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(54) Title: **SEED COATING FOR IMPROVING THE EFFICIENCY OF PLANT NUTRIENTS AND COATED SEED**

(57) Abstract: The invention relates to a seed coating for improving the efficiency of plant nutrients during the early growth of the plant, which coating comprises i) an aqueous fixing agent containing a fluid byproduct of agriculture or fermentation, and possibly an emulsified oil, and ii) a fertilizer powder comprising nutrients and trace elements required by the plant and/or other substances affecting plant growth. The invention also relates to a coated seed having such a coating and to a method for coating seeds.

Seed coating for improving the efficiency of plant nutrients and coated seed

The invention relates to a seed coating for improving the efficiency of plant nutrients, especially the efficiency of phosphorus and/or the efficiency of trace elements, during the early growth of the plant, to a coated seed, to a method for
5 coating seed, and to a method for improving the efficiency of plant phosphorus and/or the efficiency of plant trace elements and for promoting plant growth during the early growth of the plant.

The rapidity with which the roots of a plant reach the fertilizer has great
10 significance for the ability of the plant to take up the nutrients present in the fertilizer and for the success of the initial development and growth of the plant in the first three weeks.

The quantity of the principal nutrients (N, K, P, Ca, S, Mg) passing from fertilizers into plants, i.e. the efficiency of nutrients, usually varies from a few per cent to 70 –
15 80 per cent. The efficiency of phosphorus in particular is low, approx. 5 – 20 %. The efficiency of trace elements (B, Co, Cu, Fe, Mn, Mo, Zn, Cl) is often even lower than this.

The method of spreading a fertilizer, i.e. how far from the seed the fertilizer is deposited, affects the ability of the plant to take up the nutrients. The nutrients in a
20 fertilizer deposited far from a seed, for example, at a distance of 6 cm from it, may have time to react with soil minerals and form poorly soluble compounds even before the plant roots have reached the location of the fertilizer.

When, for example, phosphorus fertilization is carried out in the manner described above by conventional broadcasting of the fertilizer on the soil surface or by mixing
25 it into the surface layer of the soil, the efficiency of the phosphorus is 5 – 10 %. If the fertilizer is spread by row application or tape application at a specified distance from the seed, the efficiency of the phosphorus is approx. 10 %.

A somewhat better phosphorus efficiency is achieved when the phosphorus fertilizer is deposited in the immediate vicinity of the seed or when the seed is
30 coated with the fertilizer. In this case the efficiencies are, respectively, 15 % and 20 %.

The coating of plant seeds for various reasons has long been a known technology. There are different surface treatments, beginning from the simple and conventional seed dressing with biocides to combat plant diseases and noxious insects. In this case the seeds as such are treated with a fine-ground active agent or a powder
5 mixture containing it, or the active agent is dissolved or slurried in a suitable solvent, often water or an organic solvent, and the seeds are then treated with the obtained solution or slurry.

Coating of seeds has also been used for delaying the germination of seeds. Polymers have been used as fixing agents also in the coating of seeds with substances having
10 other effects. Coating may, for example, improve the ability of the seeds to withstand drought, heat, soil salinity, or other external stress factors.

With the help of coating, for example, lightweight seeds of rice can be rendered heavier, whereupon they will not be so easily carried by water or wind; see, for example, patent publication US 4,192,095.

15 It is also generally known to add nutrients to a coating in order to promote plant growth.

Grass seeds have been treated with, for example, lime or talc in order to ensure the establishment of a lawn (Scott 1975). The coating of seeds with nutrients is discussed in several studies (e.g. Heydecker and Coolbear 1977, Rebafka *et al.*
20 1983, Scott *et al.* 1987). The greatest problems have been a poor germination percentage of the seeds, especially when oil has been used as the fixing agent, and poor attachment of nutrients to the seed surface when aqueous solutions have been used.

A great deal of research has been conducted in order to solve these problems.
25 Various fixing agent compositions have been experimented with for fixing nutrients or other growth-promoting substances or compositions to the surfaces of plant seeds.

