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(54) Title: MICRONUTRIENT FORMULATION FOR AERIAL CROP APPLICATION

(57) Abstract: The invention relates to use of a liquid oil-miscible micronutrient composition comprising one or more substantially water-insoluble particulate micronutrient source, suspended in an oil-based liquid medium, for foliar application to crops via spray oil systems, wherein the micronutrient source has a particle size, substantially in the range of 0.1 to 100 µm.



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MICRONUTRIENT FORMULATION FOR AERIAL CROP APPLICATION

Description

5 Field of the Invention

The present invention relates to the use of oil-based dispersions of plant micronutrients for foliar application to crops via aerial application, compositions comprising mineral spray oils and oil-based dispersions of plant micronutrients, methods for making said compositions comprising mineral spray oils and oil-based dispersions of
10 plant micronutrients, and the use of said mineral spray oils for foliar application to crops via aerial application.

Background of the Invention

Plant nutrients can be divided into three main classes: primary or macronutrients,
15 such as nitrogen (N), phosphorus (P) and potassium (K) ; secondary nutrients, such as calcium (Ca), magnesium (Mg), sulphur (S), and sodium (Na) ; and micronutrients, such as boron (B), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo) and zinc (Zn). An adequate supply of these nutrients is required for healthy growth of plants, and in modern agriculture it is common practice to apply inorganic fertilizers to crops in order to
20 improve yield and quality. Solid fertilizers such as prills or granules containing one or more of the primary nutrients (N, P and K) represent the most common type of fertilizer and are typically applied to the soil. However, liquid fertilizers are also available and are becoming increasingly important in many markets due to the benefits they offer to the grower in terms of convenience, flexibility, accuracy of delivery, and ease of application.
25 Liquid fertilizers containing primary, secondary and micronutrients, alone or in any combination, are widely available and may be applied using a variety of methods such as spraying onto the soil, injection into the soil, banding, incorporation into the seedbed during drilling; in the irrigation water (via fertigation or hydroponics systems); by spray application onto the foliage of the crop (foliar application); or in seed treatment.

Foliar application is particularly relevant to micronutrient fertilizers as it is an efficient and convenient way to deliver the relatively small quantities of these nutrients, required by the crop. Micronutrient fertilizers, intended for foliar application, are available in a variety of physical forms such as soluble powders or granules, water-dispersible granules, wettable powders, soluble (liquid) concentrates and suspension concentrates. Soluble powders and granules and soluble (liquid) concentrates are typically based on water-soluble inorganic salts of the micronutrients such as sulphates, chlorides and nitrates; or on water-soluble chelates such as EDTA, or on water-soluble complexes such as ligninsulphonates or citrates. Said water-soluble compounds are used to produce aqueous compositions comprising said water-soluble compounds.

Water-dispersible granules and wettable powders may be based on substantially water-insoluble inorganic compounds. Although these compounds are substantially water-insoluble, the prior art describes how, after application to the foliage, the slightly acidic conditions present on the leaf surface facilitate the release of the micronutrients leading to assimilation by the plant. Aqueous suspension concentrate micronutrient fertilizers based on similar substantially insoluble sources are also widely used and offer the advantages of providing high nutrient content in an easy to use aqueous form.

Irrespective of the physical form, in conventional agricultural practice, the micronutrient would typically be diluted in water and applied to the crop using tractor-drawn spray equipment, although, for smaller areas, manual knapsack sprayers may be used. For economic reasons it is common for farmers to co-apply micronutrients along with agrochemicals by “tank mixing” them together in the same spray tank.

In the case of tropical plantation agriculture involving crops such as banana, oil palm, coffee, cocoa, and pineapple, aerial application of agrochemicals and fertilizers using a specially designed aircraft is a common practice. In such situations, the carrier used for the spray is usually a mineral oil or an oil-in-water emulsion rather than simply water. This is because the oil used (spray oil) facilitates the production of small spray droplets which do not evaporate before reaching the target, and also improves the coverage when using low spray volumes, thus increasing productivity of the spray

operation. Spray oils also have an inherent fungicidal effect and can act as adjuvants to improve the efficacy of certain agrochemicals.

Many plant protection agrochemicals are commercially available in forms which are readily mixable with spray oils. However, the range of micronutrient fertilizers
5 suitable for application in spray oil systems is far more restricted.

