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(54) Title: A FUNGICIDAL TREATMENT FOR BLACK SIGATOKA

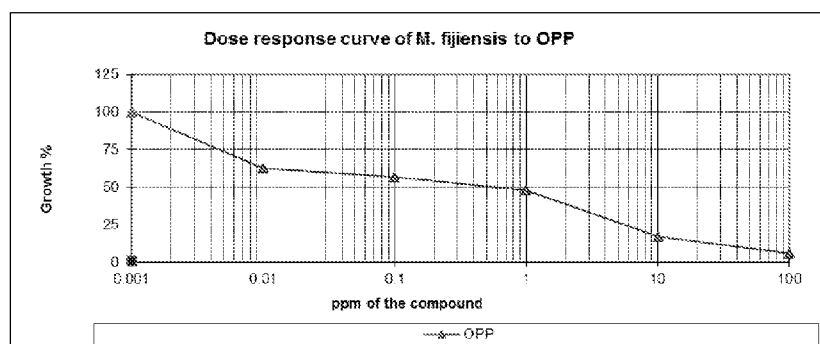


Figure 7 – Dose response curve for OPP.

(57) Abstract: A method and composition for preventive and/or curative control of black sigatoka disease in banana is disclosed.



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A FUNGICIDAL TREATMENT FOR BLACK SIGATOKA

TECHNICAL FIELD:

The present invention relates to methods of controlling fungal diseases in plants. More specifically, the present invention relates to use of fungicides for the treatment of foliar diseases in banana.

BACKGROUND AND PRIOR ART:

Banana is of the most economically important crops grown in Asian, Africa and the Americas. Like all plants, the banana plant is subject to many diseases. The most damaging and possibly commercially important disease in banana is the black sigatoka diseases also known as black leaf streak. The disease is characterized by dark leaf spots that eventually enlarge and coalesce, causing much of the leaf area to turn yellow then brown to finally black. The disease is caused by Ascomycetes fungi *Mycosphaerella fijiensis* (Morelet). *Mycosphaerella fijiensis* (Morelet) is a very specific filamentous fungi, extremely slow growing, its properties differ significantly from the other plant pathogens such as powdery mildew and *Botrytis cinerea*.

Black Sigatoka attacks leaves during the entire growth period up to the time of harvesting. It initially causes spotting and blotching of the leaf surfaces that results in necrosis and withering of the leaf tissue. The course of the disease is usually slow, but on account of the reduction of the active leaf surface leads to decrease in photosynthesis. This in turn results in decrease in growth and maturity of the fruit, which directly impacts the yield and quality of the fruit. Black Sigatoka has a wide host range and infects most species of banana including dessert bananas, cooking bananas, and plantains.

The ascospores, and to a certain extent conidia, are the propagules by which the fungus is dispersed by wind. The conidia form readily in high humidity, especially if a film of free water is present on leaves. These asexual spores disperse during rain-wash and splashing, causing local spread of the disease. The spread of the disease is rapid and chemical control is usually used to control and treat the disease. There are many chemical fungicides known to treat and control the spread of Black Sigatoka disease. These fungicides include

commonly known contact fungicides such as mancozeb, chlorothalonil, as well as systemic fungicides such as morpholine, demethylation inhibitors (DMI), or strobiliurin (QoI) fungicides, benzimidazoles etc. Resistance to benzimidazole, DMI, and strobiliurin fungicides is widespread in many production areas.

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Researchers are constantly in search of newer fungicides that can control the disease without resistance developing, since developing resistance results in decreased sensitivity, which increases dosage as well as renewed efforts to find newer fungicides that can control and treat the disease.

10

O-Phenylphenol or OPP is a versatile compound that has over the years been used in many applications such as, fungicide for use in post-harvest, to use as a fungicidal agent in the leather industry. OPP is also used in the paint and paper industry as well as in the metallurgy industry. **US1200104 (Gray)** teaches the use of OPP as a foliar fungicide for control of canker, mildew, scab and blossom wilt in apples, pears, tomato, wheat and barley. The patent teaches the lowered incidences of diseases on the affected crop. **GB2288980 (A) (Ruess)** teaches the use of fenpropidin on black sigatoka. However, the use of the active is not effective enough.

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There is therefore a need in the art for a fungicide that can be used to control/treat Black Sigatoka disease without the risk of resistance being developed. There is a need in the art for a fungicide that completely controls the disease and prevents the spread of the disease further.

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Embodiments of the present invention can therefore provide for one or more advantages of the present invention:

Objects of the invention:

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One object of the present invention is to provide a method of controlling black Sigatoka disease in banana.

Another object of the invention is to provide a method of increasing yield in banana crop.

Another object of the present invention is to provide a method of improving plant health in banana.

- 5 Yet another object of the present invention is to provide a composition for the control of Black Sigatoka in banana.

Yet another object of the present invention is to provide the following advantages –

- 10 (1) A fungicide that was hitherto not known to be used to control black sigatoka for banana.
- (2) A method of controlling black sigatoka and improving the health of the plant.
- (3) A method of controlling black sigatoka and improving yield of the plant.
- (4) A method of controlling black sigatoka that can rapidly prevent spread of the disease of the plant.

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Some or all of these and other objects of the invention are can be achieved by way of the invention described hereinafter.

SUMMARY OF THE INVENTION:

- 20 Therefore, in one aspect, the present invention can provide a method of preventing or partially preventing black sigatoka or a symptom or condition associated with black sigatoka in banana, said method comprising applying ortho-phenylphenol or a salt thereof to the locus of the disease.
- 25 Therefore, in another aspect, the present invention may provide a method for partial or complete curative control of the disease, condition, symptom or adverse effect associated with the incidence of black sigatoka in banana, said method comprising applying ortho-phenylphenol or a salt thereof and at least another fungicide to the locus of the disease.
- 30 In yet another aspect, the present invention may provide a method of increasing yield of a banana tree, said method comprising applying ortho-phenylphenol or a salt thereof to the banana tree.

Another aspect of the present invention may provide a composition for preventing or partially preventing black sigatoka or a symptom or condition associated with black sigatoka in banana, said composition comprising ortho-phenylphenol or a salt thereof.

