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(54) COMPOSITIONS CONTAINING PLANT GROWTH REGULANTS

(71) We, THE RUBBER RESEARCH INSTITUTE OF MALAYA, a Body Corporate of Malaysia, of 3rd Mile Ampang Road, Kuala Lumpur, Malaya, do hereby declare the invention, for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

It has long been known that ethylene occurs in traces in plant tissues and that it plays an important role in plant physiology and biochemistry, though the precise nature of this role is still not clear. The application of additional ethylene to plants or to portions of them, is known to affect the physiology of growth and development, flowering, fruiting or seed germination, and in particular, in many instances to speed maturation. Thus, accelerated ripening of fruits after harvesting has been achieved by storing them in an atmosphere containing small amounts of ethylene. However, ethylene, being a gas at normal temperature and pressure, is by no means an easy material to apply to growing plants. For one reason, a gas-tight container or generator has to be fixed to the plant, and such articles may be large and are inconvenient and expensive. For another reason, regulation of dosage and a steady slow release of ethylene are difficult to achieve; a sudden high dose of ethylene is more likely to damage the plant than to benefit it. For these and other reasons, and despite the obvious potential attractions of stimulating growing plants in this way, ethylene treatment of growing plants has never proved a commercially viable proposition.

One solution to these problems is to supply to the plant a compound which gives rise to a controlled slow release of ethylene in the plant tissues themselves. One such compound, which is currently commercially available for this purpose, is 2-chloroethylphosphonic acid. Such compounds are attractive in that, being non-volatile, they can be sprayed over plants or applied to the trunks of trees in controlled

quantities at comparatively little expense, but they suffer from three disadvantages, namely that, the compounds themselves are expensive compared to the ethylene which they generate, that the other decomposition products which are inevitably produced in the plant tissues may be harmful to the plant, and that some compounds may be irritant to the skin, eyes or nasal mucosa of persons handling or coming into contact with such compounds, or they may be toxic when inhaled or ingested.

Another solution to these problems is to supply the ethylene adsorbed on the surface of a solid non-volatile adsorbent material, such as a zeolite molecular sieve. A disadvantage of this solution is that much of the ethylene may be rapidly released (e.g. 80% of the ethylene in 20 minutes) from the solid adsorbent material in contact with the atmosphere. The amount of ethylene available for controlled release over a period of weeks or months is therefore reduced in relation to the weight of the zeolite.

Ethylene is the best known and most effective gaseous plant stimulant, but it is not the only one, other volatile or gaseous plant stimulants include acetylene, propylene and the volatile halogenoparaffins.

The present invention provides a composition comprising a volatile or gaseous plant growth regulant and a solid non-volatile adsorbent material dispersed in a viscous fluid medium, at least a part of the volatile or gaseous plant growth regulant being releasably adsorbed on the surface of the non-volatile adsorbent material.

The composition of this invention may conveniently be made by rapidly dispersing the non-volatile adsorbent material on whose surface the volatile or gaseous plant growth regulant has been releasably adsorbed, in the viscous fluid medium. The composition may suitably contain from 5% to 75%, preferably from 15% to 50%, by weight of the non-volatile material.

In order to be capable of adsorbing a sub-

stantial amount of the plant growth regulant, the adsorbent material should have a high surface area, of, for example, at least 100 square metres per gram, and a suitably larger pore diameter in relation to the molecular size of the adsorbate. Preferred materials are aluminosilicates, known as zeolites or molecular sieves, silica gel, and activated charcoal. Such materials are normally provided in a finely divided form, though they may be granulated or tableted for ease of handling.

Any volatile or gaseous plant growth regulants that does not react with the substrate or the fluid medium may be used, though ethylene is the preferred growth regulant. The weight of the volatile or gaseous plant growth regulant adsorbed on the adsorbent material will normally be at least 0.1%, preferably at least 1.0% of the weight of the adsorbent material. There is no upper limit of these ranges, in general, the more volatile or gaseous growth regulant that can be adsorbed on a given volume of adsorbent material, the better. Adsorption of the growth regulant on to the adsorbent material can be easily effected by conventional methods. We find that zeolites will adsorb about 7% by weight of ethylene, and activated charcoal about 4% by weight at ambient temperature and pressure.

The composition also comprises a viscous fluid, e.g. greasy or aqueous, medium, for example, animal, vegetable or mineral fats or oils, petroleum jelly B.P., paraffin or other waxes, polyethylene oxide or polyethylene glycol materials, gelatin or agar, or appropriate mixtures of such materials, or natural rubber coagulum derived after dispersion of the growth regulant-bearing material in fresh *Hevea* latex. If desired, this viscous fluid medium may include a miscible organic liquid which is a solvent for the growth regulant which may be helpful in promoting solution and diffusion of the growth regulant as it is desorbed from the adsorbent material.