In situations where an oil-in-water emulsion carrier system is employed, it is possible to use conventional water soluble micronutrient fertilizers such as inorganic salts, complexes or chelates by dissolving these in the aqueous phase and using a surfactant to form the emulsion with the oil. However, this approach has several
10 limitations. Firstly, the amount of micronutrient that can be incorporated is limited by the aqueous solubility of the nutrient source and the proportion of water in the emulsion. Consequently, only low inputs of fertilizer can be applied in this way. Also, mixing the separate components can be arduous and great care must be taken to ensure the micronutrient is fully dissolved otherwise blockages in the spray nozzles may occur.
15 Furthermore this approach often requires the use of high quantities of surfactant. Some types of surfactant used in such systems have been shown to have adverse environmental and health effects; for example, nonylphenol ethoxylates, which have been widely used in the industry, are considered to be endocrine disrupting chemicals.

In systems where only mineral oil is used as the carrier, conventional dry forms of
20 micronutrient fertilizer and aqueous-based solutions or suspension concentrates generally cannot be used as they are incompatible.

In the prior art, several micronutrient compositions are described, specifically designed for use with spray oils. US 3,982,920 (Cross et al., 1976) discloses a water-in-oil emulsion containing water-soluble micronutrients, dispersed in oil. GB 1,456,623 (Texaco,
25 1976) discloses water-soluble micronutrient suspensions in oil and an alcohol emulsion stabilizer. US 4,026,694 (Cross et al, 1977) discloses suspensions in oil containing water soluble micronutrients and an emulsifier. The suspensions can be diluted with a spray oil and sprayed onto plants. GB 1,532,085 (Texaco Trinidad Inc., 1978) discloses compositions comprising 0.05 to 8 vol% (based on oil amount) of overbased trace metal

salts of naphthenic acid in a mineral oil and US 4,125,395 (Texaco Trinidad Inc., 1978) describes micronutrient compositions comprising 0.025 - 8 % (w/v) of overbased trace metal salts of naphthenic acid in a mineral oil. US 4,111,678 (Downer, 1978) discloses a foliar spray composition comprising a metal chelate in oil. US 4,165,230 (Gavrok et al., 5 1979) discloses an agricultural spray oil composition containing low amounts (0.1-0.25 % (w/v)) of zinc dialkyl dithiophosphates. US 4,155,739 (Downer et al., 1979) discloses spray oil compositions comprising 0.01 to 2 weight% of oil-soluble boron compounds. US 4,133,668 (Young, 1979) discloses suspensions of micronutrients in spray oil to be added in a sulphur melt to produce sulphur particles containing micronutrients. WO 10 2009/083585 (Blackman et al., 2009) discloses suspensions comprising an oil and a boron chelate or complex to be sprayed on banana trees. Whilst these compositions are claimed to perform effectively, they all suffer from significant drawbacks such as high production costs and low nutrient content.

Hence, there is a need for improved micronutrient fertilizer compositions which 15 are compatible with mineral spray oils for foliar application to crops via aerial application and which have a higher amount of micronutrients than the prior art compositions.

Summary of the Invention

It has been discovered that the above problems can be solved by using liquid oil- 20 miscible suspensions of substantially water-insoluble particulate micronutrient source(s) suspended in an oil-based liquid medium. Surprisingly, the prior art does not contemplate the use of this type of micronutrient dispersions that are miscible with spray oils, in particular for foliar application to crops via spray oil systems, in particular aerial application.

25 Aspects of the invention are specified in the independent claims. Preferred features are specified in the dependent claims.

Detailed Description of the Invention

According to one embodiment, the use of a liquid oil-miscible micronutrient composition comprising one or more substantially water-insoluble particulate micronutrient source(s) suspended in an oil-based liquid medium for foliar application to crops via spray oil systems, wherein the micronutrient source has a particle size, substantially in the range of 0.1 to 100 μm , is claimed. Such a composition *per se* has been disclosed, a.o. in US 3,692,529 (Rychman, 1972) for coating a granular solid fertilizer, in WO 97/19030 (Norsk Hydro, 1997) as a composition for colour-coating fertilizer particles and in WO 2014/128468 A1 (Yara UK Ltd, 2014) for use as a coating for solid fertiliser particles for preparing a free-flowing, non-dusting micronutrient-coated particulate solid fertiliser material.

Surprisingly, the inventors have now discovered that such composition could also be used for foliar application to crops via spray oil systems.