5 **DETAILED DESCRIPTION OF THE INVENTION:**

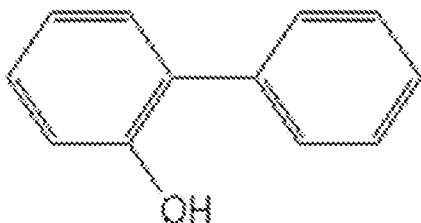
Therefore embodiments of the present invention provide methods of preventing or partially preventing black sigatoka or a symptom or condition associated with black sigatoka in banana, comprising applying an agriculturally acceptable amount of ortho-phenylphenol to the infected loci.

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It has now been surprisingly found that ortho-phenylphenol has a preventive or prophylactic effect on black sigatoka in banana. In this embodiment, ortho-phenylphenol was found to be prophylactic in terms of preventing or partially preventing black sigatoka or a symptom or condition associated with black sigatoka in banana.

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O-phenylphenol (OPP) is a phenol based compound having the structure:



20 OPP has been conventionally used in post-harvest methods to control fruit rot in citrus fruit. It is also used as a preservative and biocide in other industries. Ortho-phenylphenol and its sodium salt are used in the rubber industry, and as disinfectants. Ortho-Phenylphenol is also used as an intermediate for dyes, resins and rubber chemicals, as a germicide, and was used as a preservative in food packaging. It is used as a disinfectant
25 for impregnation of fruit wrappers and disinfection of seed boxes and is applied during the dormant period to control apple canker. It is used as a reagent for the determination of trioses, as a household disinfectant and in dish-washing formulations.

The compound has not been previously used on banana, either pre- or post-harvest. The present inventors have therefore, surprisingly found that ortho-phenylphenol can be used to prevent and/or control black sigatoka disease in banana. The present inventors have surprisingly found that use of ortho-phenylphenol in low volumes results in prevention and/or control of black sigatoka.

The present invention therefore allows for a reduction in dosage of ortho-phenylphenol whilst preventing the disease, thereby providing an improvement over the present fungicides known to be used for control of black sigatoka.

Accordingly, the present invention provides in various embodiments, methods and compositions for preventing or partially preventing black sigatoka or a symptom or condition associated with black sigatoka in banana by applying ortho-phenylphenol to the affected loci.

The present inventors have surprisingly found the following hitherto unknown benefits of ortho-phenylphenol:

- prophylactically prevents or partially prevents black sigatoka or a symptom or condition associated with black sigatoka in banana; and
- partial or complete curative control of the disease, condition, symptom or adverse effect associated with the incidence of black sigatoka in banana when administered in combination with a second fungicide.

The term 'disease control' as used herein denotes control and prevention of a disease. The term 'OPP' can be used interchangeably with o-phenylphenol or 2-phenylphenol. Controlling effects include all deviation from natural development, for example: killing, retardation, decrease of the fungal disease. The term 'plants' refers to all physical parts of a plant, including seeds, seedlings, saplings, roots, tubers, stems, stalks, foliage and fruits. The 'locus' is intended to the site of the established vegetation and/or parts of the established vegetation such as leaves or foliage, saplings etc. Banana plants may be of any

variety of the species *Musa x paradisiaca*. The term “agriculturally acceptable amount of active” refers to an amount of an active that kills or inhibits the plant disease for which control is desired, in an amount not significantly toxic to the plant being treated. It is also readily understood that OPP also encompasses its salts, namely sodium and potassium salts.

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Therefore, in one aspect, the present invention can provide a method of preventing or partially preventing black sigatoka or a symptom or condition associated with black sigatoka in banana, said method comprising applying ortho-phenylphenol or a salt thereof to the locus of the disease.

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In an embodiment, the ortho-phenylphenol may be used in the presence of a mineral oil.

Therefore, in this embodiment, the present invention can provide a method of preventing or partially preventing black sigatoka or a symptom or condition associated with black sigatoka in banana, said method comprising applying ortho-phenylphenol or a salt thereof, and a mineral oil, to the locus of the disease.

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In yet another aspect, the present invention may provide a method of increasing yield of a banana tree, said method comprising applying ortho-phenylphenol or a salt thereof to the banana tree.

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Without wishing to be bound by theory, the present inventors believe that the OPP reduces the number of ascospores, thereby arresting the growth and reducing spread of *Mycosphaerella fijiensis* (Morelet) as well as controlling the growth on the foliage. As will be demonstrated by the experiments described herein, the application of OPP controlled *Mycosphaerella fijiensis* (Morelet) with almost 95 to 100% efficacy. As demonstrated in Figures 1, 2 and 3, OPP reduced ascospores at concentrations as low as 0.001 ppm to 100 ppm.

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According to the present invention, ortho-phenylphenol may be applied in concentrations of 0.001 ppm to 100 ppm at the locus of the infection.

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In an embodiment, ortho-phenylphenol may be applied at a concentration of at least about or equal to its EC₅₀ i.e. at least about 0.80 ppm.

5 In another embodiment, ortho-phenylphenol may be applied at a concentration of at least about or equal to its EC₉₀ i.e. at least about 80.0 ppm.

In another embodiment, ortho-phenylphenol may be applied at a concentration of about its EC₉₅ i.e. about 100 ppm.

10 OPP may be sprayed alone or may be mixed with adjuvants such as oils, or surfactants etc. The oils used may include but are not limited to mineral oils, vegetable oils and fats, sunflower oil, high-oleic sunflower oil, soybean oil, corn oil, peanut oil, cottonseed oil, sesame oil, rapeseed oil, high-oleic rapeseed oil, olive oil, palm oil, palm kernel oil, coconut oil, safflower oil, high oleic safflower oil and the like.

15 Thus, in an embodiment, ortho-phenylphenol is applied to the affected banana trees in the form of a composition.

20 Thus, in one embodiment, the present invention can provide a method of preventing or partially preventing black sigatoka or a symptom or condition associated with black sigatoka in banana, said method comprising applying a composition comprising ortho-phenylphenol or a salt thereof to the locus of the disease.

25 In an aspect, the present invention may also provide a composition for preventing or partially preventing black sigatoka or a symptom or condition associated with black sigatoka in banana, said composition comprising ortho-phenylphenol or a salt thereof.

In an embodiment, the composition additionally comprises a mineral oil.

