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(54) Titre : SUSPENSION AQUEUSE CONCENTREE DE CELLULOSE MICROFIBRILLEE COMPRENANT DES SELS POUR LA NUTRITION DES PLANTES
(54) Title: CONCENTRATED AQUEOUS SUSPENSION OF MICROFIBRILLATED CELLULOSE COMPRISING SALTS FOR PLANT NUTRITION

(57) Abrégé/Abstract:
Concentrated aqueous suspension of microfibrillated cellulose (MFC) comprising salts for plant nutrition, the concentrated aqueous suspension comprises microfibrillated linear polymers of D-glucose molecules (cellulose microfibers), calcium ions, sulfate ions and other elements for plant nutrition, being the concentration of calcium ions and sulfate ions in excess of the concentration corresponding to the solubility of calcium sulfate in water and being the proportion of microfibrillated cellulose (MFC) within a range of 1% and 99% w/w of the suspension.

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(54) Title: CONCENTRATED AQUEOUS SUSPENSION OF MICROFIBRILLATED CELLULOSE COMPRISING SALTS FOR PLANT NUTRITION

(57) Abstract: Concentrated aqueous suspension of microfibrillated cellulose (MFC) comprising salts for plant nutrition, the concentrated aqueous suspension comprises microfibrillated linear polymers of D-glucose molecules (cellulose microfibers), calcium ions, sulfate ions and other elements for plant nutrition, being the concentration of calcium ions and sulfate ions in excess of the concentration corresponding to the solubility of calcium sulfate in water and being the proportion of microfibrillated cellulose (MFC) within a range of 1% and 99% w/w of the suspension.

CONCENTRATED AQUEOUS SUSPENSION OF MICROFIBRILLATED CELLULOSE COMPRISING SALTS FOR PLANT NUTRITION

RELATED APPLICATION/S

This application claims the benefit of priority of U.S. Patent Application No. 16/442,561 filed on 17 June 2019, the contents of which are incorporated herein by reference in their entirety.

FIELD AND BACKGROUND OF THE INVENTION

This invention relates to nutrient solutions for plants. More specifically, it pertains to an aqueous suspension of microfibrillated cellulose that involves nutrients which are useful for plant growth.

In hydroponics and fertirrigation, concentrated nutrient solutions called “stock” are used as fertilizers. Stock solutions are formulated by mixing inorganic salts in high concentrations and their purpose is to provide plants with all the mineral elements that they require throughout their lifecycle.

In intensive crops that require hydroponic nutrition or fertirrigation, plants are supplied with all the elements by nutrient solutions prepared by dissolving fertilizing salts in water.

Out of all the known natural elements, only 60 elements have been found in various plants and only 16 elements are generally considered essential for plant growth. Although most plants require only 16 essential elements, some species may need others.

Macroelements include carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sulfur (S) and magnesium (Mg).

Microelements include iron (Fe), chlorine (Cl), manganese (Mn), boron (B), zinc (Zn), copper (Cu), molybdenum (Mo).

Plants need calcium for growth. Calcium is generally supplied by calcium nitrate, which also provides nitrogen. Any other necessary additional nitrogen can be provided through any salt containing nitrates or through ammonium fertilizers.

Plants also require a form of sulfur to be utilized in the formation of amino acids which are involved in their process of growth. Sulfur is usually provided by inorganic sulfate, which can be easily utilized by plants.

Phosphorus is supplied through phosphates and polyphosphates: monopotassium phosphate and diammonium phosphate are the most commonly used ones. The needs for potassium are covered with potassium salts: potash, potassium nitrate, monopotassium phosphate, potassium chloride and potassium sulfate are the most frequently used ones.

The formulations for fertilizers vary according to the specific requirements of each crop, its stage of development and the surrounding climatic conditions.

