



(51) International Patent Classification:

A01N 25/04 (2006.01) A01N 57/20 (2006.01)  
A01N 43/30 (2006.01) A01P 13/00 (2006.01)  
A01N 43/40 (2006.01)

(21) International Application Number:

PCT/GB2016/051585

(22) International Filing Date:

31 May 2016 (31.05.2016)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

1509615.9 3 June 2015 (03.06.2015) GB

(71) Applicant: PANGAEA AGROCHEMICALS LIMITED

[GB/GB]; 64-66 Westwick Street, Norwich Norfolk NR2 4SZ (GB).

(72) Inventors: GIFFORD, Michael John; c/o Pangaea Agro-

chemicals Limited, 64-66 Westwick Street, Norwich Norfolk NR2 4SZ (GB). GOOCH, Nicholas Anthony; c/o Pangaea Agrochemicals Limited, 64-66 Westwick Street, Norwich Norfolk NR2 4SZ (GB).

(74) Agent: WILLIAMS POWELL; 11 Staple Inn, London,

Greater London WC1V 7QH (GB).

(81) Designated States (unless otherwise indicated, for every

kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every

kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: A PRIMER FOR PESTICIDES

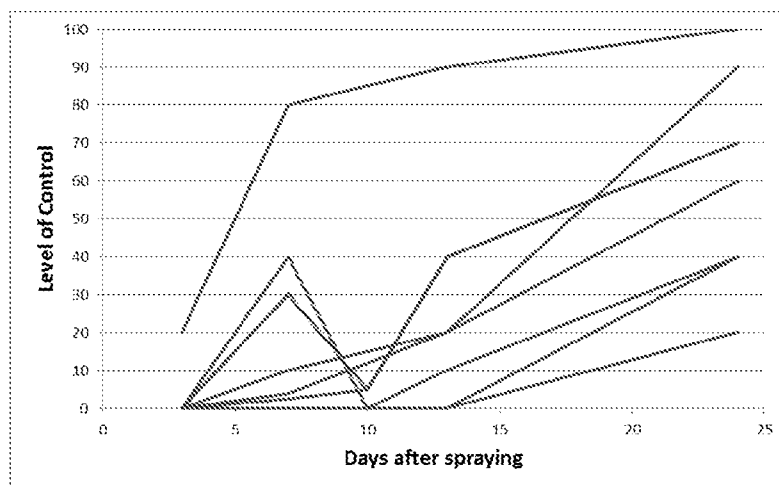


Fig. 1

(57) Abstract: An emulsion of piperonyl butoxide is employed as a primer for pesticides (especially herbicides). Three key factors can be deployed in various combinations to increase the efficacy of piperonyl butoxide, namely: (1) particle size; (2) time delay; and (3) dose rate.



## A PRIMER FOR PESTICIDES

### FIELD OF THE INVENTION

- 5 The present application relates to a method for treating a plant crop and a kit of components for carrying out such a method. In particular, it relates to a chemical primer for applying to a crop before applying a pesticide in order to improve the pesticide's efficacy.

### BACKGROUND OF THE INVENTION

10

A wide range of adjuvant chemicals are known that are routinely added to spray tanks together with active herbicides. These adjuvants act to aid or modify the action of a herbicide or the physical characteristics of the mixture. One class of adjuvants are synergists which can be simply defined as chemical additives to a mixture containing herbicides that increase the efficacy of the mixture beyond the efficacy of the component parts.

15

Piperonyl butoxide is a synergist that is known to inhibit the activity of the P450 cytochrome enzyme group. This group of enzymes is responsible for the detoxification of many living organisms including plants. When applied to plants in the absence of any active ingredients the toxicity of piperonyl butoxide alone is not detectable and the plants show no ill effects of the treatment.

20

In experiments the synergistic effects of using piperonyl butoxide in a tank mix with herbicides have been either undetectable or extremely limited. They have been insufficient to warrant the additional expense of including piperonyl butoxide in a field based herbicide treatment.

25

EP 1 499 183 B1 (Rothamsted Research Limited) discloses a method for preventing or reducing resistance of a pesticide (such as an insecticide) to a substrate pest comprising administering to the substrate or the pest (a) a rapid release formulation of an activity inhibitor (such as piperonyl butoxide) and substantially simultaneously (b) a pesticide encapsulated in a degradable capsule.