In particular, the inventors have discovered that such composition will readily disperse in spray oils and could therefore be used for preparing a spray oil composition, comprising a spray oil and the liquid oil-miscible micronutrient composition comprising one or more substantially water-insoluble particulate micronutrient source(s) suspended in an oil-based liquid medium.

Furthermore, the inventors have discovered that such composition is physically compatible with a wide range of plant protection agrochemicals, avoiding the requirement for addition of water or extra surfactant (unless specifically required by the agrochemical) in the case the plant protection agrochemicals are used together with such composition.

Suitable micronutrient sources are any substantially water-insoluble compounds of the micronutrient elements boron, copper, iron, manganese, molybdenum and zinc, such as, but not limited to, oxides, hydroxides, carbonates, phosphates, oxychlorides, oxysulphates and borates.

We have found that the best results in terms of product stability, mixability, spray performance and coverage are obtained when the micronutrient source has a very small

particle size, preferably in the range of 0.1 to 50 μm , even more preferably wherein 90 % of particles have a particle size ranging from 0.1 to 50 μm , ideally wherein 90 % of particles have a particle size ranging from 0.1 to 20 μm . Such fine particle size may be obtained by milling coarser materials or result from the synthetic process employed to produce the compounds.

The liquid oil-miscible micronutrient composition essentially consists of an oil-based liquid medium as suspension medium for the one or more substantially water-insoluble particulate micronutrient sources. Preferably, no water is present in the liquid oil-miscible composition.

The liquid micronutrient composition comprising one or more substantially water-insoluble particulate micronutrient source, suspended in an oil-based liquid medium should be oil-miscible. Preferably, it should be miscible with spray oil for foliar application.

The oil-based liquid medium can be any suitable natural, mineral or synthetic oil, such as white mineral oil, but preferably an environmentally acceptable oil such as a vegetable oil is used. Suitable vegetable oils include rapeseed (canola) oil, soya oil, sunflower oil, linseed oil, castor oil, or any other similar vegetable oils. Other oil-based liquid mediums are methylated oils, modified vegetable oils, glycols, glycerols and the like.

Surprisingly, vegetable oil was found to be much better for producing stable dispersions of said particles than white mineral oil.

It is advantageous to achieve as high a loading of the micronutrient in the suspension as possible because this allows sufficient application rates to be used whilst maintaining a low spray volume which is desirable in order to improve the productivity of the spray operation. A highly concentrated composition is also advantageous in terms of cost savings related to transport and storage of the composition and reduced packaging waste. In a preferred embodiment, a solids loading of 30 to 80 weight% (w/w), more preferably a solids loading of 50 to 80 weight% (w/w) should be achieved, relative to the total weight of the composition.

The loading depends on the type of carrier oil, the type of dispersant, etc. A method to achieve such a high loading of the micronutrient in the suspension is disclosed in WO 2014/128468 A1 (Yara UK Ltd, 2014), which publication is entirely incorporated herein by reference. As an example, it can be mentioned that rapeseed (canola) oil with 5 60 weight% zinc oxide could still be pumped and could be produced using the method of WO 2014/128468 A1. However, rapeseed (canola) oil with 70 weight% zinc oxide turned out to be too thick to be pumped, but by adding a dispersion agent, the amount could be increased to 70 weight% without increasing the viscosity of the resulting dispersion. It was an inventive aspect of the invention disclosed in WO 2014/128468 A1 that it has 10 been found possible to produce a dispersion with 65 to 70 weight% zinc oxide.

It is also advantageous to achieve a mobile liquid form so that the micronutrient suspension can be easily pumped and dosed into the spray tank. In order to achieve a liquid suspension at this high solids loading, a dispersing agent may need to be incorporated into the formulation. Suitable dispersing agents may be natural or synthetic, 15 such as but not limited to, fatty acids, mono- and diglycerides, polycondensed fatty acids, polymerized fatty acid esters, phosphoric esters of polyethoxyethylated fatty alcohols, ethoxylated fatty alcohols, fatty acid modified polyesters, non-ionic block copolymers. It is an inventive aspect of the present invention that it has been discovered that inclusion of a suitable dispersing agent also facilitates easy and efficient dispersion of the 20 micronutrient composition into the spray oil carrier prior to application, leading to improved productivity in the spray operation.

