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(54) Title: METHOD OF CONTROLLING FUSARIUM VIGULIFORME

(57) Abstract: Methods of controlling *Fusarium virguliforme* and Soybean Sudden Death Syndrome (SSDS) through the use a combination of thiabendazole and a nematicide.

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METHOD OF CONTROLLING FUSARIUM VIGULIFORME

[0001] The present technology relates to methods of controlling or reducing *Fusarium virguliforme* and Soybean Sudden Death Syndrome (SSDS) using a combination of thiabendazole and a nematicide or nematicides. More specifically, the present technology relates to methods of controlling or reducing *Fusarium virguliforme* and Soybean Sudden Death Syndrome (SSDS) using a combination of thiabendazole, abamectin and/or *bacillus firmus*.

[0002] Thiabendazole is a benzimidazole fungicide commonly used to control certain types of mold (e.g. blue and grey molds) and blight. Abamectin is an insecticide and nematicide commonly used to control certain types of insect and nematode pests. *Bacillus firmus* is an nematicide commonly used to control certain types of nematode pest. *Bacillus firmus*, strain I-1582, is commercially available nematicde available from Bayer CropScience sold under the trade name VoTiVo® (2011).

[0003] *Fusarium virguliforme*, formally known as *F. solani* f. sp. *glycines* (Aoki et al., 2003), is a soybean pathogen affecting soybean roots, and which later develops into the disease Soybean Sudden Death Syndrome (SSDS).

[0004] Methods of controlling *Fusarium virguliforme* and subsequently SSDS are limited. Certain soybean seed varieties have proven somewhat tolerant to *F. virguliforme* and SSDS, however no known commercial varieties are resistant enough to provide adequate disease control. Various in-furrow and seed applied fungicides are also used combat the pathogens, but the pathogens have proven hard to control and no suitable chemical fungicide was previously known for its ability to adequately control *F. virguliforme* and SSDS.

[0005] The present technology provides for the control of *F. virguliforme* and SSDS by applying the chemical thiabendazole in combination with either or both abamectin and *bacillus firmus* to plant propagation material prior to sowing. The present technology also provides for the application of thiabendazole in combination with either or both abamectin and *bacillus firmus* to the locus of the plant propagation material for the control of *F. virguliforme* and SSDS. The present technology also provides for the application of thiabendazole in combination with either or both abamectin and *bacillus firmus* to the soil where the plant propagation material has been, or will be, sown for the control of *F. virguliforme* and SSDS, for example, as an in-furrow application.

[0006] Plant propagation material, as defined herein, encompasses both true seeds and plant propagation material. While plant propagation material encompasses true seeds, plant propagation material itself is commonly referred to as a seed and is defined as such herein. Most seed treatments are applied to true seeds, which have a seed coat surrounding an embryo. Seed treatments are also applied to plant propagation materials such as rhizomes, bulbs, corms or tubers.

[0007] The active ingredient may be used in unmodified form but is normally used in the form of compositions. It can be applied together with further carriers, surfactants or other application-promoting adjuvants customarily employed in formulation technology. Suitable carriers and adjuvants can be solid or liquid and are the substances ordinarily employed in formulation technology, e.g. natural or regenerated mineral substances, solvents, dispersants, wetting agents, tackifiers, thickeners, binders or fertilizers.

[0008] The active ingredient is conveniently formulated in known manner e.g. into emulsifiable concentrates, coatable pastes, directly sprayable or dilutable solutions, dilute emulsions, wettable powders, soluble powders, dusts, granules, or by encapsulation in e.g. polymer substances. As with the nature of the compositions, the methods of application, such as spraying, atomising, dusting, scattering, coating or pouring, are chosen in accordance with the intended objectives and the prevailing circumstances.

[0009] The present technology provides for the application of thiabendazole to a seed at a rate of from about 0.1 to about 100 g thiabendazole/100 kg seed. Additionally preferred rate ranges in (g thiabendazole)/(100 kg seed) include 0.5 to 50, 1 to 50, 1 to 25, 5 to 25, 10 to 25, 15 to 25, 17.5 to 22.5. In one embodiment the preferred target application rate is 20 g thiabendazole/100 kg seed.

[0010] The present technology provides for the application of abamectin to a seed at a rate of from about 0.1 to about 200 g abamectin/100 kg seed. Additionally preferred rate ranges in (g abamectin)/(100 kg seed) include 0.5 to 150, 50 to 125, 50 to 115, 75 to 110, 90 to 110, 95 to 105. In one embodiment the preferred target application rate is 100 g abamectin/100 kg seed.