30 Thus, in this embodiment, the present invention can provide a method of preventing or partially preventing black sigatoka or a symptom or condition associated with black

sigatoka in banana, said method comprising applying a composition comprising ortho-phenylphenol or a salt thereof and a mineral oil to the locus of the disease.

In an aspect, the present invention may also provide a composition for preventing or partially preventing black sigatoka or a symptom or condition associated with black sigatoka in banana, said composition comprising ortho-phenylphenol or a salt thereof and a mineral oil.

In an embodiment, the composition of the invention may additionally include mineral oil. The mineral oil of the present invention, may be the ones commonly used in combination with synthesised chemical fungicides available in the state of the art. Said mineral oils are characterised for being effective by themselves in treatments against Sigatoka, since they produce the physical effect of covering the leaves. In addition, the physical and chemical properties of vegetable extracts, generally lipophilic oils, make them suitably compatible with mineral oils. For this reason, using mineral oil in the composition achieves a special synergy for the treatment against Sigatoka. Although the mineral oil selected can be any of the ones commonly used in the field, the preferred embodiment uses at least one mineral oil based on distilled hydrocarbons and light paraffinic oils (such as for example, mineral oil CAS No. 64742-56-9). The mineral oil may be added preferably in the concentration of 10 to 75% of the total weight of the composition, most preferably 30 to 50 % of the total weight of the composition.

The surfactants selected may include but are not limited to, nonionic surfactants, amphoteric surfactants, cationic surfactant and anionic surfactants. The addition of a surfactant can improve adhesion of the active to the surface of the leaf as well as improve bio-availability of the active.

Exemplary nonionic surfactants may include polyoxyethylene alkyl ethers, polyoxyethylene castor oil, polyoxyethylene sorbitan fatty acid esters, polyoxyethylene alkyl phenyl ether and the like, polyoxyethylene alkyl ethers, polyoxyethylene castor oil, polyoxyethylene sorbitan fatty acid esters; alcohol ethoxylates, alkylpyrrolidones, alkyl phenol ethoxylated alcohol such as nonylphenol ethoxylated alcohol amphoteric surfactant

such as poly-octyl amino ethyl glycine, coconut oil fatty acid amide propyl betaine, such as imidazoline derivatives, and among others, poly-octyl amino ethyl glycine, coconut oil fatty acid amide propyl betaine may be used. Exemplary cationic surfactant may be selected from polyoxyethylene cocoamine, lauryl dihydroxyethyl amine, cationized cellulose, 5 chloride lauryl trimethyl ammonium, quaternary ammonium salts, such as stearyltrimethylammonium chloride, and among others, polyoxyethylene cocoamine, cationized cellulose, lauryl dihydroxyethyl amine is preferably used. Anionic surfactant may be selected from potassium soap, sodium lauryl sulfate, polyoxyethylene sodium lauryl sulfate, sodium polyoxyethylene alkyl ether sulfate, castor oil sodium sulfate, an 10 alkyl ether phosphoric acid esters.

In an embodiment, any biodegradable surfactant may be used in the compositions of the present invention.

15 In an embodiment, OPP may be mixed with oil based adjuvant selected from but not limited to mineral oils, vegetable oils and fats, sunflower oil, high-oleic sunflower oil, soybean oil, corn oil, peanut oil, cottonseed oil, sesame oil, rapeseed oil, high-oleic rapeseed oil, olive oil, palm oil, palm kernel oil, coconut oil, safflower oil, high oleic safflower oil or combinations thereof.

20 In an embodiment, OPP may be mixed with an oil based adjuvant and a surfactant.

In an aspect, the present inventors have further surprisingly found that ortho-phenylphenol exerts a curative control of black sigatoka, in terms of a partial or complete control of the disease, condition, symptom or adverse effect attributed to the incidence of black sigatoka 25 in banana, by applying ortho-phenylphenol to the effected loci in combination with a second fungicide.

Therefore, in this embodiment, the present invention can provide a method of partial or complete curative control of the disease, condition, symptom or adverse effect associated 30 with the incidence of black sigatoka in banana, said method comprising applying ortho-phenylphenol or a salt thereof in combination with a second fungicide to the locus of the disease.

In an embodiment, the ortho-phenylphenol in combination with a second fungicide, may be applied to the effected locus in the form of a composition.

5 Therefore, in this embodiment, the present invention can provide a composition for partial or complete curative control of the disease, condition, symptom or adverse effect associated with the incidence of black sigatoka in banana, said composition comprising ortho-phenylphenol or a salt thereof and a second fungicide.

10 In an embodiment, OPP may be mixed with other fungicides which are known to be used for prophylactic or curative control of black sigatoka disease, such fungicides may be tank mixed or formulated into a specific formulation.

In an embodiment, the second fungicide may be selected from contact fungicides such as
15 dithiocarbamate fungicides and chlorothalonil; or systemic fungicides such as those selected from DM inhibitors, QoI inhibitors, amines, anilinopyrimidines, Benzimidazoles, SDHI fungicides, Guanidines or mixtures thereof.

The dithiocarbamate fungicides may be selected from mancozeb, maneb, metiram,
20 polycarbamate, propineb, zineb, mancopper, ziram, thiram or mixtures thereof.

The DM inhibitor fungicides may be selected from imazalil, oxpoconazole, pefurazoate, prochloraz, Triflumizole, triforine, pyrifenoxy, fenarimol, nuarimol, azaconazole, bitertanol, bromuconazole, cyproconazole, difenoconazole, diniconazole, epoxiconazole,
25 fenbuconazole, fluquinconazole, Flusilazole, flutriafol, hexaconazole, imibenconazole, ipconazole, metconazole, myclobutanil, Penconazole, Propiconazole, prothioconazole, simeconazole, tebuconazole, tetraconazole, Triadimefon, triadimenol, triticonazole or combination thereof.

30 The QoI inhibitor fungicides may be selected from azoxystrobin, enestrobin, picoxystrobin, pyraclostrobin, kresoxim-methyl, trifloxystrobin, dimoxystrobin, metominostrobin, orysastrobin, famoxadone, fluoxastrobin, fenamidone or combinations thereof.

The amine fungicides may be selected from aldimorph, dodemorph, fenpropimorph, tridemorph, fenpropidin, piperalin or combinations thereof.