It is also desirable for the micronutrient suspension to have good stability so as to prevent rapid settlement of the micronutrient from the suspension in order to allow for storage, transport and ease of handling. Accordingly, it has been found advantageous to 25 include any one of a dispersing agent, rheology agent, thickener and anti-settle agent or any combination thereof, in the micronutrient suspension. Suitable rheology agents, thickeners and anti-settle agents include, but are not limited to, clays such as sepiolite, bentonite, attapulgite, hectorite, palygorscite and organically-modified clays;

polyurethanes, polyurea; fumed silica, hydrophobically modified fumed silica; fumed mixed oxides.

A colorant material, either dye or pigment, may be added to the formulation in order to aid monitoring of the spray process or to assist with product identification.

- 5 Examples of suitable pigments include, but are not limited to, Phthalocyanine Blues (for example, C.I. Pigment Blues 15, 15:1, 15:2, 15:3, 15:4) and Aluminium Chlorophthalocyanine (for example, C.I. Pigment Blue 79); Ultramarine Blue; red, yellow and green iron oxides.

- 10 The micronutrient suspension can be prepared by blending a suitable source of micronutrient in the form of a finely divided solid powder with an oil. The pre-prepared non-aqueous liquid suspensions, based on substantially water-insoluble micronutrient compounds can be prepared according to WO 2014/128468 A1 (Yara UK Ltd, 2014) and were found to be fully pumpable, having a viscosity in the range 500 to 6000 cPs at 20 °C, preferably 2000 to 5000 cPs at 20 °C measured on a Brookfield LVD viscometer using
15 Spindle 3 at 12 rpm.

According to one embodiment, the micronutrient composition according to the application is admixed with a spray oil, in particular a mineral spray oil, for use in foliar application to crops.

- 20 According to one embodiment, a spray composition comprising a mineral spray oil and a liquid oil-miscible micronutrient composition comprising one or more substantially water-insoluble particulate micronutrient source(s) suspended in an oil-based liquid medium, wherein the oil-based liquid medium is a vegetable oil, is claimed.

- Preferably, the spray composition essentially consists of a mineral spray oil and a liquid oil-miscible micronutrient composition comprising one or more substantially water-
25 insoluble particulate micronutrient source, suspended in an oil-based liquid medium, wherein the oil-based liquid medium is a vegetable oil,. Preferably, no water is present in the spray composition.

The mineral spray oil and the oil-based liquid medium of the liquid oil-miscible micronutrient composition comprising one or more substantially water-insoluble

particulate micronutrient source, suspended in an oil-based liquid medium are fully miscible, i.e. they do not form an emulsion.

Preferably, the oil-based liquid medium is selected from the group of rapeseed (canola) oil, soya oil, sunflower oil, linseed oil, castor oil, methylated oil, modified
5 vegetable oil, glycols and glycerols.

The spray composition according to the invention is prepared by mixing an appropriate amount of mineral spray oil and an appropriate amount of a liquid oil-miscible micronutrient composition comprising one or more substantially water-insoluble particulate micronutrient source, suspended in an oil-based liquid medium, wherein the
10 oil-based liquid medium is a vegetable oil until an essentially fully dispersed spray composition is obtained. With essentially fully dispersed spray composition" is meant a dispersion which shows minimal settlement and is easily re-dispersed, or is stable and does not show any separation.

Appropriate amounts are typically 10 to 30 litres of mineral spray oil mixed with 0.5
15 to 5 litres of liquid oil-miscible micronutrient composition. Typically, per hectare, 10 to 30 litres of mineral spray oil is used, mixed with 0.5 to 5 litres of liquid oil-miscible micronutrient composition.

According to one embodiment, the use of a spray composition comprising a mineral spray oil and a liquid oil-miscible micronutrient composition comprising one or more
20 substantially water-insoluble particulate micronutrient source(s) suspended in an oil-based liquid medium is claimed for foliar application to crops via spray oil systems. Preferably, the spray oil system is selected from aerial application, tractor-drawn spray equipment, manual knapsack application, boomspray application and permanent spray lines, or any combination thereof.

25 According to one embodiment, a kit of parts, comprising an amount of mineral spray oil and an amount of a liquid oil-miscible micronutrient composition comprising one or more substantially water-insoluble particulate micronutrient source, suspended in an oil-based liquid medium, wherein the oil-based liquid medium is a vegetable oil, is provided

The invention will now be further described with reference to the following examples.