In particular, the usability of various polymers has been experimented with. It is, for example, a known method to coat seeds with water-soluble polymers such as starch,
30 methyl cellulose and gum arabic. The greatest disadvantage is the large amount of water associated with the use of these polymers. The handling of a large amount of water requires special apparatus, and the coating process is slow. In order to prevent the wetting of the seeds, the seeds must often be dried at a low temperature. The above-mentioned polymers often form a hard, easily breaking coat around the seeds.

Patent publication WO 9325078 describes a composition used for the coating of seeds, which composition contains a polysaccharide hydrolysate, for example, carboxymethyl cellulose or carboxymethyl starch hydroxylate. The aqueous solutions of these may also be sprayed in the form of relatively concentrated aqueous solutions (30 %) onto the seed surfaces.

The use of water-insoluble polymers, on the other hand, usually requires the use of an organic solvent, in which case a large solvent amount may promote the penetration of the polymer into the seed. It is also possible to use aqueous suspensions of these polymers for the treatment of seeds. For example, CA PLUS 112:17756 (PL 14618) and CA PLUS 122:49097 (PL 159474) describe such an application.

US patent publication 4,251,952 describes seeds coated with a mixture of a water-insoluble polymer and sugar. The polymers used are various commercial poly- or copolymers.

In addition to the disadvantages already stated above, the prior-known methods may also have the disadvantage of stickiness of the coated seed surfaces, causing the seeds to stick together and giving the seeds poor flow properties. The apparatuses required for the handling of the seeds also become easily soiled. A coating too moist, for its part, may cause premature germination of the seeds.

According to the present invention, a seed coating is provided for improving the efficiency of plant nutrients, in particular the efficiency of phosphorus and/or the efficiency of trace elements, during the early growth of the plant, which coating comprises

- i) an aqueous fixing agent containing a fluid byproduct of agriculture or fermentation, and possibly an emulsified oil, and
- ii) a fertilizer powder comprising nutrients and trace elements required by the plant and/or other substances affecting plant growth.

According to the invention there is also provided a coated seed having a coating for improving the efficiency of plant nutrients, in particular the efficiency of phosphorus and/or the efficiency of trace elements, during the early growth of the plant, which coating comprises:

- i) an aqueous fixing agent containing a fluid byproduct of agriculture or fermentation, and possibly an emulsified oil, and
- ii) a fertilizer powder comprising nutrients and trace elements required by the plant and/or other substances affecting plant growth.

- 5 The size of the seeds to be surface-treated and the type of their surface, which are properties specific to a plant species, affect the quantity of fixing agent that is required for fixing the desired amount of fertilizer powder to the seed surface. Preferably, the fixing agent is used in an amount of 0.5-5 parts by weight (w/w) and the fertilizer in an amount of 1-25 parts by weight (w/w) per 100 parts by weight
10 (w/w) of seeds.

The said fixing agent may contain a fluid byproduct of agriculture or fermentation in an amount of 30-100 % by weight (w/w) and oil in an amount of 0-50 % by weight (w/w), any balance being water. The amount of oil is preferably 0-30 % by weight (w/w).

- 15 The said fluid byproduct of agriculture or fermentation may be, for example, molasses, such as root or cane molasses, vinasse or syrup, or a mixture thereof. The said byproducts contain varying amounts of water.

The said fixing agent may also contain polymers conventionally used as fixing agents in seed coating and mentioned also in the description of the state of the art.

- 20 In addition to the fluid byproduct of agriculture or fermentation, the said fixing agent may contain an emulsified oil, which is typically an oil in water emulsion. Such an emulsion is prepared from oil, water and a dispersing agent. Conventional dispersing agents suitable for this purpose may be used as the dispersing agent.

- 25 The said fixing agent may also be made up of only an aqueous, fluid byproduct of agriculture or fermentation.

The said fixing agent may also contain conventional preservatives and/or pH control agents.

The said oil is preferably a biodegradable or readily biodegradable plant or animal oil or mineral oil, such as white oil, or a mixture thereof.