[0011] The present technology provides for the application of *bacillus firmus* to a seed at a rate of from about 0.1 to about 50 g *bacillus firmus*/100 kg seed. Additionally preferred rate ranges in (g *bacillus firmus*)/(100 kg seed) include 0.5 to 50, 1 to 25, 5 to 25, 5 to 20, 5 to 15, and 5 to 10. In one embodiment the preferred target application rate is 7 g *bacillus firmus* /100 kg seed. In one embodiment the *bacillus firmus* is the strain I-1582 and contains 1.5×10^{11} CFU's (colony forming units) per gram.

[0012] The present technology provides for the application of thiabendazole, abamectin and/or *bacillus firmus* in synergistically effective application rates.

[0013] The present technology can also be used in combination with other additional pesticides in order to increase the pest control spectrum. Other pesticides include, but are not limited to, insecticides, fungicides, nematicides, acaricides, molluscicides, and bacteriacides.

[0014] Suitable additions of insecticidally, acaricidally, nematicidally, or molluscicidally active ingredients are, for example and not for limitation, representatives of the following classes of active ingredients: organophosphorus compounds, nitrophenols and derivatives, formamidines, triazine

derivatives, nitroenamine derivatives, nitro- and cyanoguanidine derivatives, ureas, benzoylureas, carbamates, pyrethroids, chlorinated hydrocarbons and *Bacillus thuringiensis* products. Especially preferred components in mixtures are abamectin, cyanoimine, acetamiprid, thiodicarb, nitromethylene, nitenpyram, clothianidin, dinotefuran, fipronil, lufenuron, pyripfoxyfen, thiacloprid, fluxofenime; imidacloprid, thiamethoxam, chlorantraniliprole, cyantraniliprole, spinosad, sulfloxaflor, beta cyfluthrin, lambda cyhalothrin, fenoxycarb, diafenthiuron, pymetrozine, diazinon, disulphoton; profenofos, furathiocarb, cyromazin, cypermethrin, tau-fluvalinate, tefluthrin or *Bacillus thuringiensis* products, very especially abamectin, thiodicarb, cyanoimine, acetamiprid, nitromethylene, nitenpyram, clothianidin, dinotefuran, fipronil, thiacloprid, imidacloprid, thiamethoxam, chlorantraniliprole, cyantraniliprole, spinosad, beta cyfluthrin, lambda cyhalothrin, and tefluthrin.

[0015] Preferred insecticidally, acaricidally, nematicidally, or molluscicidally active ingredients are, for example and not for limitation thiamethoxam, imidacloprid, thiacloprid, clothianidin, chloranthraniliprole, thiodicarb, abamectin, acetamidrprid, fipronil, tefluthrin, lambda cyhalothrin, and beta cyfluthrinSuitable additions of fungicidally active ingredients are, for example and not for limitation, representatives of the following classes of active ingredients: strobilurins, triazoles, ortho-cyclopropyl-carboxanilide derivatives, phenylpyrroles, and systemic fungicides. Examples of suitable additions of fungicidally active ingredients include, but are not limited to, the following compounds: azoxystrobin; sedaxane, bitertanol; carboxin; Cu_2O; cymoxanil; cyproconazole; cyprodinil; dichlofluamid; difenoconazole; diniconazole; epoxiconazole; fenpiclonil; fludioxonil; fluoxastrobin, fluquiconazole; flusilazole; flutriafol; furalaxyl; guazatin; hexaconazole; hymexazol; imazalil; imibenconazole; ipconazole; kresoxim-methyl; mancozeb; metalaxyl; mefenoxam; metconazole; myclobutanil, oxadixyl, pefurazoate; penconazole; pencycuron; prochloraz; propiconazole; pyroquilone; (±)-*cis*-1-(4-chlorophenyl)-2-(1*H*-1,2,4-triazol-1-yl)cycloheptanol; spiroxamin; tebuconazole; thiabendazole; tolifluamide; triazoxide; triadimefon; triadimenol; trifloxystrobin, triflumizole; triticonazole and uniconazole. Particularly preferred fungicidally active agents include azoxystrobin, difenoconazole, fludioxonil, thiabendazole, tebuconazole, metalaxyl, mefenoxam, sedaxane, myclobutanil, fluoxastrobin, tritaxonazole, and trifloxystrobin.