EXPERIMENTAL

5

Example 1

The following example shows the formulation required to make 1 kg of an oil-based suspension of zinc oxide containing 50 weight% Zn (zinc oxide USP grade having an average particle size of approximately 0.5 μm , 90 % of particles are smaller than 2 μm).

10	Rapeseed (canola) oil	0.3320 kg
	Polycondensed fatty acid dispersant	0.0300 kg
	Zinc oxide	0.6230 kg
	Pigment Blue 15:1	0.0150 kg

15		<u>1.0000 kg</u>

The above components are added to a beaker in the order listed and mixed under high shear for 30 minutes after the last addition of dry ingredient. The resultant product is a fluid suspension at ambient temperature with a viscosity of 4000+/- 1000 cPs at 20 °C as measured on a Brookfield LVD viscometer using spindle 3 at 12 rpm.

20

Samples of the product were subjected to storage testing under various conditions. A sample stored at 20°C for a period of 4 months remained stable and fluid with no significant settlement of the suspended solids.

25

Example 2

The following example shows the formulation required to make 1 kg of an oil based suspension of zinc oxide and calcium borate (colemanite) containing 12.2 weight% Zn and 4.9 weight% B (zinc oxide USP grade having an average particle size of approximately 0.5 μm , 90% of particles less than 2 μm ; colemanite ground to achieve a particle size specification of 90 % particles smaller than 13 μm).

	Rapeseed (canola) oil	0.4090 kg
	Phosphate ester dispersant	0.0590 kg
	Yellow iron oxide	0.0056 kg
10	Zinc oxide	0.1515 kg
	Colemanite	0.3740 kg
	Sepiolite clay thickener	0.0009 kg

		<u>1.0000 kg</u>

15

The above components are added to a beaker in the order listed and mixed under high shear for 30 minutes after the last addition of dry ingredient. The resultant product is a fluid suspension at ambient temperature with a viscosity of 2500+/- 500 cPs at 20 °C as measured on a Brookfield LVD viscometer using spindle 3 at 12 rpm.

20

Samples of the product were subjected to storage testing under various conditions. A sample stored at 45 °C for a period of 2 months remained stable and fluid with no significant settlement of the suspended solids.

Example 3

25

The following example shows the formulation required to make 1 kg of an oil based suspension of cuprous oxide containing 68.8 weight% Cu (cuprous oxide having an average particle size specification of 99 % of particles smaller than 5 μm ; 80 % particles smaller than 2 μm).

Methylated seed oil	0.1570 kg
Phosphate ester dispersant	0.0400 kg
Sepiolite clay thickener	0.0030 kg
Cuprous oxide	0.8000 kg
5	-----
	<u>1.0000 kg</u>

The above components are added to a beaker in the order listed and mixed under high shear for 30 minutes after the last addition of dry ingredient. The resultant product is a fluid suspension at ambient temperature with a viscosity of 3000+/- 500cPs at 20°C as measured on a Brookfield LVD viscometer using spindle 3 at 12 rpm.

Samples of the product were subjected to storage testing under various conditions. A sample stored at 20°C for a period of 2 months remained stable and fluid with no significant settlement of the suspended solids.

15 Example 4

The following example shows the formulation required to make 1 kg of an oil based suspension of manganese carbonate containing 29 weight% Mn (manganese carbonate having an average particle size specification of 100 % of particles smaller than 50 µm; 50 % particles smaller than 5 µm).

20

Methylated seed oil	0.2991 kg
Polycondensed fatty acid dispersant	0.0290 kg
Pigment Blue 15:1	0.0029 kg
Manganese carbonate	0.6603 kg
25 Fumed silica	0.0087 kg

	<u>1.0000 kg</u>

The above components are added to a beaker in the order listed and mixed under high shear for 30 minutes after the last addition of dry ingredient. The resultant product is a fluid suspension at ambient temperature with a viscosity of 2500+/- 500 cPs at 20°C as measured on a Brookfield LVD viscometer using spindle 3 at 12 rpm.

- 5 Samples of the product were subjected to storage testing under various conditions. A sample stored at 20 °C for a period of 2 months remained stable and fluid with no significant settlement of the suspended solids.