- 30 The said fertilizer powder may contain, for example, monocalcium phosphate, monopotassium phosphate, ammonium phosphate, urea phosphate or a mixture of

these, or any readily water-soluble multi-nutrient fertilizer. In addition it may contain micronutrients and/or trace elements. One kilogram of fertilizer may contain, for example, 5-200 g of magnesium, 1-50 g of zinc, 1-50 g of manganese, 30-200 g of sodium, and/or 1-20 mg of selenium. The fertilizer powder may also
5 contain other substances affecting plant growth, such as a pesticide and/or a growth control agent and/or a growth promoter.

The particle size of the said fertilizer powder is typically 1-100 μm , preferably 10 - 50 μm .

According to the invention there is also provided a method for coating plant seeds,
10 in which method

- a) the seeds to be coated are placed in an apparatus suitable for the treatment of seeds,
- b) an aqueous fixing agent is added, which contains a fluid byproduct of agriculture or fermentation, and possibly an emulsified oil, so that a fixing agent
15 layer is formed on the seed surfaces,
- c) a fertilizer powder is added, which comprises nutrients and trace elements required by the plant and/or other substances affecting plant growth, so that a coating is formed.

The method does not require special apparatus; the treatment of seeds may be
20 carried out in any apparatus suitable for the treatment of seeds, even in a concrete mixer.

According to a preferred embodiment, in step a) there are used 100 parts by weight (w/w) of the seeds to be coated, in step b) 0.5-5 parts by weight (w/w) of the fixing agent, and in step c) 1-25 parts by weight (w/w) of the fertilizer.

25 In the method according to the invention, the fixing agents and fertilizer powder and material amounts defined above are used. The seeds may have been treated by known methods, for example, with a pesticide, even before the surface treatment according to the invention. The adding of the pesticide and/or growth control agent and/or growth promoter may also take place after the fixing agent treatment
30 according to the invention before the adding of the fertilizer powder, or only after the fertilizer powder treatment or simultaneously therewith.

According to the invention it is also possible to repeat the above-mentioned procedure according to the invention, whereby the thickness of the fertilizer layer around the seed can be increased.

5 If it is desired to pellet the seeds, water and a clay mineral are added after the treatment according to the invention or simultaneously therewith.

According to the invention there is even provided a method for improving the efficiency of plant phosphorus and/or the efficiency of plant trace elements and for promoting plant growth during the early growth of the plant, in which method the plant seed is coated with a coating which contains

- 10 i) an aqueous fixing agent containing a fluid byproduct of agriculture or fermentation, and possibly an emulsified oil, and
- ii) a fertilizer powder comprising nutrients and trace elements required by the plant and/or other substances affecting plant growth,

15 in which case the said coating can be used for replacing, especially during the early development of the plant, a portion of the phosphorus fertilizer required by the plant, conventionally given as surface or row fertilization.

In this method according to the invention, the fixing agents and fertilizer powder and material amounts defined above are used.

The following examples are intended to describe the invention in greater detail.

20 **Example 1**

Effect of the oil amount present in an oil in water emulsion on the emergence of wheat seeds

25 The effect of the oil amount present in an oil in water emulsion, used for the surface treatment of seeds, on the emergence of wheat seeds was studied in emergence tests carried out in field soils when the seeds had been treated with oil in water emulsions containing oil and water in different proportions.

For purposes of the test, three oil in water emulsions were prepared, the emulsions containing 25 ml, 30 ml and 55 ml of a biodegradable oil in 100 ml of emulsion. For introducing the emulsion onto the seed surfaces, the seeds were treated in a
30 commercial test seed-dressing device (Hege) so that each emulsion was added to the

seeds in an amount of 0.5 (v/w) %, 1.0 (v/w) % or 1.5 (v/w) %, whereby 9 batches of seeds with different surface treatments were obtained. From each surface-treated batch of seeds, 4 x 100 seeds were planted to germinate at a depth of 4 cm in 1-liter plastic pots filled with field soil. The controls were 100 untreated, similarly planted seeds. Each pot was watered at fixed intervals to maintain the soil moisture constant. When 11 days had elapsed from the planting, the emergence percentage was determined using the standard 5.4.A.3 defined by ISTA. The effect of the amount of oil introduced onto the seed surface on the emergence of wheat seeds is shown in Table 1.