30

Other background art is disclosed in GB 1556372 (Shell International Research); US 2013/288897 (Babcock); and CN 102885091 (Wang).

## 5 SUMMARY OF THE INVENTION

The present applicant has discovered three key factors which can be deployed in various combinations to increase the inhibitor efficacy of piperonyl butoxide: (1) particle size; (2) time delay; and (3) dose rate.

10

### Particle size

In accordance with a first aspect of the present invention, there is provided a kit including a first component which is an emulsion of piperonyl butoxide in which the majority of  
15 piperonyl butoxide is in the form of particles having a particle size of 1 micrometre or less, and a second component which has herbicidal properties, for example glyphosate, clodinafop propargyl, clethodim, propaquizafop, cycloxadim, diclofop-methyl or fenoxaprop.

Experiments have shown that surprisingly an emulsion concentrate in which the bulk of the  
20 piperonyl butoxide is in the form of particles with a size of 1µm or less, preferably 500nm or less, has a good synergistic effect. Most preferably, the emulsion has a mono-modal particle size distribution in which 75% of the particles are from 80 nm to 400 nm in size.

Although piperonyl butoxide is known as an adjuvant for use with pesticides, there is no  
25 suggestion in the prior art that it can be used as an adjuvant for herbicides nor that particle size is a key factor in increasing its adjuvant efficacy.

### Time delay

30 In a second aspect of the present invention, there is provided a method for treating a plant crop comprising applying to the plant a first component as defined above and applying to the

plant a second component as defined above. Preferably, the first component is applied first and the second component applied second after a time delay.

5 It has surprisingly been discovered that in order to get a high degree of synergism between piperonyl butoxide and a herbicide the piperonyl butoxide must be applied ahead of the herbicide.

10 It has also been discovered that a time delay increases the inhibitor efficacy of piperonyl butoxide in relation to any pesticide. By “pesticide” is meant any herbicide, insecticide, insect growth regulator, nematicide, termiticide, molluscicide, piscicide, avicide, rodenticide, predacide, bactericide, insect repellent, animal repellent, antimicrobial, fungicide, disinfectant (antimicrobial), or sanitizer.

15 Thus, in a third aspect of the present invention, there is provided a method for treating a plant crop comprising applying to the plant a first component of the kit as defined above and applying to the plant a second component which is a pesticide, wherein the first component is applied first and the second component applied second after a time delay.

20 Preferably, the time delay is from 1 to 24 hours, preferably from 2 to 8 hours. However, the time delay required varies with temperature and dose rate. As temperature increases the optimum time delay required decreases from 8 hours at 11 °C to 4 hours at 15 °C to 2.5 hours at 25 °C (these time delays assume an optimised dose rate).

25 As dose rate is decreased the optimum time delay also decreases from 5 hours at 825 grams per hectare to 2.5 hours at 412.5 grams per hectare (both points at 25 °C).

#### Dose rate

30 Further experiments relating to the dose rates that are required for effectiveness have shown that as expected for any plant protection product there is a minimum effective dose rate.

Much more surprisingly it has been shown in experiments that application rates of piperonyl

butoxide at 825 g per hectare result in considerably worse efficacy than when applied at 412.5 g per hectare. This effect is extremely unusual in any pesticide or plant protection product.

- 5 In accordance with a fourth aspect of the invention, therefore, there is provided a method for treating a plant crop comprising applying to the plant a first component of the kit as defined above and applying to the plant a second component which is a pesticide, wherein the first component is applied at a concentration of piperonyl butoxide of from 100 to 500 grams of piperonyl butoxide per hectare of crop, preferably from 160 to 320 grams of piperonyl  
10 butoxide per hectare of crop.

The first and second components are preferably applied in the methods defined above by spraying.

- 15 Utilising the prior art described in patent EP 1,499183 B2 it is possible to get the time delay required through the microencapsulation of the clodinafop propargyl. Providing the conditions around droplet size of the surrounding piperonyl butoxide emulsion and the dose rates for the piperonyl butoxide are within the limits previously defined, this will allow a single-spray solution to be developed.