Example 5: Tank mix tests

- 10 Physical compatibility tests ("tank-mix" tests) were carried out using the formulation based on zinc oxide and colemanite described in Example 2 in order to assess mixability with spray oil and typical agrochemicals used on plantation crops such as banana, for example those disclosed in EP 2077075 A1 [Realco SA, 2009]. The spray oil used for the tests was light mineral oil with a density of 0.838 g/ml at 25°C and flash point
15 (closed cup) of 112°C. A commercially available aqueous-based suspension concentrate zinc micronutrient fertilizer, YaraVita Zintrac 700 (Yara) was included as comparative experiment.

- The agrochemicals used in the tests were as follows: Tilt 250E (fungicide, Syngenta, 250g/l propiconazole), Bumper (fungicide, Adama, 250g/l propiconazole), Impulse 500 EC
20 (fungicide, BayerCropScience, 500 g/l spiroxamine), Emulsifier (C11-15 ethoxylated alcohol 7EO).

- The tests were carried out using stoppered glass test tubes. The oil, micronutrient composition and agrochemical were added in the order listed using quantities in proportion to the application rates shown but scaled down to 20 ml of spray oil, thus for
25 tank mix) below 20 ml Spray Oil was mixed with 3 ml Composition 2, and so on.. After each addition, the test tube was inverted 20 times in order to thoroughly mix the components. The tank mixes were assessed immediately after mixing and then again after standing for 2 hours.

The tank mixes carried out were as follows:

According to invention:

- i) Spray Oil (20 l/ha) + Example 2 (3 l/ha)
- ii) Spray Oil (20 l/ha) + Tilt 250EC (0.4 l/ha)
- iii) Spray Oil (20 l/ha) + Example 2 (3 l/ha) + Tilt (0.4 l/ha)
- 5 iv) Spray Oil (20 l/ha) + Bumper (0.4 l/ha)
- v) Spray Oil (20 l/ha) + Example 2 (3 l/ha) + Bumper (0.4 l/ha)
- vi) Spray Oil (20 l/ha) + Impulse 500 EC (0.4 l/ha)
- vii) Spray Oil (20 l/ha) + Example 2 (3 l/ha) + Impulse 500 EC (0.4 l/ha)

Comparative experiment:

- 10 viii) Spray Oil (20 l/ha) + Emulsifier (0.2 l/ha) + YaraVita Zintrac 700 (3 l/ha)
- ix) Spray Oil (20 l/ha) + Emulsifier (0.2 l/ha) + YaraVita Zintrac 700 (3 l/ha) + Impulse 500 EC (0.4 l/ha)
- x) Spray Oil (20 l/ha) + Emulsifier (0.2 l/ha) + Water (10 l/ha) + YaraVita Zintrac 700 (3 l/ha)
- 15 xi) Spray Oil (20 l/ha) + Emulsifier (0.2 l/ha) + Water (10 l/ha) + YaraVita Zintrac 700 (3 l/ha) + Impulse 500 EC (0.4 l/ha)

The results are as shown in the table below:

Tank Mix No.	Initial assessment	Assessment after 2 hours
According to invention		
i)	Fully dispersed	Minimal settlement; easily re-dispersed
ii)	Fully dispersed	Stable; no separation
iii)	Fully dispersed	Minimal settlement; easily re-dispersed
iv)	Fully dispersed	Stable; no separation
v)	Fully dispersed	Minimal settlement; easily re-dispersed

vi)	Fully dispersed	Stable; no separation
vii)	Fully dispersed	Minimal settlement; easily re-dispersed
Comparative experiment		
viii)	Grainy appearance	Phase separation; heavy sedimentation
ix)	Grainy appearance	Phase separation; heavy sedimentation
x)	Grainy appearance	Phase separation; heavy sedimentation
xi)	Grainy appearance	Phase separation; heavy sedimentation

Example 6: Glasshouse trials

Glasshouse trials were carried out in order to assess spray performance and crop safety of the micronutrient compositions described in Examples 1 and 2 above. The trials were carried out using a sorghum test crop grown in pots in a sand medium and fed via a nutrient solution. A randomised block design using 4 replicates was employed.

Micronutrient compositions 1 and 2 were applied by foliar spraying at the growth stage defined as immediately pre-ear emergence using rates equivalent to 2 litre/ha and 4 litre/ha in 30 litre/ha spray oil. Two control treatments were carried out for comparison: the first using spray oil alone at 30 litres/ha, the second using a commercially available water based zinc suspension concentrate, YaraVita Zintrac 700 (Yara) at 1 litre/ha in 30 litres/ha water. The crop was assessed for symptoms of phytotoxicity seven days after spraying.