In order to provide the crops with all the needed elements, two different “stock” solutions, generally called “A” and “B”, must be prepared. The solutions need to be prepared separately in order to avoid precipitation of calcium sulfate from calcium provided in stock A and sulfur – in the form of inorganic sulfate- provided in stock B. If they were to precipitate, the elements would stop being available for plants. It is important to clarify that both calcium and sulfur are essential elements for plants and must be necessarily added to nutrient solutions. Calcium is utilized for growth while sulfur is utilized to form amino acids. The latter is usually provided as inorganic sulfate since, in this form, it can be easily absorbed by the plants.

Since calcium sulfate is poorly soluble in water (at a rate of 0.67 grams/liter at 77?F and neutral pH), nutrient solutions are formulated as stock A and B so as to add calcium and sulfate separately. It would not be commercially viable to formulate a diluted solution combining calcium and sulfate at such low levels of concentration in order to avoid the precipitation of calcium sulfate.

Chelates are widely used in hydroponics, fertirrigation and fertilization, since they are essential to provide the nutrient solutions with microelements. Chelates are organic structures that are capable of “wrapping” the ions of the microelements, thus making them stable in the solutions and preventing them from bonding with other cations and precipitating. Besides, together with the microelements, they form a ligation that improves the plant’s absorption capacity of the latter.

Chelates are particularly important for the provision of iron, since it is the microelement that can more easily form hydroxides and insoluble salts with other ions that are present in the nutrient solutions. It is worth mentioning that iron is essential for chlorophyll synthesis because it acts as a carrier of electrons during photosynthesis and cellular respiration, activating some enzymes as well. There cannot be a nutrient solution formulation without the incorporation of iron. As result of this, it is added in its chelated form. A preferred chelating agent is EDTA.

There have been attempts to solve the problem of calcium precipitation with sulfates by chelating calcium, although the latter is not a microelement and it can be perfectly assimilable if it is incorporated through a salt such as calcium nitrate.

However, calcium chelate only remains stable in a pH that ranges from 6 to 14, while on the other hand iron chelate remains stable only under acidic conditions. Therefore, the pH range that would enable the incorporation of all the nutrients by using both chelates is very limited (6 to 7). This complicates the obtainment process of the solution and threatens the concentrations of salts that implies higher levels of acidity.

It would be desirable to have a single concentrated solution of the necessary ingredients for plant growth where the precipitation of calcium and sulfur as calcium sulfate could be prevented, as well as the precipitation of other salts such as iron sulfate.

Surprisingly, the inventors of this patent application have found that microfibrillated cellulose (MFC) prevents the precipitation of salts in a pH range from 1 to 13.

SUMMARY OF THE INVENTION

The main object of the invention is a nutrient solution that combines stock A (which provides calcium) and stock B (which provides sulfates) in a single stabilized solution, in a microfibrillated cellulose medium, having a concentration of calcium and sulfate in excess of that corresponding to the normal solubility of calcium sulfate in water.

More specifically, the object of the invention is a concentrated aqueous suspension of microfibrillated cellulose comprising salts for plant nutrition wherein the concentrated aqueous suspension comprises microfibrillated linear polymers of D-glucose molecules (cellulose microfibers), calcium ions, sulfate ions and other elements for plant nutrition such as nitrogen, phosphorus, potassium, magnesium, iron, chlorine, manganese, boron, zinc, copper, molybdenum, and others, being the concentration of calcium ions and sulfate ions in excess of the concentration corresponding to the solubility of calcium sulfate in water and being the proportion of microfibrillated cellulose (MFC) within a range of 1% and 99% w/w of the suspension.

Another object of the invention is the use of microfibrillated cellulose for the preparation of a concentrated suspension comprising the mixing of microfibrillated linear polymers of D-glucose molecules (cellulose microfibers), calcium ions, sulfate ions and other elements for plant nutrition such as nitrogen, phosphorus, potassium, magnesium, iron, chlorine, manganese, boron, zinc, copper, molybdenum, and others, being the concentration of calcium ions and sulfate ions in excess of the concentration corresponding to the solubility of calcium sulfate in water and being the proportion of microfibrillated cellulose (MFC) within a range of 1% and 99% w/w of the suspension.