Table 1

Effect of the water content of the oil on the emergence of wheat, data in table form

Test member	Wheat emergence % Oil in water emulsion added to seeds, (v/w) %		
	0.5	1.0	1.5
Untreated	95	95	95
White oil, water content 45 %	50	44	24
White oil, water content 70 %	77	68	49
White oil, water content 75 %	90	70	60

Table 1 shows that emergence is improved when the proportion of oil in the emulsion decreases. Furthermore, the fixing of the fertilizer powder to the seed surface was studied with the oil in water emulsions according to the example and with water. The fixing of the fertilizer improved when an oil in water emulsion was used.

Example 2

Effect of molasses added to a water in oil emulsion on the emergence of wheat seeds

For purposes of the test, there was prepared a series of oil in water emulsions containing different amounts of molasses. Each emulsion contained 25 % by volume (v/v) of a biodegradable oil and additionally so much molasses that in the completed emulsions the volume ratio of oil in water to molasses was 4:0, 3:1, 2:2, 1:3 and 0:4. The emergence tests were carried out as in Example 1.

The tests results are shown in Table 2.

Table 2

Effect of the mixing ratio of aqueous oil to molasses on the emergence of wheat, data in table form

Test member	Emergence %
Untreated	93
Molasses	93
Molasses + oil (1:3)	89
Molasses + oil (2:2)	95
Molasses + oil (3:1)	94
Oil	81

5

The results show that the adding of molasses to the oil in water emulsion significantly promoted the emergence of wheat. Furthermore, the fixing of the fertilizer powder to the seed surface was studied with the emulsions according to the example. A molasses/oil in water emulsion fixed the fertilizer powder uniformly and better than the oil in water emulsion alone, and the technical quality was higher. On the other hand, when molasses alone was used, fixing of the fertilizer powder was sufficient in terms of technical quality.

10

Examples 3 and 4

During the growth seasons of 1998 and 1999, a series of nine field tests was carried out in different parts of Finland to study the growth of barley seeds surface-treated with a phosphorus fertilizer by the procedure according to the invention and the uptake of phosphorus by the plants in cultivated soils whose phosphorus number, depicting their phosphorus status, ranged within 4.2 – 34.3 mg of phosphorus / 1 liter of soil. The determination of the phosphorus number was carried out on a solution obtained by leaching a soil sample batch with an ammonium acetate solution (pH 4.65).

15

20

The seeds according to the invention were treated, in the manner presented in Examples 1 and 2, by using a fixing agent which contained 12.5 % by weight (w/w) oil, 37.5 % by weight (w/w) water, and 50 % by weight (w/w) molasses. The seeds treated in this manner were coated with monopotassium phosphate.

25

In the study, the procedure according to the invention was compared with the growth and phosphorus uptake of barley seeds fertilized with conventionally used fertilization methods.

5 In the tests, the growth of the seedlings and their phosphorus uptake were measured after the first weeks after the planting. Samples were taken 3-4 weeks after the planting of the seed. The aboveground mass, i.e. phytomass, and the total phosphorus content of the seedlings were determined from the sample. The phosphorus uptake, which is the product of the phytomass and the total phosphorus content, was calculated.

10 The results of Example 3 are shown in Table 3 and the results of Example 4 in Figure 1.

Table 3

Effect of the fertilization method on the phytomass formation and phosphorus uptake of barley one month after the planting of the seed. The seeds according to 15 the invention were coated with a molasses/oil in water emulsion (2:2) and monopotassium phosphate. N and K fertilization was the same for all test members (five tests, Finland 1999).

Fertilization method	Phosphorus as granular fertilizer 6 cm from seed (local fertilizing)	Phosphorus as granular fertilizer 1 cm from seed (local fertilizing)	Seed treated in accordance with the invention with phosphorus	Seed treated in accordance with the invention with phosphorus
Total fertilizer phosphorus amount, kg/ha	9	9	9	4.5
Phytomass of barley one month after the planting of seed (control=100)	100	104	111	113
Relative phosphorus uptake by barley one month after the planting of seed (control = 100)	100	104	111	113

The results in Table 3 show that barley seeds treated in accordance with the invention grew better and used phosphorus more effectively than did the test members fertilized by conventional local methods.