- 5 The anilinopyrimidine fungicides may be selected from cyprodinil, mepanipyrim, pyrimethanil or combinations thereof.

The benzimidazole fungicides may be selected from albendazole, benomyl, carbendazim, chlorfenazole, cypendazole, debacarb, fuberidazole, mecarbinzid, rabenzazole,
10 thiabendazole or combinations thereof.

The SDHI inhibitor fungicides may be selected from benodanil, boscalid, carboxin, fenfuram, flutolanil, furametpyr, mepronil, oxycarboxin, penthiopyrad, thifluzamide or combinations thereof.

15 The guanidine fungicide may be selected from guazatine, iminoctadine or combinations thereof.

In an embodiment, the present invention provides a method of partial or complete curative
20 control of the disease, condition, symptom or adverse effect associated with the incidence of black sigatoka in banana, said method comprising applying ortho-phenylphenol or a salt thereof in combination with a second fungicide selected from the group consisting of dithiocarbamates, chlorothalonil, DM inhibitors, QoI inhibitors, SDH inhibitors, amines, anilinopyrimidines, benzimidazoles, guanidines and combinations thereof.

25 In an embodiment, the present invention can provide a composition for partial or complete curative control of the disease, condition, symptom or adverse effect associated with the incidence of black sigatoka in banana, said composition comprising ortho-phenylphenol or a salt thereof and a second fungicide selected from the group consisting of
30 dithiocarbamates, chlorothalonil, DM inhibitors, QoI inhibitors, SDH inhibitors, amines, anilinopyrimidines, benzimidazoles, guanidines and combinations thereof.

In an embodiment, the compositions of the present invention optionally comprise an adjuvant.

In an embodiment, a mineral oil may be used to exert a curative control of black sigatoka.

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Therefore, in this embodiment, the present invention can provide a method of partial or complete curative control of the disease, condition, symptom or adverse effect associated with the incidence of black sigatoka in banana, said method comprising applying ortho-phenylphenol or a salt thereof, at least one mineral oil in combination with a second
10 fungicide to the locus of the disease.

In an embodiment, the ortho-phenylphenol, at least one mineral oil, in combination with a second fungicide, may be applied to the effected locus in the form of a composition.

15 Therefore, in this embodiment, the present invention can provide a composition for partial or complete curative control of the disease, condition, symptom or adverse effect associated with the incidence of black sigatoka in banana, said composition comprising ortho-phenylphenol or a salt thereof, at least one mineral oil and a second fungicide.

20 In an embodiment, the composition may additionally comprise additional insecticides, nematicide, herbicide, biocides, fertilizer, plant activators, plant extracts or mixtures thereof.

In an embodiment, the composition may be formulated as commonly known formulations
25 such as solid, or liquid formulations, including but not limited to, wettable powders, granules, dusts, Soluble (liquid) concentrates, suspension concentrates, oil in water emulsion, water in oil emulsion, emulsifiable concentrates, capsule suspensions, ZC formulations, oil dispersions or other known formulation types.

30 In a preferred embodiment, the formulation is an oil-in-water emulsion. In another preferred embodiment, the oil-in-water emulsion of ortho-phenylphenol may be applied to

the affected locus in an amount from about 1.0 L/Ha to about 4.0 L/Ha, preferably from about 1.0 L/Ha to about 2.0 L/Ha, more preferably about 1.0 L/Ha or about 2.0 L/Ha.

In an embodiment, the formulations can comprise agriculturally acceptable surfactants, dispersants, polymers, wetting agents, other adjuvants stabilizers, pH modifiers, anti-freeze agents, suspending agents, emulsifiers, antifoam agents, pH stabilising agents, preservatives and the like.

In an embodiment, the present invention may provide a method of preventing or partially preventing black sigatoka or a symptom or condition associated with black sigatoka in banana, said method comprising applying an oil-in-water emulsion comprising ortho-phenylphenol.

In another embodiment, the present invention may provide a method of preventing or partially preventing black sigatoka or a symptom or condition associated with black sigatoka in banana, said method comprising applying an oil-in-water emulsion comprising ortho-phenylphenol and at least one mineral oil.

In another embodiment, the present invention may provide a method of preventing or partially preventing black sigatoka or a symptom or condition associated with black sigatoka in banana, said method comprising applying an oil-in-water emulsion comprising ortho-phenylphenol, mineral oil and at least one emulsifier.

In an embodiment, the oil-in-water emulsion may be used in an amount of about from 1 L to about 2L per hectare for preventive and/or curative control of black sigatoka in banana.

Therefore, in aspect of the present invention ortho-phenylphenol present in the composition may be used as part of a liquid solution that may comprise, as a percentage by weight of the total percentage of the solution:

- . from 10% to 70% of the active ingredient;
- . from 10% to 80% of at least one emulsifying substance; and
- . from 5% to 20% (and preferably 10%) of at least one solvent, preferably propylene glycol.

In an embodiment the ortho-phenylphenol is 30% of the total weight of the formulation.

In an embodiment, the emulsifying agent is 50 -70% of the total weight of the formulation.

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In a preferred embodiments of the invention, this liquid solution of the active ingredient can comprise the following components as percentages by weight of the total percentage of the solution;

- . 30% of ortho-phenylphenol;
- 10 . 10% of emulsifying agent;
- . 10% of a surfactant;
- . 40% of first solvent; and
- . 10% of second solvent.

- 15 One of the advantages of the composition of the present invention is that it is compatible with synthesised chemical fungicides commonly used for controlling Sigatoka. Therefore, in the embodiments of the invention, ortho-phenylphenol and/or the composition can be used in combination with synthetic agrochemicals as well organic actives known to be used in the control of Black Sigatoka, which creates a synergy that improves the effect achieved
- 20 by using synthesised chemical fungicides, or it can also be used to control the appearance of strands that are resistant to said synthetic fungicides. This way, in the embodiments of the invention, ortho-phenylphenol and/or the composition may be used in combination with at least one synthesised chemical fungicide, or it may be used alternatively with other treatments, in which case a series of treatments based on the composition of the invention
- 25 would be applied followed by a series of treatments based on at least one synthesised chemical fungicide. Preferably, the synthesised chemical fungicide will be selected from among the fungicides authorised for controlling Black Sigatoka in banana crops such as those fungicides belonging to dithiocarbamates, carbamates, aromatic fungicides, benzimidazoles, strobilurins, conazoles, amines, anilinopyrimidines, succinate
- 30 dehydrogenase inhibitors and combinations thereof.