Another object of the invention is a process for the preparation of a concentrated aqueous suspension of microfibrillated cellulose comprising salts for plant nutrition wherein the method comprises the step of mixing microfibrillated linear polymers of D-glucose molecules (cellulose microfibers), calcium ions, sulfate ions and other elements for plant nutrition such as nitrogen, phosphorus, potassium, magnesium, iron, chlorine, manganese, boron, zinc, copper, molybdenum, and others, being the concentration of calcium ions and sulfate ions in excess of the concentration corresponding to the solubility of calcium sulfate in water and being the proportion of microfibrillated cellulose (MFC) within a range of 1% and 99% w/w of the suspension.

Another object of the invention is a process for plant nutrition using hydroponic or fertirrigation techniques comprising the step of supplying a concentrated aqueous suspension of microfibrillated cellulose comprising salts for plant nutrition wherein the concentrated aqueous suspension comprises microfibrillated linear polymers of D-glucose molecules (cellulose microfibers), calcium ions, sulfate ions and other substances for plant nutrition such as nitrogen, phosphorus, potassium, magnesium, iron, chlorine, manganese, boron, zinc, copper, molybdenum, and others, being the concentration of calcium ions and sulfate ions in excess of the concentration corresponding to the solubility of calcium sulfate in water and being the proportion of microfibrillated cellulose (MFC) within a range of 1% and 99% w/w of the suspension.

Another object of the invention is the use of a concentrated aqueous suspension of microfibrillated cellulose comprising salts for plant nutrition wherein the concentrated aqueous suspension comprises microfibrillated linear polymers of D-glucose molecules (cellulose microfibers), calcium ions, sulfate ions and other elements for plant nutrition such as nitrogen, phosphorus, potassium, magnesium, iron, chlorine, manganese, boron, zinc, copper, molybdenum, and others, being the concentration of calcium ions and sulfate ions in excess of the concentration corresponding to the solubility of calcium sulfate in water and being the proportion of microfibrillated cellulose (MFC) within a range of 1% and 99% w/w of the suspension, for the attainment of a solid fertilizer.

DESCRIPTION OF SPECIFIC EMBODIMENT OF THE INVENTION

The formulations for fertilizers vary according to the specific requirements of each crop, its stage of development and the surrounding climatic conditions.

The salts that are most commonly used for the formulation of stock A are as follows:

Calcium nitrate

Potassium nitrate (optional, since it is also present in stock B)

Ammonium nitrate
Potash
Potassium chloride
Calcium oxide
Calcium chloride
Iron ethylenediamine tetraacetic acid (Ferric EDTA)
Sodium molybdate (dihydrate)
Ammonium molybdate
Ethylenediamine tetraacetic manganese (Mn EDTA)
Manganese chloride
Ethylenediamine tetraacetic zinc (Zn EDTA)
Zinc chloride
Ethylenediamine tetraacetic magnesium (Mg EDTA)
Magnesium oxide
Ethylenediamine tetraacetic copper (Cu EDTA)
Ethylenediamine tetraacetic cobalt (Co EDTA)
Boric acid
Sodium tetraborate

The most common salts to formulate stock B are:

Potassium sulfate
Magnesium sulfate
Ammonium sulfate
Ferrous sulfate
Copper sulfate
Magnesium sulfate
Zinc sulfate
Phosphate
Monopotassium phosphate
Diammonium phosphate
Phosphoric anhydride
Potassium nitrate

As described above, stock A usually includes the nitrates (calcium, potassium and ammonium) and the EDTA-chelated microelements. However, another possible common formulation is to incorporate only the nitrates (calcium, potassium and ammonium) and the iron EDTA in stock A; and to incorporate the microelements in the form of sulfates (magnesium, manganese, copper, zinc, etc.) in stock B, so that sulfates and calcium do not precipitate as calcium sulfate.