The composition of this invention are principally intended for application to plants, particularly trees, in order to affect their development. The amount applied will depend upon the size of the plant and on the nature of the plant growth regulant. Where ethylene is the stimulant, the amount of composition applied to each plant will generally be such as to contain from 0.005 g to 2.5 g, preferably from 0.025 g to 1.0 g, of ethylene.

We have found that ethylene can be applied to *Hevea brasiliensis* so as to stimulate the yield of rubber latex. It will be readily appreciated that the compositions of the present invention are very well suited for this purpose.

They can be applied to the trunks of the trees much more easily than previously known ethylene gas containers or generators, and, unlike e.g. 2-chloroethylphosphonic acid, they do

not involve the introduction into the tree of undesirable or potentially toxic chemicals.

The composition may be applied to the trunk of the tree in any convenient manner. It may be smeared on to scraped bark. The smear may optionally be covered with a protective layer, which may conveniently be adhered to the tree trunks round the smear, and which may or may not be impervious to the volatile plant growth regulant. Alternatively, a small hole may be bored in the trunk of the tree and the composition inserted, the hole optionally being resealed to protect the composition.

In contact with the trunk of the tree, it is believed that the plant growth regulant is slowly desorbed from the adsorbent material, passes into solution in the fluid medium, and from there passes into the tissues of the tree. The viscous fluid, in addition to constituting a convenient medium for application of the plant growth regulant to the tree and protecting the adsorbent from rapid loss to the atmosphere of the adsorbate (stimulant), is believed also to moderate the desorption of the plant growth regulant from the adsorbent material, thus providing a controlled slow release of plant growth regulant to the tree. Many of the suitable viscous fluid media are themselves slowly absorbed into the tissues of the tree, probably carrying the plant growth regulant with them.

The composition is preferably applied to scraped bark near the tapping cut. A suitable area of application is roughly one to six square inches of bark on a fully grown tree and this may be laterally extended to suit viscous compositions. An advantage of these compositions is that, having once stimulated the tree, one may either recover an increased yield of rubber from the tree, or reduce the tapping frequency without loss of yield, or reduce the length of the tapping cut without loss of yield. Tapping costs are a major factor in the price of natural rubber, and the benefit of reducing the tapping frequency, say from 2 to 4 days, may therefore be great. Alternatively, a reduction in the length of the tapping cut, e.g., from half spiral to one eighth spiral, may prolong the useful life of the tree.

The following examples illustrate the invention. Example 1 shows the preparation of compositions according to the invention. Examples 2 to 4 relate to the treatment of *Hevea brasiliensis*.

Example 1

The required amount of finely powdered or granular adsorbent material contained in an open Petri dish or similar though larger heat-proof dish to a depth of approximately 1 cm is dehydrated in a drying oven at a temperature of about 340°C for about 12 hours and then quickly transferred to a vacuum desiccator

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of suitable size from which all air is then evacuated. When cool, the evacuated desiccator is filled with ethylene gas from a cylinder via a suitably arranged tap system and the progress of adsorption of ethylene followed by means of a manometer attached to the apparatus. As the ethylene in the desiccator is depleted by adsorption into the adsorbent material, more ethylene is supplied until the manometer registers that adsorption has ceased. This process is complete in 3 to 5 hours depending on the amount of adsorbent material used.

Such ethylene saturated adsorbent material is rapidly mixed with a chilled, weighed amount of the chosen viscous fluid medium, the components being contained in a strong plastic bag of suitable size which is kneaded externally by hand or mechanical means.

Example 2

Three six year old greenhouse RRIM 501 illegitimate seedling trees about 4.5 metres high and with a girth of approximately 25 cms were used. The yield of latex was recorded for each tree from daily tappings by means of single 2 mm horizontal scapel incisions over a period of one month. Then on to each tree, 3.75 gms of a mixture containing 2.75 g of white petroleum jelly and 1 g of finely powdered activated charcoal was applied to an area of lightly scraped bark, measuring 1 inch by 3 inches horizontally just below the point of tapping.

In the case of two trees, the charcoal when mixed with the petroleum jelly contained about 4% by weight of ethylene, while in the case of the third tree, the control, no ethylene was present in the charcoal or the mixture containing it. The results are given in Table I.