Both oil-based micronutrient compositions were found to spray without any problems and no evidence of phytotoxicity was observed at the seven day assessment.

Summary

The invention provides a use of a liquid oil-miscible micronutrient composition comprising one or more substantially water-insoluble micronutrient source, suspended in an oil-based liquid medium, for foliar application to crops via spray oil systems, and in particular for aerial application to tropical plantation crops. The advantages of the invention over current practice are as follows:

- 1) Greater flexibility for aerially applying micronutrients to crops.
- 2) Superior compatibility with mineral spray oils and agrochemicals than conventional micronutrient fertilizer compositions.
- 3) Eliminates the need to add extra water and/or adjuvant to the spray mix.
- 4) Facilitates lower spray volumes leading to improved spray productivity.
- 5) Provides micronutrients in a concentrated, easy to use liquid form, reducing packaging and transport costs.
- 6) Delivers micronutrients to the crop in a safe and effective manner.

Claims

1. Use of a liquid oil-miscible micronutrient composition comprising one or more substantially water-insoluble particulate micronutrient source, suspended in an oil-based liquid medium, for foliar application to crops via spray oil systems, wherein the micronutrient source has a particle size, substantially in the range of 0.1 to 100 μm .
5
2. Use of the micronutrient composition according to claim 1, wherein the one or more substantially water-insoluble particulate micronutrient source is a substantially water-insoluble compound of the micronutrient elements boron, copper, iron, manganese, molybdenum and zinc, or mixtures thereof.
10
3. Use of the micronutrient composition according to claim 2, wherein the one or more substantially water-insoluble particulate micronutrient sources is selected from the group of oxides, hydroxides, carbonates, phosphates, oxychlorides, oxysulphates and borates.
15
4. Use of the micronutrient composition according to any one of the preceding claims, wherein the micronutrient source has a particle size, substantially in the range of 0.1 to 50 μm , more preferably wherein 90 % of particles have a particle size ranging from 0.1 to 50 μm , even more preferably wherein 90 % of particles have a particle size ranging from 0.1 to 20 μm .
20
5. Use of the micronutrient composition according to any one of the preceding claims, wherein the oil-based liquid medium is a vegetable oil.
25

6. Use of the micronutrient composition according to any one of the preceding claims, having a solids loading in the range of 30 to 80 weight% (w/w), more preferably 50 to 80 weight% (w/w), relative to the total weight of the composition.
- 5 7. Use of the micronutrient composition according to any one of the preceding claims, wherein the composition includes a dispersing agent.
8. Use of the micronutrient composition according to any one of the preceding claims, wherein the composition includes any one of a rheology agent, thickener and anti-settle agent, or any combination thereof.
10
9. Use of the micronutrient composition according to any one of the preceding claims, wherein the composition includes a colorant material.
- 15 10. Use of the micronutrient composition according to any one of the preceding claims, wherein the composition is admixed with a spray oil, in particular a mineral spray oil.
11. Spray composition, comprising a mineral spray oil and a liquid oil-miscible
20 micronutrient composition as defined in any one of claims 1 to 9, wherein the oil-based liquid medium is a vegetable oil.
12. Spray composition, prepared by mixing an appropriate amount of mineral spray oil and an appropriate amount of a liquid oil-miscible micronutrient composition as
25 defined in any one of claims 1 to 9, wherein the oil-based liquid medium is a vegetable oil, until an essentially fully dispersed spray composition is obtained.
13. Spray composition according to claim 11 and 12, comprising 0.5 to 5 litres of liquid oil-miscible micronutrient composition and 10 to 30 litres of mineral spray oil.

14. Use of a spray composition according to claim 11 to 13, for foliar application to crops via spray oil systems.
- 5 15. Use according to claim 14, wherein spray oil system is selected from aerial application, tractor-drawn spray equipment, manual knapsack application, boomspray application and permanent spray lines, or any combination thereof.
- 10 16. Kit of parts, comprising an amount of mineral spray oil and an amount of a liquid oil-miscible micronutrient composition as defined in any one of claims 1 to 9, wherein the oil-based liquid medium is a vegetable oil.

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
INV. C05D9/02 C05F11/00 C05G3/00
ADD.

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)
C05D C05F C05G

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)

EPO-Internal, WPI Data, BIOSIS, COMPENDEX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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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

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"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

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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