In an embodiment, the second fungicide maybe selected from the group consisting of dithiocarbamate, chlorothalonil, DM inhibitors, QoI inhibitors, SDH inhibitors, amines, anilinopyrimidines, benzimidazoles, and guanidines or combinations thereof.

5 ADVANTAGES OF THE INVENTION:

1. The present provides a new and environmentally safe solution that is not based on synthesised chemical fungicides, which is especially efficient for controlling Black Sigatoka in banana crops, showing acceptable effectiveness levels, no phytotoxicity and high biodegradability.
- 10 2. The present invention may eliminate or at least reduce in large quantities the massive use of synthesised chemical fungicides, which incur a large financial cost, and above all have a significant environmental impact. Said environmental impact is worsened by the fact that the areas affected by Black Sigatoka are mostly tropical areas with very precious yet also fragile ecosystems. This policy to reduce the use of synthesised chemical fungicides is being promoted with the aim of protecting the environment in countries that grow bananas, since these compositions are especially polluting. The present invention gives the possibility of using it alternatively with said chemical treatments, replacing them or at least reducing their usage. In addition, the new use of ortho-phenylphenol and the composition comprising ortho-phenylphenol can be used alongside said conventional chemical treatments, preferably in lower doses.
- 15 20 3. Finally, the composition of the invention is a stable formulation that is compatible with the use of mineral oils commonly used in treatments for controlling banana diseases, which is free from antioxidants.

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Using ortho-phenylphenol, or the composition of the invention comprising ortho-phenylphenol, for the treatment and/or prevention of Black Sigatoka, either by itself or in combination with at least one synthesised chemical fungicide suitable for treating said disease, is therefore an additional object of the invention. In the case when said synthesised chemical fungicide is used in the usual dose (as detailed in the technical data sheet of the product or on its label), using the composition that is the object of the invention will reinforce its effectiveness for the treatment of Sigatoka. If, by contrast, a lower dose than

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usual of the chemical fungicide was used, the main advantage of the invention in this case would be reducing the amount of said synthesised chemical fungicide used, achieving synergy with the composition of the invention.

- 5 The method of control of the present invention may be carried out by spraying the suggested tank mixes, or the individual fungicides and/or adjuvants may be formulated as a kit-of-parts containing various components that may be mixed as instructed prior to spraying.

In an embodiment, the components of the present invention may be packaged such that the
10 OPP and/or a second fungicide and/or adjuvant may be packaged separately and then tank mixed before the spraying.

In another embodiment the components of the present invention may be packaged such that OPP may be packaged separately, whereas, the second fungicide and other additives are
15 packaged separately, such that the two maybe tank mixed at the time of spraying.

Additionally, the composition can be applied using the same conventional system for applying treatments based on synthesised chemical fungicides on banana crops (plantation) during preharvest, preferably by means of spraying or fumigating the field (land or aerial).
20

The fungicidal method and composition of the present invention can offers some particular advantages over the compositions and methods known in the prior art. The method of the can be used to control and prevent black sigatoka in banana. The present invention demonstrates a better control capacity at reduced volumes thereby making it more
25 environmentally friendly.

The invention shall now be described with reference to the following specific examples. It should be noted that the example(s) appended below illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the present invention.
30

EXAMPLES:

Example 1:

A non-limiting exemplary formulation was prepared using ortho-phenylphenol in required quantities, about 20% of biodegradable anionic and non-ionic surfactants, ammonium hydroxide 0.5%, propylene glycol, C₁₁ – C₁₃ ethoxylated alcohol, about 5% as the emulsifier and the remaining required quantities of demineralized water.

Example 2:

The following formulation was used in the treatment:

Table 1. Formulation 1

Percentage (weight)	
45.26%	O-phenylphenol solution
0.54%	Imbirex® (mixture of nonionic surfactants esp. ethoxylated alcohol)
54.2%	Mineral oil (CAS No. 64742-56-9)

Experiments were conducted evaluate the efficacy of OPP for control of Black Sigatoka, as well as comparative tests were carried out to compare efficacy to known treatment regimens. The banana strain used in the present experiment were *Grande naine* banana plants and the experiments were carried out in Rita, Guapiles (Costa Rica). An experimental unit consisted of 10 banana plants planted in a line at a distance of 2.5 meters between each plant. The test design was completely random and each treatment was repeated three times.

Every treatment was applied using a motor sprayer for a volume of OPP formulation of 2.5l/Ha. The volumes of the tested products were mixed in a mineral oil emulsion in a dose of 3 l/Ha of mineral oil with 0.03/Ha of surfactant (1% of the mineral oil used).

Brief description of the accompanying drawings:

In vitro tests were carried out using minimum dose levels of OPP starting from 0.001 ppm to 100 ppm and a dose response curve was plotted based on the results which is demonstrated in Figure 5.

Figures 1 to 4 demonstrate the results of the decreasing amount of ascospores as the concentration of OPP increased.

Figure 1 demonstrates ascospores at 0 ppm.

Figure 2 demonstrates decrease in ascospores at 0.01 ppm of OPP.

5 Figure 3 demonstrates further decrease in ascospores at 0.1 ppm of OPP.

Figure 4 shows significant decrease in ascospores at 1.00 ppm of OPP.

Figure 5 shows decrease in ascospores at 10.00 ppm of OPP.

Figure 6 shows complete control of ascospores at 100.00 ppm of OPP.

10 Figure 7 represents the dose response curve of *M. fijiensis* percentage growth vs. the concentration of OPP in ppm levels.