TABLE I

Yield of dried rubber (mg)

	Tree 1	Tree 2	Tree 3 (control)
Average pre-treatment daily yield over one month	3.053	16.58	3.3
Average post-treatment daily yield over 6.5 months	179.7	153.6	11.07

Example 3

Two 10 year old greenhouse trees of clone PB86, and one 10 year old greenhouse illegitimate seedling tree of mother clone RRIM 501, each about 6 metres high and with a girth of 20—26 cms at the tapping point were used.

The yield of latex was recorded as for

Example 2 prior to treatment with similar amounts of similar mixtures of charcoal in white petroleum jelly. In the cases of one PB86 tree, and the RRIM 501 seedling tree, the mixture applied contained ethylene, while in the case of the other PB86 tree, the ethylene was omitted. The results are set out in Table II.

TABLE II

Yield of dried rubber (mg)

	PB86	RRIM 501	PB86 (control)
Average pre-treatment daily yield over one week	73.75	9.37	125.8
Average post-treatment daily yield over three months	543.56	216.63	263.45

Example 4

Three formulations were made up by dispersing activated charcoal containing about 4% by weight of adsorbed ethylene in:—

5 A. White petroleum jelly, such that the weight of the charcoal plus ethylene amounted to 25% of the weight of the composition (25%/WPJ).

10 B. White petroleum jelly, such that the weight of the charcoal plus ethylene amounted to 17.5% of the weight of the composition (17.5%/WPJ).

15 C. Palm oil, such that the weight of the charcoal plus ethylene amounted to 25% of the weight of the composition (25%/palm oil).

20 These formulations were made up in England and despatched to Malaysia where they were applied, 10 days after manufacture, to mature trees of two clones, RRIM 513 and RRIM 527. Eight trees of each clone, making a total of 16 trees, were involved in each treatment. The composition was applied to the trees in various different ways, as follows, the amounts of composition used being in all cases
25 sufficient to provide about 2 g of charcoal plus ethylene per tree:—

(i) Four grams of palm oil composition smeared on to a 1½" wide strip of scraped bark immediately below the tapping cut;

(ii) Three grams of WPJ composition 30 smeared on to a 1½" wide strip of scraped bark 6 inches below the tapping cut and the smear immediately covered by a 1½" wide strip of gas-impermeable PVC tape;

(iii) Five grams of composition placed on a 35 paper tissue pad and held in contact with an area of scraped bark 12" below the tapping cut by means of an annular foam rubber sheet adhered to the tree round the tissue pad and sealed off from the atmosphere with plastic 40 sheet.

(iv) Five grams of composition applied in a bore hole, 1" diameter by 3" length drilled at an angle of 45°C just above the graft union and below the tapping cut. The hole was sealed 45 with a tightly fitting plastic stopper.

The trees were tapped with a half-spiral, alternate daily system. The mean yields in grams of dry rubber per tree per week (after adjustment for pre-treatment differences) for 50 the treated trees and the control trees are given in the following table:—

TABLE III

Mean yields in gm/tree/week adjusted for differences before treatment and expressed as % of control

Treatment	Method of Application	Weeks after first application				Mean
		1	2	3	4	
Control Palm Oil	(i)	105.4 (100)	85.8 (100)	80.4 (100)	76.8 (100)	87.1 (100)
25% W.P.J.	(ii)	144.2 (136.8)	91.9 (107.1)	96.2 (119.6)	81.0 (105.4)	103.3 (118.6)
25% W.P.J.	(iii)	178.8 (169.6)	91.0 (106.0)	78.5 (97.6)	79.9 (104.0)	107.1 (123.0)
17.5% W.P.J.	(iv)	148.7 (141.0)	116.0 (135.1)	84.4 (104.9)	80.1 (104.2)	107.3 (123.2)
25% W.P.J.	(iv)	177.2 (168.1)	102.1 (118.9)	91.2 (113.4)	89.8 (116.9)	115.1 (132.1)
25% Palm Oil	(i)	124.8 (118.4)	110.8 (129.1)	104.9 (130.4)	96.2 (125.2)	109.2 (125.4)
25% Palm Oil	(iv)	155.3 (147.3)	94.0 (109.5)	86.5 (107.5)	76.3 (99.3)	103.0 (118.3)

Example 5

For this experiment there were used four small illegitimate seedlings of *Hevea brasiliensis*, about 18 months old, 1—1½ metres high and 3—4 cm in circumference at the tapping point, grown in 22 cm diameter pots in a tropical greenhouse. Daily tapping was by a single prick with a fine needle. The average yield over a 12-day period prior to treatment was 1.26 mgs dry rubber per plant per day. The average yields of all four plants were very similar. To each plant was affixed by self-adhesion to the bark just below the tapping point, a conical flexible gas-impermeable PVC cap containing about 1 g of a composition comprising 0.25 g of 4A grade molecular sieve and 0.75 g of palm oil. The area of bark in contact with the composition was approximately 0.75 sq. cms.