20

- The use of very fine droplet emulsions of piperonyl butoxide may provide additional efficacy when applying the same approach of either time split applications or encapsulated time-delayed applications (as described in EP 1,499183 B2) of insecticides and fungicides. In particular, with insecticides, it has been found that the optimum delay for application is  
25 highly variable and ranges between approximately 1 hour for pollen beetle and 8 hours for white fly. If a finer droplet size is able to increase the rate of uptake of the PBO by an insect it may be possible to reduce the longer time delays and hence make the encapsulation methods easier to apply and the product more effective in climates where meteorological conditions may change on an hourly basis.

30

A number of preferred embodiments of the present invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a graph showing how in 8 replicated trials the level of herbicidal control varies a number of days after spraying for Italian ryegrass treated with glyphosate;

Figure 2 is a graph showing the effect on efficacy of a time delay between the application of piperonyl butoxide and glyphosate;

Figure 3 is a similar graph as for Figure 2 but with a lower dose rate of piperonyl butoxide;

Figure 4 is a graph showing the effect of dose rate of piperonyl butoxide on efficacy of the herbicidal effect of clodinafop propargyl on blackgrass;

Figure 5 is an optical micrograph of conventional piperonyl butoxide emulsion;

Figure 6 shows the particle size distribution for a conventional piperonyl butoxide emulsion showing peak at 20 $\mu$ m;

Figure 7 is an optical micrograph of a piperonyl butoxide micro-emulsion for use in the present invention;

Figure 8 shows the particle size distribution for the micro-emulsion of Figure 7; and

Figure 9 shows the effect on efficacy of a time delay between the application of piperonyl butoxide and clodinafop on blackgrass.

## EXAMPLES

20

Experiments carried out in Western Australia showed considerably improved control of a glyphosate resistant strain of Italian ryegrass. As can be seen in Figure 1, in 8 replicated trials the level of control achieved without piperonyl butoxide was minimal. Figure 2 shows that some control is achieved through the pre-treatment of the weed with piperonyl butoxide at 825 grams per hectare. The control achieved in Figure 3 using 412.5 grams per hectare is significantly better.

25

Figure 2 and Figure 3 show that at the higher temperature of 25 °C, good efficacy can be obtained using a delay between the piperonyl butoxide and the active pesticide of between 2.5 and 7.5 hours. Specifically, Figure 2 shows results from glyphosate resistant Italian ryegrass treated with optimised piperonyl butoxide at 825 g/ha followed at a delay with a treatment of glyphosate at 900 g ai/ha and Figure 3 shows results from glyphosate resistant

30

Italian ryegrass treated with optimised piperonyl butoxide at 412.5 g/ha followed at a delay with a treatment of glyphosate at 900 g ai/ha.

5 These results also indicate that the optimum time-delay is lower when the piperonyl butoxide dose is lower. It is clear that for the 412.5 g per hectare dose rate (Figure 3) the optimum time delay is approximately 2.5 hours whereas for the 825 g per hectare dose rate (Figure 2) the optimum time delay is around 5 hours.

10 Further experiments were carried out using clodinafop resistant strains of blackgrass. These showed the same trend of there being an optimum piperonyl butoxide dose rate above which increasing doses lead to reductions in absolute efficacy. The results of these experiments are shown in Figure 4, which relates to Clodinafop resistant blackgrass treated with optimised piperonyl butoxide at different dose rates followed after a 4 hour delay with a treatment of clodinafop propargyl at 250 g ai/ha.

15

It has been seen in a number of field trial experiments that where piperonyl butoxide is presented in the form of large irregular droplets (see Figure 5 and Figure 6) the efficacy of the material is substantially reduced. Use of a suitable emulsifying agent consisting of a combination of anionic and non-anionic surfactants and appropriate mixing produces a  
20 micro-emulsion (see Figure 7 and Figure 8). In particular, Figure 8 is a particle size distribution of an optimised piperonyl butoxide micro-emulsion. The principal peak is below 200nm. Microscopy showed the other peaks to be due to agglomerations which are easily dispersed with agitation.

25 Use of such a micro-emulsion has been shown in field trials to be far more effective. The method for creating the micro-emulsion is well established in the literature and the novel element is in establishing its necessity for use as a synergist for herbicidal activity against resistant pest species.

30 In early autumn trials where the ambient temperature has been of the order of 18 °C the optimum delay has been shown to be between 2 – 8 hours (preferably 4 hours) with no measureable efficacy remaining at the 24-hour point. In the trial shown in Figure 9, the peak

efficacy takes place significantly later than this with high levels of control being shown with delays of 8 – 16 hours. Specifically, Figure 9 shows control of resistant blackgrass strain using optimised piperonyl butoxide at 320 grams per ha followed by clodinafop at 250 g ai/ha. Daytime temperature of 11 °C. Night time temperature of 8 °C. Optimum delay for efficacy is approximately 8 hours.