Surprisingly, applicants of the present patent application found another alternative which involves the use of microfibrillated cellulose (MFC), obtained from a fibrillation process of cellulose in wet state.

Microfibrillated cellulose (MFC) is a substance composed of cellulose and water, with a cellulose concentration of less than 15%. It is characterized by being able to store large quantities of water in relation to its mass, obtaining "creamy" or "gel-type" suspensions with very low proportions of microfibrillated cellulose (as low as 2%). Its pH varies in a range from 4 to 8 and its density between 1.2 and 1.6 kg/L.

Cellulose microfibrils are very small cellulose fibers obtained from the mechanical disintegration of plant fibers and by a sequence of specific chemical and mechanical treatments (fibrillation process).

When the cellulose goes through a fibrillation process, the surface area becomes much larger in comparison with the original raw material, thus generating a significant increase in the quantity of hydroxyl groups (OH) available on the surface of the microfibrils. As this hydroxyl groups have a natural negative charge, they will be able to capture ions with positive charge, such as calcium ions. In this way, the calcium ions are prevented from bonding with the sulfates, avoiding altogether its precipitation as calcium sulfate.

In the case of suspensions with low humidity proportion, it is possible to obtain a solid fertilizer with highly beneficial characteristics. One of them is to allow the release of the nutrients on demand of the plant. This happens because the electrochemical force of the leaves is higher than the ionic forces of the elements with the hydroxyl in the solid suspension, which generates the nutrients release. On the other hand, these hydroxyl ionic forces are stronger than the polar forces of water, so the degree of leaching of nutrients is reduced, since they are withheld by such force in the presence of rain.

A preferred aqueous suspension of the present invention involves:

(all percentages in the following description and in the examples correspond to % w/w)

between 60% and 90% of water

between 1% and 40% of microfibrillated cellulose (MFC)
between 1% and 55% of calcium nitrate
between 0.01% and 0.5% of magnesium EDTA
between 0.01% and 0.7% of manganese EDTA
between 0.01% and 0.7% of zinc EDTA
between 0.01% and 0.9% iron EDTA
between 0.01% and 0.1% of copper EDTA
between 0.001% and 0.01% sodium molybdate (Dihydrate)
between 0.0001% and 0.001% of cobalt EDTA
between 0.01% and 0.4% of boric acid
between 1% and 12% of potassium nitrate
between 0.5% and 25% of monopotassium phosphate
between 0.5% and 42% of magnesium sulfate
between 0.1% and 11% of potassium sulfate

A most preferred aqueous suspension of the present invention involves:
18.6 liters of water (68.2%)
6,000 grams of microfibrillated cellulose (22.0%)
1,000 grams of calcium nitrate (3.7%)
12 grams of magnesium EDTA (0.0440%)
20 grams of manganese EDTA (0.0733%)
20 grams of zinc EDTA (0.0733%)
25 grams of iron EDTA (0.0916%)
3 grams of copper EDTA (0.0110%)
0.3 grams of sodium molybdate (Dihydrate) (0.0011%)
0.03 grams of cobalt EDTA (0.0001%)
10 grams of boric acid (0.0366%)
300 grams of potassium nitrate (1.10%)
400 grams of monopotassium phosphate (1.47%)
750 grams of magnesium sulfate (2.75%)
150 grams of potassium sulfate (0.55%)

The following examples show the preparation of concentrated solutions that may contain all the necessary components for a plant. The formulations are not intended to specify the required quantities or to restrict the ingredients used. Their main intention is to show the preparation of a concentrated aqueous suspension of this invention.

EXAMPLES

Example 1:

Preparation of concentrated aqueous suspension

Example to prepare 10 liters of stock A:

The following elements were mixed into 9.3 liters of water at 77°F and neutral pH (the reason that 9.3 liters of water are added is to get 10 liters of stock A, as salts provide approximately 700cc of the volume):

1,000 grams of calcium nitrate

12 grams of magnesium EDTA

20 grams of manganese EDTA

20 grams of zinc EDTA

25 grams of iron EDTA

3 grams of copper EDTA

0.3 grams of sodium molybdate (Dihydrate)

0.03 grams of cobalt EDTA

10 grams of boric acid

The weight of the resulting 10 liters of stock A is 10,390 grams.