For the first group of 2 plants the zeolite contained initially 5% by weight of ethylene. For the second group of 2 plants, plain zeolite was used.

Average yields in the six days following stimulation were:—

1st Group: 3.8 mg dry rubber per plant per day with two consecutive daily yields of 5.9 mg and 5 mg respectively.

2nd Group: 1.4 mg dry rubber per plant per day.

WHAT WE CLAIM IS:—

1. A composition comprising a volatile or gaseous plant growth regulant and a solid non-volatile adsorbent material dispersed in a viscous fluid medium, at least a part of the volatile or gaseous plant growth regulant being releasably adsorbed on the surface of the non-volatile adsorbent material.

2. A composition as claimed in claim 1 wherein the volatile or gaseous plant growth regulant is ethylene.

3. A composition as claimed in claim 1 or claim 2, wherein the solid non-volatile adsorbent material is activated charcoal or an aluminosilicate.

4. A composition as claimed in any one of

claims 1 to 3, wherein the volatile or gaseous plant growth regulant is present in a proportion of at least 0.1% by weight on the weight of the solid non-volatile adsorbent material.

5. A composition as claimed in any one of claims 1 to 4, wherein the solid non-volatile adsorbent material is present in a proportion of from 5% to 75% by weight on the weight of the composition.

6. A composition as claimed in any one of claims 1 to 5, wherein the viscous fluid medium comprises an animal, vegetable or mineral fat or oil or a petroleum jelly, paraffin or other waxes, or polyethylene oxide or polyethylene glycol, gelatin or agar, or appropriate mixtures of such materials, or natural rubber coagulum derived after dispersion of the growth regulant bearing material in fresh *Hevea* latex.

7. A method of treating a plant which method comprises applying to the plant the composition claimed in any one of claims 1 to 6.

8. A method of treating *Hevea brasiliensis* for the purpose of stimulating the yield of rubber latex therefrom, which method comprises applying to the trunk of the tree the composition claimed in any one of claims 1 to 6.

9. A method as claimed in claim 8, wherein the volatile or gaseous plant growth regulant is ethylene, and the amount of composition applied to each tree is such as to contain from 0.005 g to 2.5 g of ethylene.

10. A method as claimed in claim 8 or claim 9, wherein the composition is applied to scraped bark near the tapping cut.

11. A method as claimed in any one of claims 8 to 10 and substantially as hereinbefore described in any one of Examples 2 to 4.

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Example 5

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For the first group of 2 plants the zeolite contained initially 5% by weight of ethylene. For the second group of 2 plants, plain zeolite was used.

Average yields in the six days following stimulation were:—

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2. A composition as claimed in claim 1 wherein the volatile or gaseous plant growth regulant is ethylene.

3. A composition as claimed in claim 1 or claim 2, wherein the solid non-volatile adsorbent material is activated charcoal or an alumino-silicate.

4. A composition as claimed in any one of

claims 1 to 3, wherein the volatile or gaseous plant growth regulant is present in a proportion of at least 0.1% by weight on the weight of the solid non-volatile adsorbent material.

5. A composition as claimed in any one of claims 1 to 4, wherein the solid non-volatile adsorbent material is present in a proportion of from 5% to 75% by weight on the weight of the composition.

6. A composition as claimed in any one of claims 1 to 5, wherein the viscous fluid medium comprises an animal, vegetable or mineral fat or oil or a petroleum jelly, paraffin or other waxes, or polyethylene oxide or polyethylene glycol, gelatin or agar, or appropriate mixtures of such materials, or natural rubber coagulum derived after dispersion of the growth regulant bearing material in fresh *Hevea* latex.

7. A method of treating a plant which method comprises applying to the plant the composition claimed in any one of claims 1 to 6.

8. A method of treating *Hevea brasiliensis* for the purpose of stimulating the yield of rubber latex therefrom, which method comprises applying to the trunk of the tree the composition claimed in any one of claims 1 to 6.

9. A method as claimed in claim 8, wherein the volatile or gaseous plant growth regulant is ethylene, and the amount of composition applied to each tree is such as to contain from 0.005 g to 2.5 g of ethylene.

10. A method as claimed in claim 8 or claim 9, wherein the composition is applied to scraped bark near the tapping cut.

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