[0016] Depending upon the particular plant propagation material to be treated, the conditions under which it is to be stored, and the soil and weather conditions under which it is expected to germinate and grow, the compositions of the present invention may include a wide spectrum of one or more additives. Such additives include, but are not limited to, uv-protectants, pigments, dyes, extenders such as flour, dispersing agents, excipients, anti-freezing agents, preservatives, herbicidal safeners, seed safeners, seed conditioners, micronutients, fertilizers, biocontrol agents, inoculants,

surfactants, sequestering agents, plasticizers, colorants, brighteners, emulsifiers, flow agents such as calcium stearate, talc and vermiculite, coalescing agents, defoaming agents, humectants, thickeners, waxes, bactericides, insecticides, pesticides, and fillers such as cellulose, glass fibers, clay, kaolin, talc, pulverized tree bark (e.g., Douglas fir bark or alderbark), calcium carbonate and wood meal, and odor-modifying agents. Typical excipients include finely divided mineral substances such as pumice, attapulgite, bentonite, kaoline zeolite, diatomite, and other clays, modified diatomaceous adsorbents, charcoal, vermiculite, finely divided organic substances such as peat moss, wood powder, and the like. Such additives are commercially available and known in the art.

[0017] Typically, when a mixture of the components is prepared, either as tank-mixes, pre-mixes, dry dust-mixes, wettable powders, granules, soluable concentrates, emulsifyable concentrates, or flowable solutions, other formulation auxiliaries may also be used. Such formulation auxiliaries are known in the art.

CLAIMS

1. A method for controlling or reducing *Fusarium virguliforme* in plants comprising:

applying thiabendazole and abamectin to a plant seed prior to planting; and

planting said plant seed.

2. A method for controlling or reducing *Fusarium virguliforme* in plants comprising:

planting a plant seed treated with thiabendazole and abamectin.

3. A method for reducing damage to a plant or plant seed caused by *Fusarium virguliforme* comprising:

applying thiabendazole and abamectin to a plant seed prior to planting; and

planting said plant seed.

4. A method for reducing damage to a plant or plant seed caused by *Fusarium virguliforme* comprising:

planting a plant seed treated with thiabendazole and abamectin.

5. A method for controlling or reducing Sudden Death Syndrome in plants comprising:

applying thiabendazole and abamectin to a plant seed prior to planting; and

planting said plant seed.

6. A method for controlling or reducing Sudden Death Syndrome in plants comprising:

planting a plant seed treated with thiabendazole and abamectin.

7. A method for reducing damage to a plant or plant seed caused by Sudden Death Syndrome comprising:

applying thiabendazole and abamectin to a plant seed prior to planting; and

planting said plant seed.

8. A method for reducing damage to a plant or plant seed caused by Sudden Death Syndrome comprising:

planting a plant seed treated with thiabendazole and abamectin.

9. A method for controlling or reducing *Fusarium virguliforme* in plants comprising:

applying thiabendazole and abamectin to the locus of a plant seed or to the soil where a plant seed has been, or will be, sown.

10. A method for reducing damage to a plant or plant seed caused by *Fusarium virguliforme* comprising:

applying thiabendazole and abamectin to the locus of a plant seed or to the soil where a plant seed has been, or will be, sown.

11. A method for controlling or reducing Sudden Death Syndrome in plants comprising:

applying thiabendazole and abamectin to the locus of a plant seed or to the soil where a plant seed has been, or will be, sown.

12. A method for reducing damage to a plant or plant seed caused by Sudden Death Syndrome comprising:

applying thiabendazole and abamectin to the locus of a plant seed or to the soil where a plant seed has been, or will be, sown.

13. The methods of any of claims 1-12 wherein said plant seed is a soybean seed.

14. The methods of any of claims 1-13 wherein said plant seed exhibits a resistant trait to soybean sudden death syndrome.

15. The methods of any of claims 1-14 , further comprising the application of *bacillus firmus*.

16. The methods of claim 15, where said *bacillus firmus* is the strain I-1582.

17. A method for controlling or reducing *Fusarium virguliforme* in plants comprising:

applying thiabendazole and *bacillus firmus* to a plant seed prior to planting; and

planting said plant seed.

18. A method for controlling or reducing *Fusarium virguliforme* in plants comprising:

planting a plant seed treated with thiabendazole and *bacillus firmus*.

17. A method for controlling or reducing *Fusarium virguliforme* in plants comprising:

applying thiabendazole and a nematcide to a plant seed prior to planting; and

planting said plant seed.