Example to prepare 10 liters of stock B:

The following elements were mixed into 9.3 liters of water at 77°F and neutral pH (the reason that 9.3 liters of water are added is to get 10 liters of stock B since salts provide approximately 700cc of the volume):

300 grams of potassium nitrate

400 grams of monopotassium phosphate

750 grams of magnesium sulfate

150 grams of potassium sulfate

The weight of the resulting 10 liters of stock B is 10,900 grams.

Example to obtain 27.3 kilos of concentrated aqueous suspension of stock A and B in microfibrillated cellulose:

The reason that 27.3 kilos are prepared is because the proportions, in this formulation, are 6 parts of microfibrillated cellulose (MFC) for every 10 parts of Stock A (10,390 grams) and 10 parts of Stock B (10,900 grams), which results in the aforementioned quantity.

Six kilos of microfibrillated cellulose (MFC) were mixed into 10 liters of stock A and stirred manually for 5 minutes. Then, 10 liters of stock B were added to the resulting solution and stirred manually for 5 minutes. The resulting solution has the initial composition of stock A and stock B as well as the microfibrillated cellulose (MFC), with a pH of 3.4. This means:

18.6 liters of water (68.2%)

6,000 grams of microfibrillated cellulose (22.0%)

1,000 grams of calcium nitrate (3.7%)

12 grams of magnesium EDTA (0.0440%)

20 grams of manganese EDTA (0.0733%)

20 grams of zinc EDTA (0.0733%)

25 grams of iron EDTA (0.0916%)

3 grams of copper EDTA (0.0110%)

0.3 grams of sodium molybdate (Dihydrate) (0.0011%)

0.03 grams of cobalt EDTA (0.0001%)

10 grams of boric acid (0.0366%)

300 grams of potassium nitrate (1.10%)

400 grams of monopotassium phosphate (1.47%)

750 grams of magnesium sulfate (2.75%)

150 grams of potassium sulfate (0.55%)

The weight of the suspension is 27,290 grams.

Examples of mixes with and without precipitates

Example 2

Stock A and stock B were mixed

One hundred (100) cc of the obtained stock A and 100 cc of the obtained stock B were mixed at 77°F; the mixture was stirred and after 3 minutes the emergence of a precipitate was observed.

Thirty minutes later the mixture was stirred again and 2 minutes after that the precipitate was still present, thus confirming that the precipitate does not re-dissolve.

Example 3

Stock A and MFC were mixed, then stock B was added

One hundred (100) cc of the obtained stock A were mixed into 60 grams of microfibrillated cellulose (MFC); the mixture was stirred manually, and then 100 cc of the obtained stock B were immediately added. After 3 minutes, no precipitate emergence was observed. The sample was monitored 24 hours later, 48 hours later and even 90 days later but no modifications were found in its appearance.

Example 4

Stock B and MFC were mixed, and then stock A was added.

In this example, the order of the stocks in the preparation of the aqueous suspension was exchanged. One hundred (100) cc of the obtained stock B were mixed into 60 grams of microfibrillated cellulose (MFC); the mixture was manually stirred and then 100 cc of the obtained stock A were added. After 3 minutes no precipitate was seen emerging. The sample was monitored 24 hours later, 48 hours later and even 90 days later but no modifications were found in its appearance.

Example 5

This example aims to demonstrate that there is no evidence of toxicity in the use of microfibrillated cellulose (MFC) when it is used in a nutrient solution. We prepared 3 identical small hydroponic floating systems where 2 lettuce specimens were grown.