CLAIMS

1. A method of preventing or partially preventing black sigatoka or a symptom or condition associated with black sigatoka in banana, said method comprising
5 applying ortho-phenylphenol or a salt thereof to the locus of the disease.
2. The method as claimed in claim 1, wherein ortho-phenylphenol is applied in the presence of at least one adjuvant selected from mineral oil, vegetable oils and fats, sunflower oil, high-oleic sunflower oil, soybean oil, corn oil, peanut oil, cottonseed
10 oil, sesame oil, rapeseed oil, high-oleic rapeseed oil, olive oil, palm oil, palm kernel oil, coconut oil, safflower oil, high oleic safflower oil and combinations thereof.
3. The method as claimed in any one of the preceding claims, wherein ortho-phenylphenol is applied at a concentration between 0.001 ppm to 100 ppm.
15
4. The method as claimed in any one of the preceding claims, wherein ortho-phenylphenol is applied at a concentration of at least about 0.80 ppm.
5. The method as claimed in any one of the preceding claims comprising applying an
20 oil-in-water emulsion comprising ortho-phenylphenol.
6. The method as claimed in claim 5 comprising applying the oil-in-water emulsion in an amount of about from 1 L to about 2L per hectare for preventive and/or curative control of black sigatoka in banana.
25
7. A composition for preventing or partially preventing black sigatoka or a symptom or condition associated with black sigatoka in banana, said composition comprising ortho-phenylphenol or a salt thereof.
8. The composition as claimed in claim 7, additionally comprising at least one
30 adjuvant selected from mineral oil, vegetable oils and fats, sunflower oil, high-oleic sunflower oil, soybean oil, corn oil, peanut oil, cottonseed oil, sesame oil, rapeseed

oil, high-oleic rapeseed oil, olive oil, palm oil, palm kernel oil, coconut oil, safflower oil, high oleic safflower oil or combinations thereof.

- 5 9. The composition as claimed in claim 8, wherein the adjuvant comprises about 10 to 75% of the total weight of the composition.
- 10 10. The composition as claimed in claims 7 – 9, wherein the composition is an oil-in-water emulsion.
- 10 11. The composition as claimed in claims 7 – 10 comprising from about 10% to about 70% of ortho-phenylphenol.
- 15 12. A method for partial or complete curative control of the disease, condition, symptom or adverse effect associated with the incidence of black sigatoka in banana, said method comprising applying ortho-phenylphenol or a salt thereof in combination with a second fungicide to the locus of the disease.
- 20 13. The method as claimed in claim 12 additionally comprising applying at least one adjuvant selected from mineral oil, vegetable oils and fats, sunflower oil, high-oleic sunflower oil, soybean oil, corn oil, peanut oil, cottonseed oil, sesame oil, rapeseed oil, high-oleic rapeseed oil, olive oil, palm oil, palm kernel oil, coconut oil, safflower oil, high oleic safflower oil or combinations thereof to the locus of the disease.
- 25 14. The method as claimed in claim 12, wherein the second fungicide is selected from the group consisting of:
- (a) at least one dithiocarbamate fungicide selected from mancozeb, maneb, metiram, polycarbamate, propineb, zineb, mancopper, ziram, thiram and mixtures thereof; or
- 30 (b) at least one demethylation inhibitor fungicide selected from imazalil, oxpoconazole, pefurazoate, prochloraz, Triflumizole, triforine, pyrifenoxy, fenarimol, nuarimol, azaconazole, bitertanol, bromuconazole, cyproconazole,

- difenoconazole, diniconazole, epoxiconazole, fenbuconazole, fluquinconazole, Flusilazole, flutriafol, hexaconazole, imibenconazole, ipconazole, metconazole, myclobutanil, Penconazole, Propiconazole, prothioconazole, simeconazole, tebuconazole, tetraconazole, Triadimefon, triadimenol, triticonazole and combinations thereof; or
- (c) at least one QoI inhibitor fungicide selected from azoxystrobin, enestrobin, picoxystrobin, pyraclostrobin, kresoxim-methyl, trifloxystrobin, dimoxystrobin, metominostrobin, orysastrobin, famoxadone, fluoxastrobin, fenamidone and combinations thereof; or
- (d) at least one amine fungicide selected from aldimorph, dodemorph, fenpropimorph, tridemorph, fenpropidin, piperalin and combinations thereof; or
- (e) at least one anilinopyrimidine fungicides selected from cyprodinil, mepanipyrim, pyrimethanil and combinations thereof; or
- (f) at least one benzimidazole fungicide selected from albendazole, benomyl, carbendazim, chlorfenazole, cypendazole, debacarb, fuberidazole, mecarbinzid, rabenzazole, thiabendazole and combinations thereof; or
- (g) at least one SDHI inhibitor fungicide selected from benodanil, boscalid, carboxin, fenfuram, flutolanil, furametpyr, mepronil, oxycarboxin, penthiopyrad, thifluzamide and combinations thereof; or
- (h) at least one guanidine fungicide selected from guazatine, iminoctadine and combinations thereof.
15. A composition for partial or complete curative control of the disease, condition, symptom or adverse effect associated with the incidence of black sigatoka in banana, said composition comprising ortho-phenylphenol or a salt thereof and a second fungicide selected from the group consisting of dithiocarbamates, chlorothalonil, DM inhibitors, QoI inhibitors, SDH inhibitors, amines, anilinopyrimidines, benzimidazoles, guanidines and combinations thereof.
16. The composition as claimed in claim 11, additionally comprising at least one adjuvant selected from mineral oil, vegetable oils and fats, sunflower oil, high-oleic sunflower oil, soybean oil, corn oil, peanut oil, cottonseed oil, sesame oil, rapeseed

oil, high-oleic rapeseed oil, olive oil, palm oil, palm kernel oil, coconut oil, safflower oil, high oleic safflower oil or combinations thereof.