Figure 1 depicts graphically the test results of summers 1998 and 1999. In the figure, a comparison is made between the relative phosphorus uptake by a plant and its dependence on the location of the fertilizer. In each test the seeds had been fertilized so that

- a) the fertilizer was in the immediate vicinity of the seed (in the figure, phosphorus uptake is indicated as 100 %),
- b) the fertilizer was deposited at 6 cm from the seed (in the figure, a variable quantity).

On the basis of Figure 1 it can be noted that by the method according to the invention it is possible, without endangering the early development and growth of the sprouts, to decrease the proportion of readily soluble phosphorus in the total fertilization, whereby the risk of phosphorus leaching is reduced.

It can also be observed from Figure 1 that phosphorus uptake by seeds according to the invention is also rendered more effective when the soil itself already contains a large amount of phosphorus.

The seeds surface-treated according to the invention retained their germination capacity well. They were dry on the surface and therefore did not stick together but were, for example, during planting, well flowing and spreadable. It was also noted that the fertilizer was well fixed to the seed surfaces.

Examples 5-7

In 2000, a number of experiments were performed in Denmark, Great Britain and Turkey. Seeds according to the invention were coated, in the manner presented in Examples 3 and 4, by using the coating composition presented in the examples, except in Example 7, in which urea phosphate was used in addition to monopotassium phosphate.

The results of Example 5 are shown in Table 4, those of Example 6 in Table 5, and those of Example 7 in Table 6.

Table 4

Effect of the fertilization method on the phytomass formation and phosphorus uptake of barley one month after the planting of the seed. The seeds according to the invention were coated with a molasses/oil in water emulsion (2:2) and
 5 monopotassium phosphate. N and K fertilization was the same for all of the test members (Denmark 2000)

Fertilization method	Control, no phosphorus fertilization	Phosphorus as granular fertilizer 6 cm from seed (local fertilizing)	Seed treated in accordance with the invention with phosphorus	Seed treated in accordance with the invention with phosphorus	Seed treated in accordance with the invention with phosphorus
Total fertilizer phosphorus amount, kg/ha	0	20	1	2	3
Phytomass of barley one month after the planting of seed (control = 100)	100	100	106	109	111
Relative phosphorus uptake by barley one month after the planting of seed (control = 100)	100	103	106	118	122

Table 5

Effect of the method of phosphorus fertilization on barley yield formation. The seeds according to the invention were coated with a molasses/oil in water emulsion (2:2) and monopotassium phosphate. N and K fertilization was the same for all of the test members (four tests, Great Britain 2000)

Fertilization method	Control, no phosphorus fertilization	Phosphorus as granular fertilizer 1 cm from seed (local fertilizing)	Phosphorus as granular fertilizer 1 cm from seed (local fertilizing)	Seed treated in accordance with the invention with phosphorus	Seed treated in accordance with the invention with phosphorus	Seed treated in accordance with the invention with phosphorus
Total fertilizer phosphorus amount, kg/ha	0	11	22	2	4	8
Threshed crop of barley, kg/ha, Auchmacoy (control=100)	100	120	120	116	122	120
Threshed crop of barley, kg/ha, Central (control=100)	100	170	174	172	170	170
Threshed crop of barley, kg/ha, Boscombe (control=100)	100	105	102	100	104	103
Threshed crop of barley, kg/ha, Leckford (control=100)	100	100	107	102	102	100
Mean	100	124	126	123	125	123

Table 6

Effect of the fertilization method on the emergence of a hybrid tomato, the quantity of its harvestable crop and the quality of the crop in outdoor cultivation. The seeds according to the invention were coated with a molasses/oil in water emulsion (2:2) and urea phosphate, or with a molasses/oil in water emulsion (2:2) and monopotassium phosphate (Turkey 2000).

Fertilization method	Control (no phosphorus treatment of seeds)	Seeds treated according to the invention with phosphorus	Seeds treated according to the invention with phosphorus
Fertilization procedure	Local standard	Local standard + urea phosphate on seed surface	Local standard + monopotassium phosphate on seed surface
Number of plants	94	116	96
Mean tomato weight, g/tomato	75	78	91
Total yield, kg/ha	266	273	273
pH of tomato	4.47	4.48	4.49

On the basis of Examples 5-7, a significantly improved efficiency of phosphorus uptake is achieved with the phosphorus treatment of seed according to the invention.