The hydroponic floating system consisted of 20-liter trays where 2 seedlings of lettuce were laid in each one. The trays had a flat bar of polystyrene to support the seedlings and each of them had two holes that enabled the roots to reach the water contained in the trays.

Hydroponic system number 1 was fed with stock A and stock B nutrient solutions, and no microfibrillated cellulose (MFC) was added. Hydroponic system number 2 was fed with a concentrated aqueous suspension of stock A and B in microfibrillated cellulose (MFC) having a microfibrillated cellulose (MFC) concentration of 23%. Hydroponic system number 3 was fed with a concentrated aqueous suspension of stock A and B in microfibrillated cellulose (MFC), having a microfibrillated cellulose (MFC) concentration of 80%.

The amount of solution and/or aqueous suspension added in the three systems had the same electrical conductivity in each case, ensuring the same provision of salts in each of them (electrical conductivity is a measure of the amount of dissolved solids per unit of volume)

The targeted electrical conductivity varied from week to week, depending on the requirements of the lettuce plants in their lifecycle, having 350 ppm in week 1, 700 ppm in week 2, 1,050 ppm in week 3 and 1,400 ppm in week 4.

After week 4 all the lettuce plants had showed equal growth and reached a weight ranging between 270 and 280 grams each.

Thus, we can conclude that microfibrillated cellulose (MFC) allows for the availability of salts for plants as well as the right absorption of nutrients since the growth of specimens studied did not reveal significant variations.

Example 6

This example shows how microfibrillated cellulose (MFC) prevents calcium sulfate from precipitating even when solutions of calcium nitrate and sulfates in their highest possible concentration at 77°F and neutral pH are mixed.

Two samples were tested:

A control sample where 3 salt dilutions at its highest possible concentration at 77°F and neutral pH were mixed, in this order: 180 cc of water *, 100 cc of calcium nitrate solution (1,200 grams in 1 liter of water), 100 cc of potassium sulfate solution (120 grams in 1 liter of water) and 100 cc of manganese sulfate solution (710 grams in 1 liter of water).

After mixing them mechanically, we observed a precipitate of 192 grams of calcium sulfate.

*One hundred and eighty (180) cc of water was added so as to equate the volumes in the samples (water in the first one and microfibrillated cellulose in the second one).

In the other sample, 3 salt dilutions at its highest possible concentration at 77°F and neutral pH, were mixed in microfibrillated cellulose (MFC), following this order: 100 cc of calcium nitrate solution (1,200 grams in 1 liter of water) in 60 grams of microfibrillated cellulose (MFC), 100 cc of potassium sulfate solution (120 grams in 1 liter) in 60 grams of microfibrillated cellulose (MFC), and finally 100 cc of manganese sulfate solution (710 grams in a liter) in 60 grams of microfibrillated cellulose (MFC). The 3 suspensions were mixed altogether.

There were no signs of a precipitate after 48 hours.

Example 7

This example shows that microfibrillated cellulose (MFC) makes it possible to elaborate suspensions of homogeneously distributed salts that contain solids in a much higher proportion than the quantity of salts that could be contained in a water solution of the same volume.

We ran two sample tests.

A control sample where potassium sulfate was added in an amount that exceeded twice its solubility in water at 77°F and neutral pH (111 g/L). More specifically, we mixed 28.8 grams of potassium sulfate in 130 cc of water at 77°F. It was stirred manually and immediately after that a precipitate of potassium sulfate was noted.

Sample number 2 consisted of the same amount of potassium sulfate contained in the control sample (that is, 28.8 grams) that was added into a suspension of the same volume (130 cc) with microfibrillated cellulose (MFC) at 23% (30 grams of microfibrillated cellulose in 100 cc of water). It was stirred manually and after 5 minutes no decantation of potassium sulfate was observed. The sample was monitored 24 hours later, 48 hours later and even 90 days after without having observable modifications in its appearance.

Example 8

Preparation of a solid-consistency fertilizer

An aqueous suspension prepared as described in example 1 is the starting point.