CLAIMS

1. A kit including:  
5 a first component which is an emulsion of piperonyl butoxide in which the majority of piperonyl butoxide is in the form of particles having a particle size of 1 micrometre or less, and  
a second component which has herbicidal properties.
- 10 2. A kit as claimed in claim 1, wherein said particle size is 500 nanometres or less.
3. A kit as claimed in claim 1 or 2, wherein the emulsion has a mono-modal particle size distribution in which 75% of the particles are from 80 nm to 400 nm in size.
- 15 4. A kit as claimed in any preceding claim, wherein the herbicide is glyphosate, clodinafop propargyl, clethodim, propaquizafop, cycloxadim, diclofop-methyl or fenoxaprop.
5. A method for treating a plant crop comprising applying to the plant a first component as defined in any preceding claim and applying to the plant a second component as defined in  
20 any preceding claim.
6. A method as claimed in claim 5, wherein the first component is applied first and the second component applied second after a time delay.
- 25 7. A method for treating a plant crop comprising applying to the plant a first component as defined in any of claims 1 to 4 and applying to the plant a second component which is a pesticide, wherein the first component is applied first and the second component applied second after a time delay.
- 30 8. A method as claimed in claim 6 or 7, wherein the time delay is from 1 to 24 hours.
9. A method as claimed in claim 8, wherein the time delay is from 2 to 8 hours.

10. A method as claimed in any of claims 5 to 9, wherein the second component is glyphosate, clodinafop propargyl, clethodim, propaquizafop, cycloxadim, diclofop-methyl or fenoxaprop.

5

11. A method for treating a plant crop comprising applying to the plant a first component as defined in any of claims 1 to 4 and applying to the plant a second component which is a pesticide, wherein the first component is applied at a concentration of piperonyl butoxide of from 100 to 500 grams of piperonyl butoxide per hectare of crop.

10

12. A method as claimed in any of claims 5 to 10, wherein the first component is applied at a concentration of piperonyl butoxide of from 100 to 500 grams of piperonyl butoxide per hectare of crop.

15

13. A method as claimed in claim 11 or 12, wherein the concentration is from 160 to 320 grams of piperonyl butoxide per hectare of crop.

14. A method as claimed in any of claims 5 to 13, wherein the first and second components are applied by spraying.

20

15. The use of an emulsion of piperonyl butoxide in which the majority of piperonyl butoxide is in the form of particles having a particle size of 1 micrometre or less to increase the efficacy of a pesticide applied to a plant crop.

25

16. The use as claimed in claim 15, wherein said particle size is 500 nanometres or less.

17. The use as claimed in claim 15, wherein the emulsion has a mono-modal particle size distribution in which 75% of the particles are from 80 nm to 400 nm in size.

30

18. The use as claimed in any of claims 15 to 17 wherein the emulsion is applied at a concentration of piperonyl butoxide of from 100 to 500 grams of piperonyl butoxide per hectare of crop.

19. The use as claimed in claim 18, wherein the concentration is from 160 to 320 grams of piperonyl butoxide per hectare of crop.