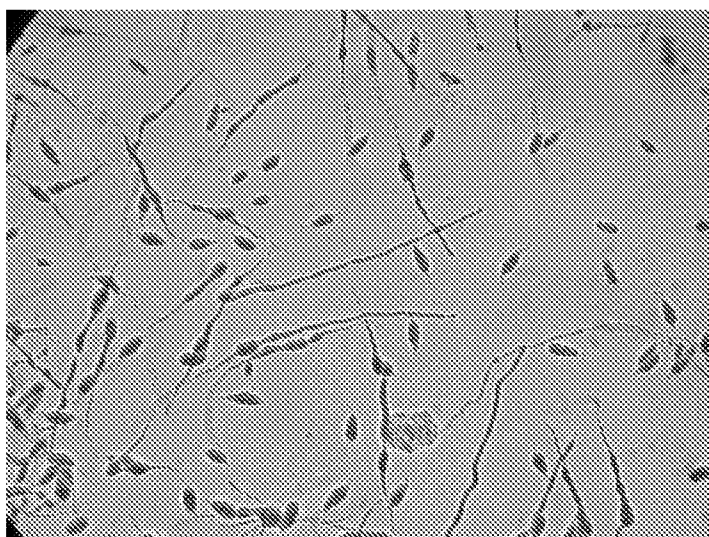


Figure 1. – OPP at 0 ppm

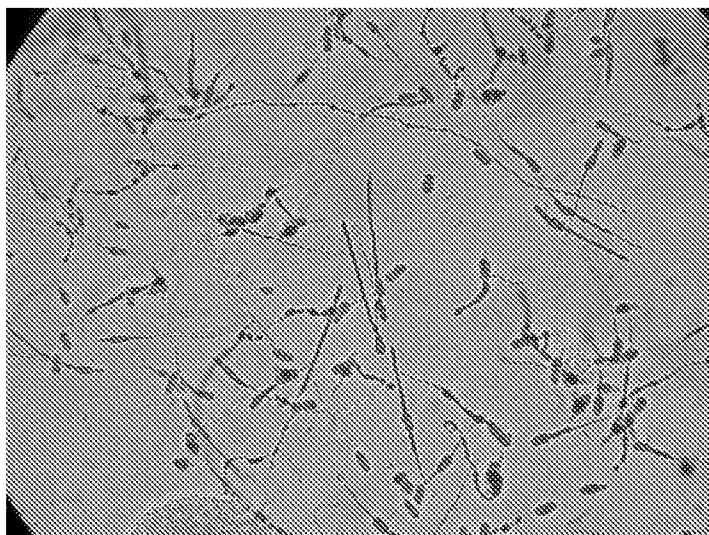


Figure 2 – 0.01 ppm OPP

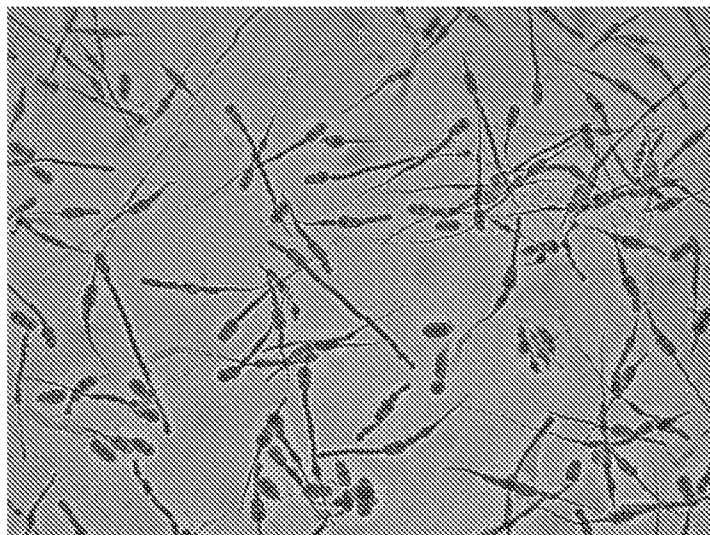


Figure 3 – 0.1 ppm OPP

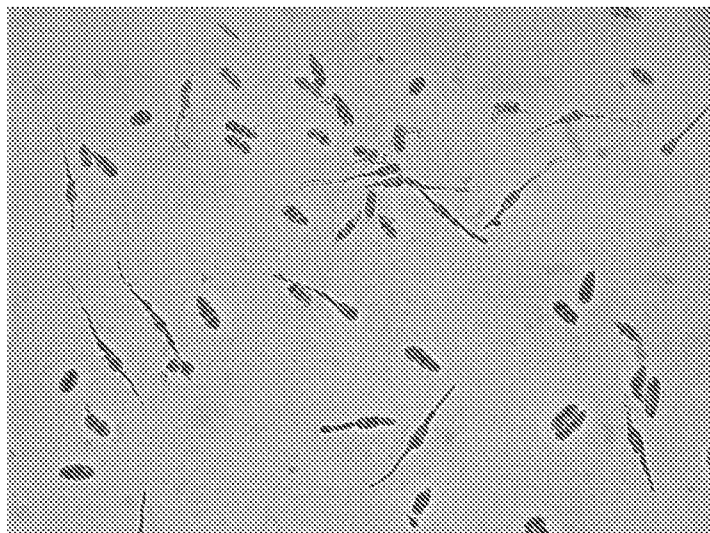


Figure 4 – 1.00 ppm OPP

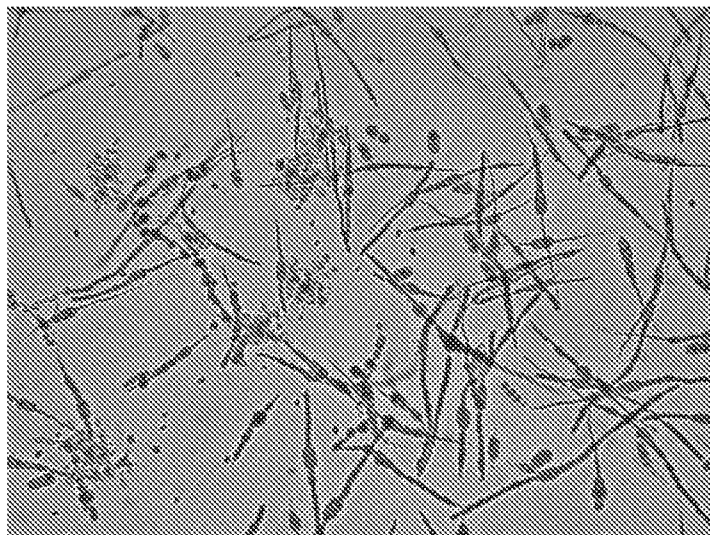


Fig. 5 – 10.00 ppm OPP

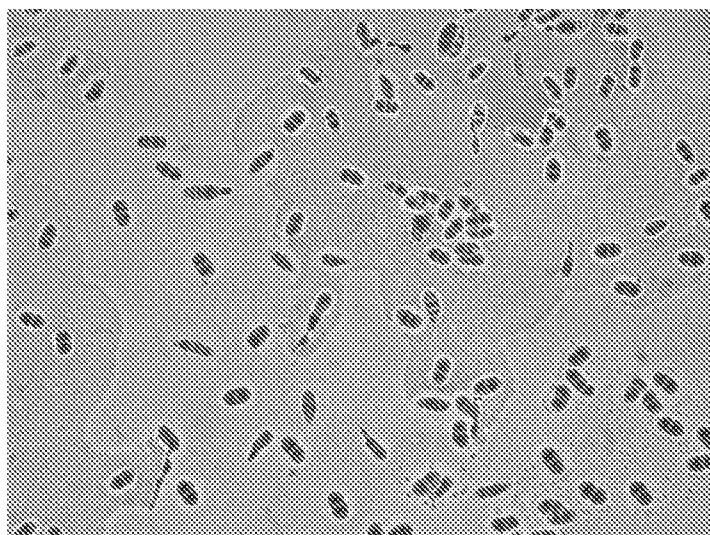


Fig. 6 – 100.00 ppm OPP

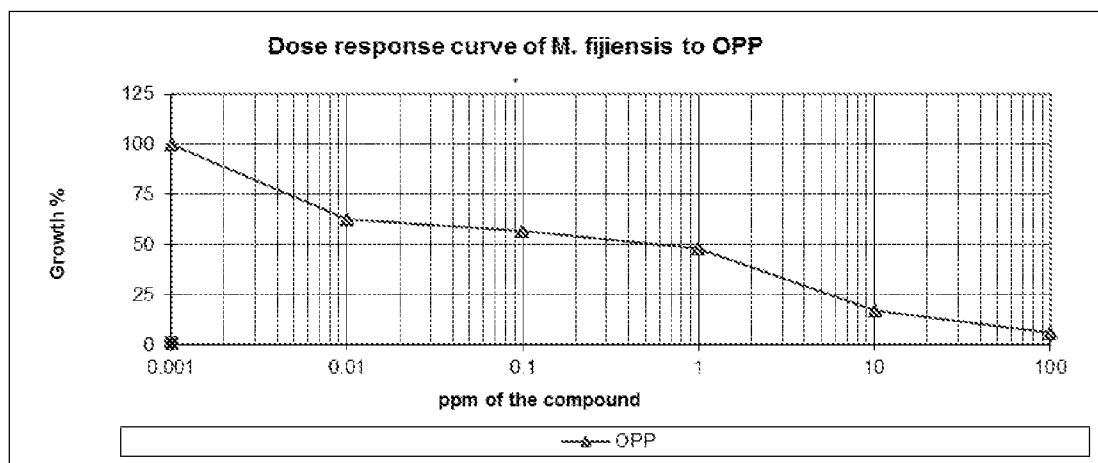


Figure 7 – Dose response curve for OPP.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2018/050032

A. CLASSIFICATION OF SUBJECT MATTER

A01N 31/08 (2006.01) A01P 3/00 (2006.01)

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)

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

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

EPOQUENET (Database: patenw); STN (Databases: CAPLUS, REGISTRY, DWPI, BIOSIS, CABA), Espacenet, Google Patents/Scholar; Keywords: ortho-phenylphenol, 2-phenylphenol, 2-biphenylol, ortho-hydroxybiphenyl, o-xenol, orthoxenol, biphenyl_2_ol, phenyl_phenate, sodium orthophenyl phenol, black sigatoka, black leaf streak, mycosphaerella/pseudocerospora fijiensis, fungicide, banana, plantain, musaceae, dithiocarbamate, demethylation/QoI/SDHI inhibitor, amine, anilinopyrimidine, benzimidazole, guanidine (and similar terms, and in combinations); IPC/CPC marks: A01N31/08, A01N25/00, A01N2300/00, A01P3/00; Applicant/inventors: Decco Worldwide Post-harvest Holdings/UPL Ltd, Akhter SOHAIL, Calderon-Kawasaki KENICHI, Madriz Acevedo GUSTAVO, Gomez Hernandez ENRIQUE, Jaidev Rajnikant SHROFF, Vikram Rajnikant SHROFF.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	



Further documents are listed in the continuation of Box C



See patent family annex

* "A"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance	"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
"E"	earlier application or patent but published on or after the international filing date	"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