We took 1,000 grams of the concentrated aqueous suspension of stock A and B in microfibrillated cellulose (MFC) as described in example 1. This suspension was poured into granular-shaped moulds of 10 cm^3, each of them containing 12 grams of suspension, and were placed in a dehydrator oven at 161.6°F for 24 hours. The final result of this process was a product with solid consistency. In each cast, a 3-gram-tablet was obtained, which implies a loss of 8 grams of water. Assuming that the microfibrillated cellulose (MFC) lost 50% of its humidity and knowing that its fiber ratio is 15%, the resulting composition of each tablet is:

10.00% water
50.56% microfibrillated cellulose
14.65% calcium nitrate
0.176% magnesium EDTA

0.293% manganese EDTA

0.293% zinc EDTA

0.366% iron EDTA

0.044% copper EDTA

0.044% sodium molybdate (dihydrate)

0.0044% cobalt EDTA

0.147% boric acid

4.39% potassium nitrate

5.86% monopotassium phosphate

10.99% magnesium sulfate

2.19% potassium sulfate

Example 9

Nutrition of a tomato specimen using the concentrated aqueous suspension in its solid form.

A tomato specimen was grown using for its nutrition only the concentrated aqueous suspension in its solid from, obtained as described in example 8.

A thin layer of leca was first placed in an 11-litre-pot to facilitate the drainage, and then filled with an inert, nutrient-free substrate (peat). Then, 12 tablets obtained as described in example 8 were placed evenly distributed throughout the pot. The pot was watered according to its demand, water being the only input added during the whole cycle. In a 105-day cycle, the plant produced 43 tomatoes with a total weight of 4.9 kilos. The plant showed a normal size with a suitable growth speed and the presence of healthy leaves in the upper part of its stem.

This experiment suggests that the nutrients were effectively released at the plant's requests throughout the cycle.

The suspension object of the present invention has the following advantages over the prior art:

Aqueous suspension permits to have in only one solution the combination of salts whose concentration would naturally lead to precipitate.

It permits to elaborate complete formulations that are totally balanced for each type of crop in only one suspension.

In its solid version, the nutrients are released on plant demand and there is a reduction in leaching

Simplification over the use of fertilizers, since there is no longer need to handle several solutions such as stock A and stock B.

Lower transportation costs and carbon footprint reduction due to the possibility to transport a greater amount of salts in the same volume.

Reduction in packaging as a result of the fewer wrappings needed to deliver the complete formulations.

Product shelf-life: the product shelf-life increases due to the stability of the suspension

Lower storage costs and convenient stock management.

In addition, any priority document(s) of this application is/are hereby incorporated herein by reference in its/their entirety.

WHAT IS CLAIMED IS:

1. Concentrated aqueous suspension of microfibrillated cellulose (MFC) comprising salts for plant nutrition wherein the concentrated aqueous suspension comprises microfibrillated linear polymers of D-glucose molecules (cellulose microfibers), calcium ions, sulfate ions and other elements for plant nutrition such as nitrogen, phosphorus, potassium, magnesium, iron, chlorine, manganese, boron, zinc, copper, or molybdenum, being the concentration of calcium ions and sulfate ions in excess of that corresponding to the solubility of calcium sulfate in water and being the proportion of microfibrillated cellulose (MFC) within a range of 1% and 99% w/w of the suspension.

2. The concentrated aqueous suspension according to claim 1, wherein it comprises:
between 0.5% and 99% of water
between 0.5% and 99% of microfibrillated cellulose (MFC)
between 0.1% and 99% of calcium nitrate
between 0.1 % and 99% of ammonium nitrate
between 0% and 99% of one of the following substances: magnesium EDTA, magnesium oxide or magnesium sulfate.
between 0% and 99% of one of the following substances: manganese EDTA, magnesium sulfate or magnesium chloride.
between 0% and 99% of one of the following substances: zinc EDTA, zinc sulfate or zinc chloride.
between 0% and 99% of one of the following substances: iron EDTA or ferrous sulfate.
between 0% and 99% of one of the following substances: copper EDTA or coper sulfate.
between 0% and 99% of one of the following substances: sodium molybdate (dehydrate) or ammonium molybdate.
between 0% and 99% of cobalt EDTA
between 0% and 99% of one of the following substances: boric acid or sodium tetraborate.
between 0% and 99% of one of the following substances: potassium nitrate, monopotassium phosphate, potassium chloride or potassium sulfate