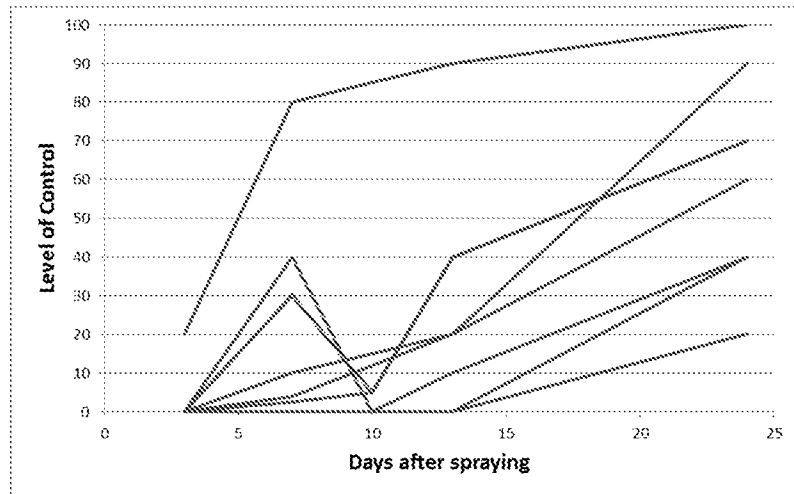


Fig. 1

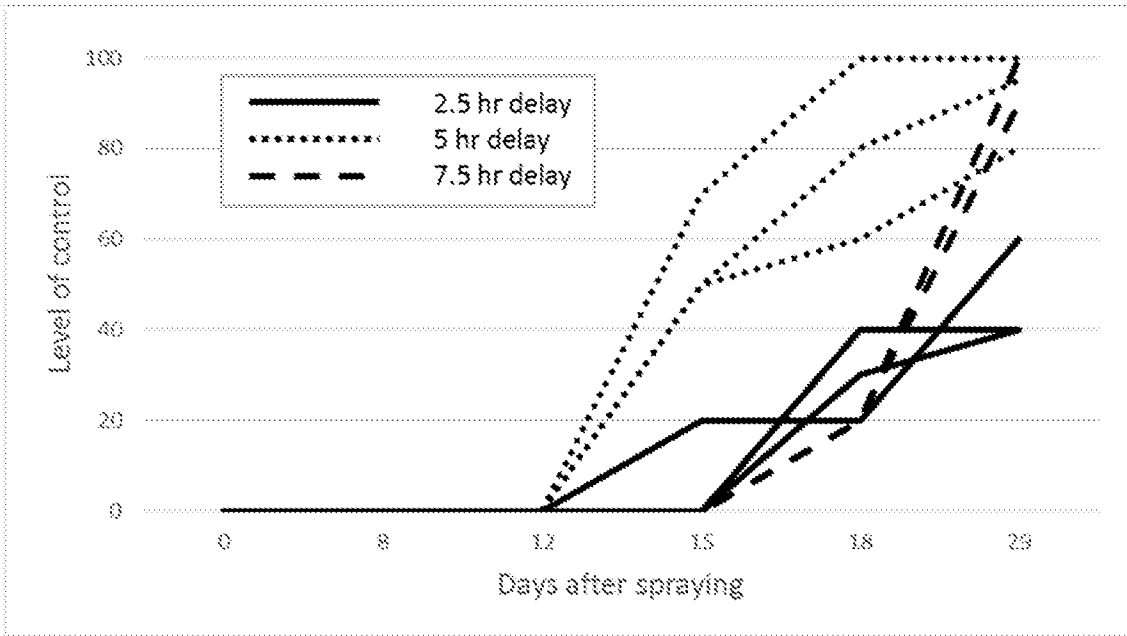


Fig. 2

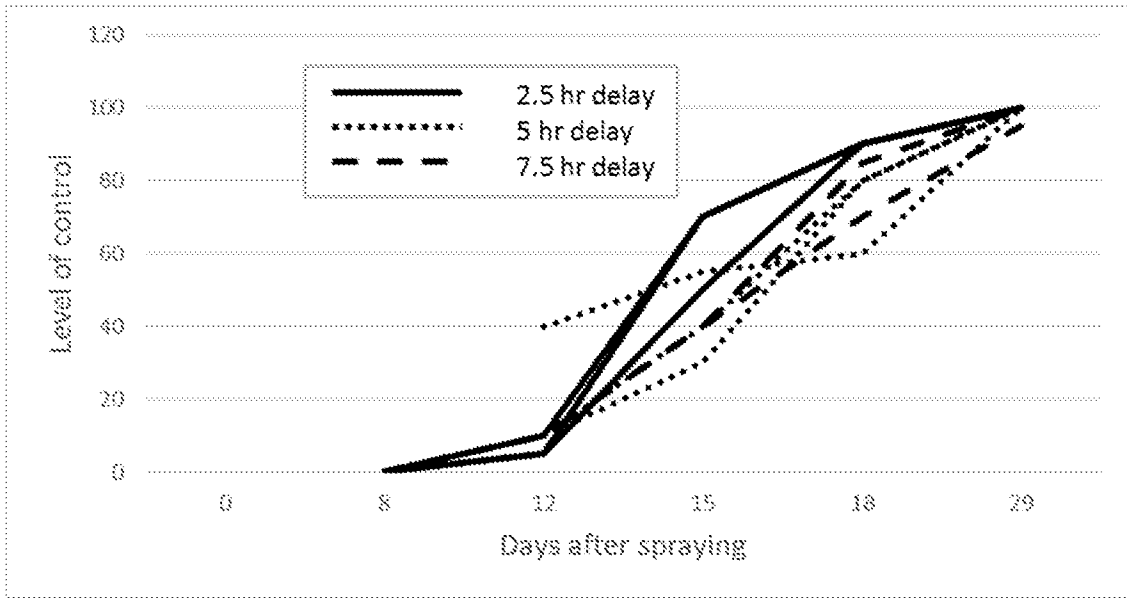


Fig. 3

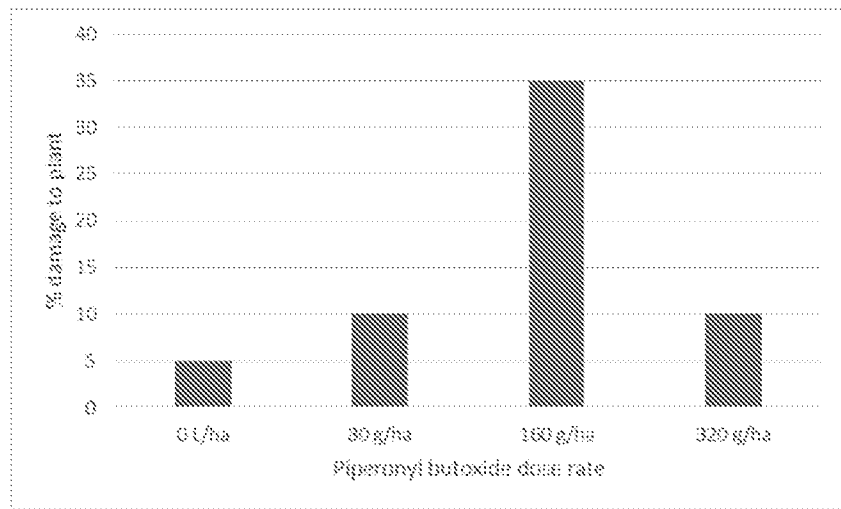


Fig. 4

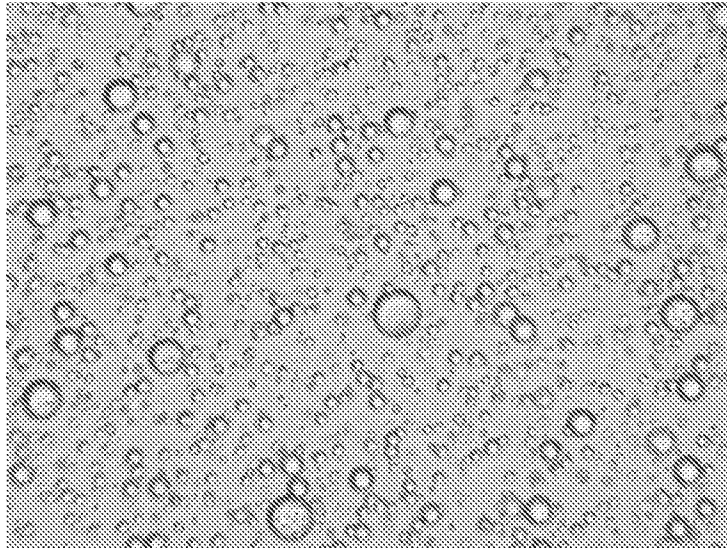


Fig. 5

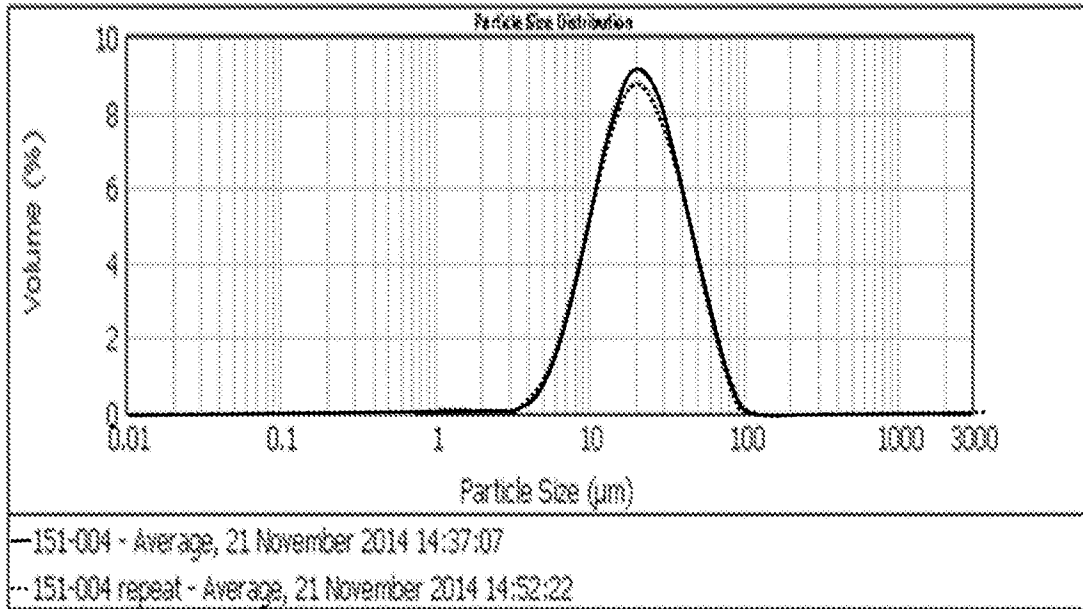


Fig. 6

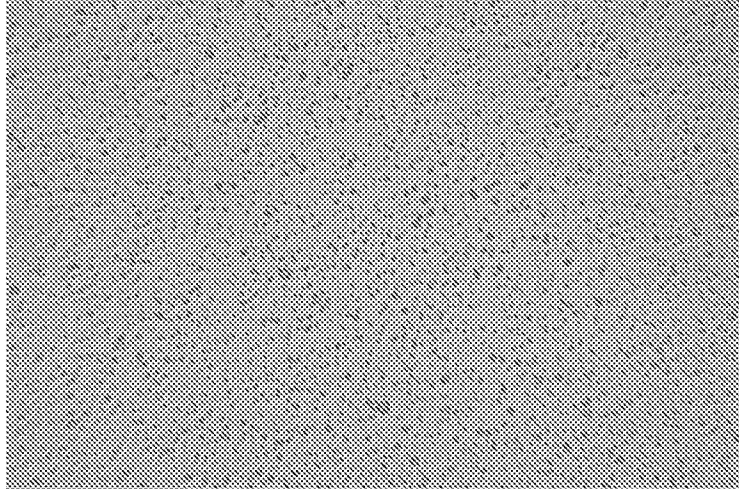


Fig. 7

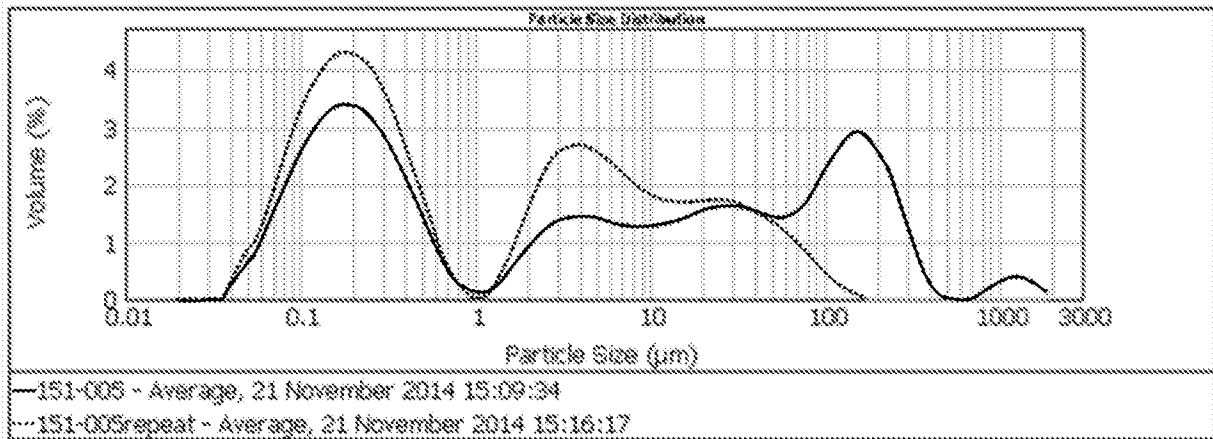


Fig. 8

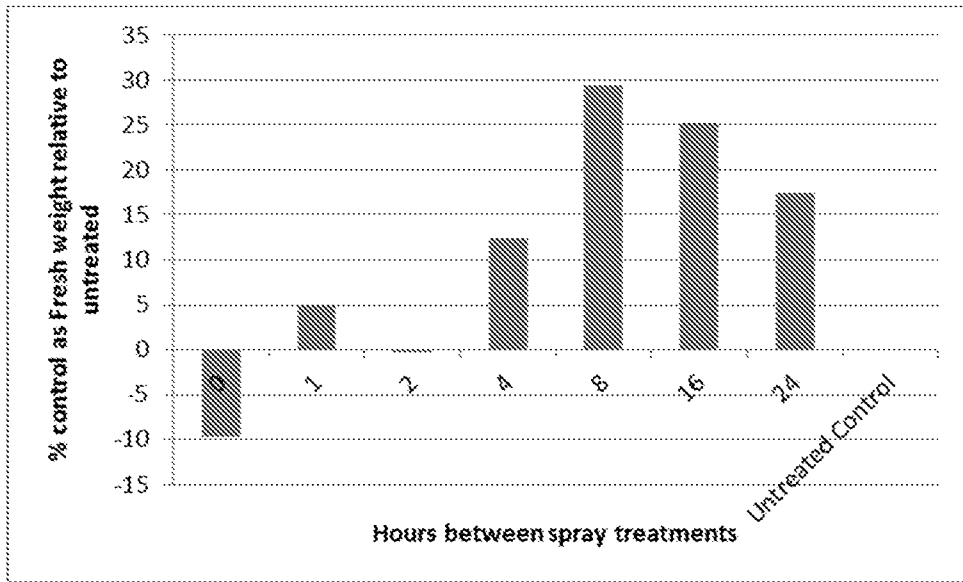


Fig. 9

INTERNATIONAL SEARCH REPORT

International application No  
PCT/GB2016/051585

A. CLASSIFICATION OF SUBJECT MATTER  
INV. A01N25/04 A01N43/30 A01N43/40 A01N57/20 A01P13/00  