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Claims

1. A seed coating for improving the efficiency of plant nutrients during the early growth of the plant, **characterized** in that the coating comprises
 - i) an aqueous fixing agent containing a fluid byproduct of agriculture or fermentation, and possibly an emulsified oil, and
 - ii) a fertilizer powder comprising nutrients and trace elements required by the plant and/or other substances affecting plant growth.
2. The plant coating according to Claim 1, **characterized** in that the said fixing agent contains a fluid byproduct of agriculture or fermentation in an amount of 30-100 % by weight (w/w) and oil in an amount of 0-50 % by weight (w/w), any balance being water.
3. The plant coating according to Claim 1 or 2, **characterized** in that the said fluid byproduct of agriculture or fermentation is molasses, vinasse or syrup, or a mixture thereof.
4. The plant coating according to any of the preceding claims, **characterized** in that the said oil is a biodegradable or readily biodegradable plant or animal oil or mineral oil such as white oil, or a mixture thereof.
5. The plant coating according to any of the preceding claims, **characterized** in that the particle size of the said fertilizer powder is 1-100 μm , preferably 10-50 μm .
6. A coated seed having a coating for improving the efficiency of plant nutrients during the early growth of the plant, **characterized** in that the coating comprises
 - i) an aqueous fixing agent containing a fluid byproduct of agriculture or fermentation, and possibly an emulsified oil, and
 - ii) a fertilizer powder comprising nutrients and trace elements required by the plant and/or other substances affecting plant growth.
7. The coated seed according to Claim 6, **characterized** in that it contains 100 parts by weight (w/w) of seeds, 0.5-5 parts by weight (w/w) of the fixing agent, and 1-25 parts by weight (w/w) of the fertilizer.

8. The coated seed according to Claim 6 or 7, **characterized** in that it contains the coating defined in any of Claims 2-5.

9. A method for the coating of plant seed, **characterized** in that

5 a) the seeds to be coated are placed in an apparatus suited for the treatment of seeds,

b) an aqueous fixing agent is added, which contains a fluid byproduct of agriculture or fermentation, and possibly an emulsified oil, so that a fixing agent layer is formed on the seed surfaces,

10 c) a fertilizer powder is added which comprises nutrients and trace elements required by the plant and/or other substances affecting plant growth, so that a coating is formed.

15 10. The method according to Claim 9, **characterized** in that in step a) there are used 100 parts by weight (w/w) of the seeds to be coated, in step b) 0.5-5 parts by weight (w/w) of the fixing agent, and in step c) 1-25 parts by weight (w/w) of the fertilizer.

11. The method according to Claim 9 or 10, **characterized** in that the fixing agent and/or the fertilizer powder defined in any of Claims 2-5 is used.

20 12. A method for improving the efficiency of plant phosphorus and/or the efficiency of plant trace elements and for promoting plant growth during the early growth of the plant, **characterized** in that the plant seed is coated with a coating comprising

i) an aqueous fixing agent containing a fluid byproduct of agriculture or fermentation, and possibly an emulsified oil, and

25 ii) a fertilizer powder comprising nutrients and trace elements required by the plant and/or other substances affecting plant growth,

in which case a portion of the phosphorus fertilizer required by the plant, conventionally given as surface or row fertilization, can be replaced with the said coating, in particular during the early development of the plant.