between 0% and 99% of one of the following substances: monopotassium phosphate, monoammonium phosphate or diammonium phosphate.

between 0.1 % and 99% of one of the following substances: magnesium sulfate or magnesium oxide

between 0.1 % and 99% of potassium sulfate

3. The concentrated aqueous suspension according to claim 1, wherein it comprises:

18.6 liters of water (68.2% w/w)

6,000 grams of microfibrillated cellulose (22.0% w/w)

1,000 grams of calcium nitrate (3.7% w/w)

12 grams of magnesium EDTA (0.0440% w/w)

20 grams of manganese EDTA (0.0733% w/w)

20 grams of zinc EDTA (0.0733% w/w)

25 grams of iron EDTA (0.0916% w/w)

3 grams of copper EDTA (0.0110% w/w)

0.3 grams of Sodium molybdate (Dihydrate) (0.0011% w/w)

0.03 grams of cobalt EDTA (0.0001% w/w)

10 grams of boric acid (0.0366% w/w)

300 grams of potassium nitrate (1.10% w/w)

400 grams of monopotassium phosphate (1.47% w/w)

750 grams of magnesium sulfate (2.75% w/w)

150 grams of potassium sulfate (0.55% w/w).

4. The use of microfibrillated cellulose (MFC) for the preparation of a concentrated suspension comprising the mixing of microfibrillated linear polymers of D-glucose molecules (cellulose microfibers), calcium ions, sulfate ions and other elements for plant nutrition, such as nitrogen, phosphorus, potassium, magnesium, iron, chlorine, manganese, boron, zinc, copper, or molybdenum, being the concentration of calcium ions and sulfate ions in excess of the concentration corresponding to the solubility of calcium sulfate in water and being the proportion of microfibrillated cellulose (MFC) within a range of 1% and 99% w/w of the suspension.

5. A process for the preparation of a concentrated aqueous suspension of microfibrillated cellulose comprising salts for plant nutrition wherein the method comprises the step of mixing microfibrillated linear polymers of D-glucose molecules (cellulose microfibers), calcium ions, sulfate ions and other elements for plant nutrition, such as nitrogen, phosphorus, potassium, magnesium, iron, chlorine, manganese, boron, zinc, copper, or molybdenum, being the concentration of calcium ions and sulfate ions in excess of the concentration corresponding to the solubility of calcium sulfate in water and being the proportion of microfibrillated cellulose (MFC) within a range of 1% and 99% w/w of the suspension.

6. A process for plant nutrition using hydroponic or fertirrigation techniques comprising the: step of supplying a concentrated aqueous suspension of microfibrillated cellulose (MFC) comprising salts for plant nutrition wherein the concentrated aqueous suspension comprises microfibrillated linear polymers of D-glucose molecules (cellulose microfibers), calcium ions, sulfate ions and other elements for plant nutrition, such as nitrogen, phosphorus, potassium, magnesium, iron, chlorine, manganese, boron, zinc, copper, or molybdenum, being the concentration of calcium ions and sulfate ions in excess of the concentration corresponding to the solubility of calcium sulfate in water and being the proportion of microfibrillated cellulose (MFC) within a range of 1% and 99% w/w of the suspension.

7. The use of the concentrated aqueous suspension according to claim 1 for the obtainment of a solid-consistency fertilizer.

8. The process for the preparation of a solid-consistency fertilizer which involves submitting the concentrated aqueous suspension according to claim 1 to thermal treatment for its dehydration.