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)  
A01N

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, CHEM ABS Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	GB 1 556 372 A (SHELL INT RESEARCH) 21 November 1979 (1979-11-21) cited in the application example 1 -----	1-19
Y	WO 2014/009269 A1 (ENDURA SPA [IT]) 16 January 2014 (2014-01-16) claims 1,6 table 2 page 39: section B) page 41: section B) -----	1-19
Y	WO 2009/060165 A2 (PLANT BIOSCIENCE LTD [GB]; MOORES GRAHAM [GB]; BINGHAM GEORGINA [GB]) 14 May 2009 (2009-05-14) page 10, line 16 - page 11, column 2 page 22, line 16 claims 8, 14 -----	1-19
	-/--	

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
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "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
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search  11 August 2016	Date of mailing of the international search report  24/08/2016
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer  Götz, Gerhard

# INTERNATIONAL SEARCH REPORT

International application No  
PCT/GB2016/051585

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	DE 37 17 467 A1 (PEARSON & CO GMBH & CO [DE]) 1 December 1988 (1988-12-01) the whole document -----	1-19

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/GB2016/051585

Patent document cited in search report	Publication date	Patent family member(s)	Publication date	
GB 1556372	A	21-11-1979	CA 1091951 A	23-12-1980
			DE 2647165 A1	05-05-1977
			FR 2328398 A1	20-05-1977
			GB 1556372 A	21-11-1979
			IT 1069042 B	21-03-1985
-----				
WO 2014009269	A1	16-01-2014	AU 2013289339 A1	22-01-2015
			EP 2871952 A1	20-05-2015
			US 2015237861 A1	27-08-2015
			WO 2014009269 A1	16-01-2014
-----				
WO 2009060165	A2	14-05-2009	AU 2008324012 A1	14-05-2009
			CA 2703985 A1	14-05-2009
			EP 2217072 A2	18-08-2010
			US 2010267677 A1	21-10-2010
			WO 2009060165 A2	14-05-2009
-----				
DE 3717467	A1	01-12-1988	NONE	
-----				