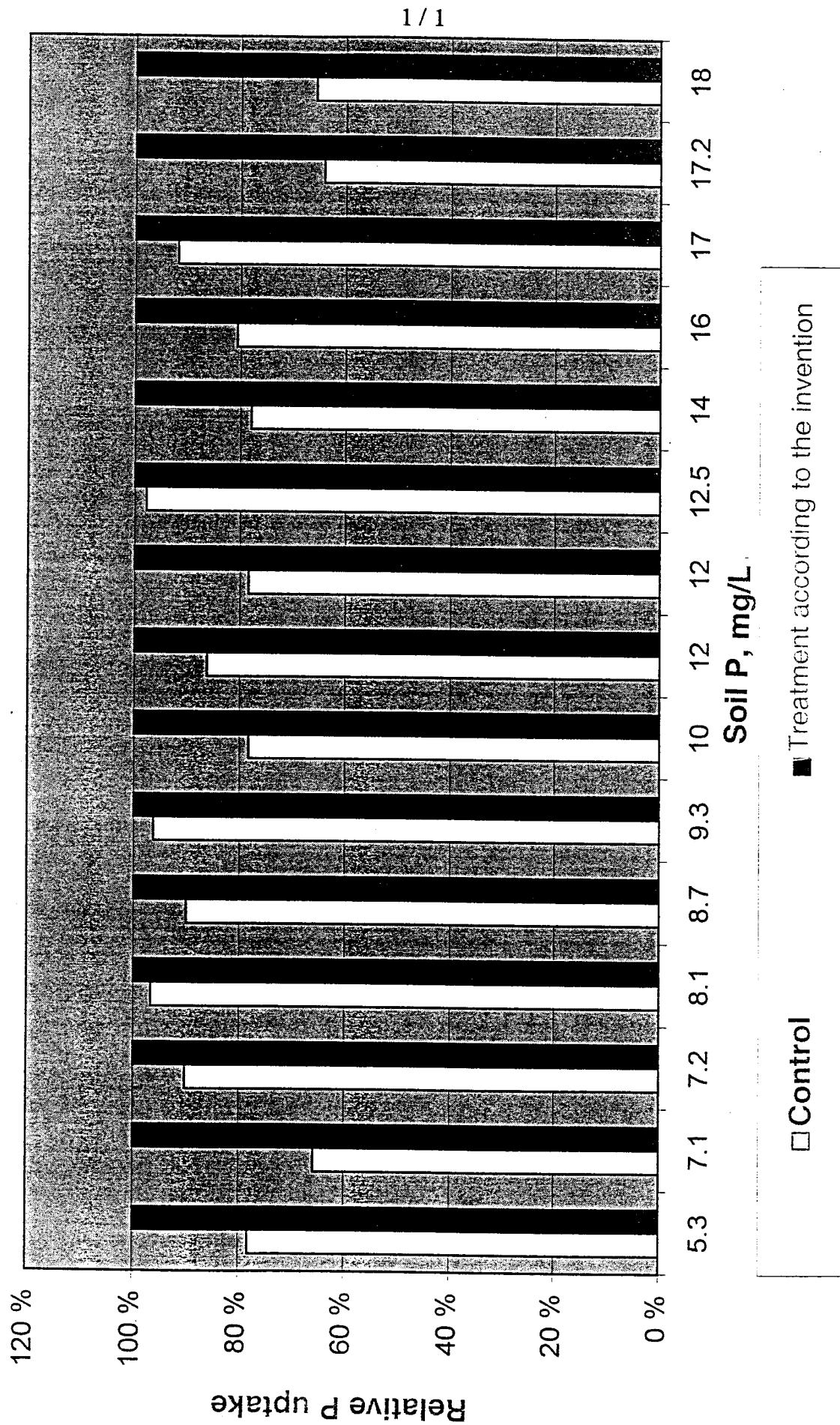


Figure 1

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 00/01143

A. CLASSIFICATION OF SUBJECT MATTER				
IPC7: A01C 1/06 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)				
IPC7: A01C				
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched				
SE,DK,FI,NO classes as above				
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)				
C. DOCUMENTS CONSIDERED TO BE RELEVANT				
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.		
X	US 4761423 US (SZEGÖ ET AL), 2 August 1988 (02.08.88), column 3, line 6 - line 51; column 4, line 24 - line 26, claim 1, abstract --	1-2,4-12		
A	WO 9325078 A1 (OY ALKO AB), 23 December 1993 (23.12.93), abstract --	1-12		
A	US 4251952 A (PORTER ET AL), 24 February 1981 (24.02.81), abstract -- -----	1-12		
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.				
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Date of the actual completion of the international search		Date of mailing of the international search report		
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INTERNATIONAL SEARCH REPORT

Information on patent family members

25/02/01

International application No.

PCT/FI 00/01143

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