"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)	"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
"O"	document referring to an oral disclosure, use, exhibition or other means	"&"	document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed		
Date of the actual completion of the international search 22 February 2018		Date of mailing of the international search report 22 February 2018	
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustalia.gov.au		Authorised officer Callen Puah AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. +61262832209	

INTERNATIONAL SEARCH REPORT		International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		PCT/IB2018/050032
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 103563946 A (SINOCHEM CORP et al.) 12 February 2014 Abstract; paragraphs [0032], [0033], [0034], [0038], [0039], [0041], [0042], [0050], [0053]; Tables 8 and 9	1-16
X	US 3674510 A (BICE, J. R. et al.) 04 July 1972 Abstract, col. 4 lines 20-22	1-16
X	US 4666706 A (FARQUHARSON et al.) 19 May 1987 col. 1 lines 16-21; Table 2	1-16
X	WO 2014/173804 A1 (BASF SE) 30 October 2014 page 1 line 9; claim 8	1-11
X	US 5827522 A (NOWAK) 27 October 1998 Example 19	1-11
A	PÉREZ-VICENTE, L., 'Manual on Fungicides and Fungicide Resistance Monitoring in Banana,' Food and Agriculture Organization of the United Nations, June 2013	
A	IWASAKI, M. et al., 'Problems of Positive List System Revealed by Survey of Pesticide Residue in Food,' The Journal of Toxicological Sciences, 2007, vol. 32(2), pages 179-184	

Form PCT/ISA/210 (fifth sheet) (July 2009)

INTERNATIONAL SEARCH REPORT		International application No.	
Information on patent family members		PCT/IB2018/050032	
This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.			
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		NO 992068 A	29 Jun 1999
		NZ 335584 A	25 May 2001
		WO 9818321 A1	07 May 1998
End of Annex			
Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001. Form PCT/ISA/210 (Family Annex)(July 2009)			