon, and Rhodosporidium, and combinations thereof.

4. The biological-laden dry fertilizer of claim 1, wherein the at least one biological agent is selected from the group consisting of metabolites, peptides, lipopeptides, hormones, peptide hormones, siderophores, glycopeptidases, humates, surfactants, vitamins, enzymes, amino acids, amino acid derivatives, nucleic acids, nucleic acid derivatives, and combinations thereof.

5. The biological-laden dry fertilizer of claim 1, wherein the at least one biological agent is applied to the fertilizer granule such that a final concentration of biological agent is of about 10⁷ to about 10¹² CFU/g.

6. The biological-laden dry fertilizer of claim 1, wherein the dry fertilizer granule comprises a phosphate material.

7. The biological-laden dry fertilizer of claim 1, wherein the dry fertilizer granule comprises potash material.

8. A method of making a biological-laden fertilizer, the method comprising:
   providing a plurality of granulated pellets comprising a fertilizer;
   mixing the plurality of granulated pellets; and
   spraying the plurality of granulated pellets with a biological coating comprising a solution or suspension comprising water or oil and at least one biological agent, or an emulsion of an oil and a solution or suspension comprising water and at least one biological agent, wherein the at least one biological agent is a biological chemical, plant extract, microbial agent, and/or a living organism.

9. The method of claim 8, wherein the oil is a deastringe oil.

10. The method of claim 8, wherein the at least one biological agent is selected from the group consisting of metabolites, peptides, lipopeptides, hormones, peptide hormones, siderophores, glycopeptidases, humates, surfactants, vitamins, enzymes, amino acids, amino acid derivatives, nucleic acids, nucleic acid derivatives, and combinations thereof.

11. The method of claim 8, wherein the at least one biological agent is a bacteria selected from the group consisting of Bacillus, Rhizobium, Azobacter, Azospirillum, and combinations thereof.

12. The method of claim 8, wherein the at least one biological agent is a fungus selected from the group consisting of Aspergillus, Mycorhiza, Beauveria, Mucor, and Trichoderma, Saccharomyces, Schizosaccharomyces, Sporobolomyces, Candida, Trichosporon, and Rhodosporidium, and combinations thereof.

13. The method of claim 8, wherein the granulated fertilizer pellets comprise a phosphate material.

14. The method of claim 8, wherein the granulated fertilizer pellets comprise a potash material.

15. The method of claim 8, wherein the biological coating comprises an emulsion of oil and a solution of water and the biological agent, and wherein the process further comprises generating the emulsion with a high-speed shear mixer.

16. The method of claim 8, wherein the process further comprises screening the size of the sprayed plurality of granulated fertilizer.

17. The method of claim 16, wherein spraying the plurality of granulated pellets occurs prior to screening.

18. The method of claim 16, wherein spraying the plurality of granulated pellets occurs after screening.

19. The method of claim 8, wherein providing a plurality of granulated fertilizer pellets comprises compaction.

20. The method of claim 8, wherein providing a plurality of granulated fertilizer pellets comprises granulation.

* * * * *