

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
27 March 2003 (27.03.2003)

PCT

(10) International Publication Number
WO 03/024218 A1

- (51) International Patent Classification⁷: **A01N 37/02**, 43/16, 25/26, 25/08, A23B 7/10 (74) Agent: AWAPATENT AB; P.O. Box 45086, S-104 30 Stockholm (SE).
- (21) International Application Number: PCT/SE02/01644 (81) Designated States (*national*): AE, AG, AL, AM, AT (utility model), AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ (utility model), CZ, DE (utility model), DE, DK (utility model), DK, DM, DZ, EC, EE (utility model), EE, ES, FI (utility model), FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK (utility model), SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.
- (22) International Filing Date:
13 September 2002 (13.09.2002)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
0103085-7 14 September 2001 (14.09.2001) SE
0103086-5 14 September 2001 (14.09.2001) SE
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- (84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).
- Published:
— with international search report
- For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

(54) Title: METHOD OF INHIBITING PLANT GROWTH OR SPROUTING OF TUBERS

(57) Abstract: The present invention relates to the field of agriculture. The present invention concerns a method of killing a plant or retarding its growth. The method is comprising the step of exposing the surface, or part thereof, of said plant to a composition. The composition is comprising a volatile pH-lowering compound and optionally a carrier substance for said pH-lowering compound. The carrier substance, if any, is capable of forming on the surface, or part thereof, of said plant a coating containing said pH-lowering compound upon vaporization of at least part of said composition. The present invention also concerns a herbicidal composition as defined in the method above. The invention also relates to a novel use of such a composition for inhibition of plant growth. The present invention also provides a method of inhibiting or delaying sprouting of tubers, comprising the step of exposing said tubers to an environment or a composition comprising acetic acid, said environment being capable of maintaining a pH of less than about 5 at the tuber surface.

METHOD OF INHIBITING PLANT GROWTH OR SPROUTING OF TUBERS

Technical field

The present invention concerns the field of agriculture. In particular, the present invention relates to the field of weed control. More specifically, the present invention relates to a herbicidal composition for plants,
5 and a method of controlling weeds.

According to another aspect, the present invention concerns the field of food processing. More specifically, the present invention relates to a novel method of inhib-
10 iting or delaying sprouting of tubers in storage, and a new use of a composition for inhibiting or delaying sprouting of tubers.

Background of the invention

15 In the field of modern agriculture, efficient crop production is of utmost importance. Crops refer to plants that are harvested by man for food or used for some other purposes, such as clothing, fuel, paper, building material and medicines.

20 Hence, it is desirable to control the growth of certain plants. In particular, it is of the greatest economical and technical interest to control the growth of weeds in the context of crop production and gardening. Weeds compete with the cultured crops for limited re-
25 sources, such as nutrients, water and light. As a result, the crop yield and/or quality is decreased substantially.

Conventional methods of controlling weeds can be mechanical, such as with a harrow or a cultivator, physical, such as with fire or hot water, and/or chemical,
30 such as with herbicides. These and similar operations are costly and/or time-consuming for the farmer, and may still result in products with decreased quality.

Herbicides may, according to the properties of the active ingredient, be classified as either selective or non-selective. Selective herbicides eliminate some members of a plant population with little or no harm to other plants, whereas non-selective herbicides destroy all vegetation in the treated area. Herbicides may also be further classified by method of application, such as pre-emergence (application to soil before plant emergence) or post-emergence (application to plant foliage). The mobility of post-emergence herbicides in the treated plant is broadly classified into two types: contact (non-mobile) or translocated (mobile, i.e. killing plants by systemic action).

During the last 50 years, it has gradually been discovered that many agents based upon herbicides are non-biodegradable and potentially toxic to end consumers of foodstuffs and other plant-derived materials.

Glyphosate (N-phosphonomethylglycine) is a translocated, post-emergent non-selective herbicide. It is known to act on various enzyme systems, interfering with the formation of amino acids and other endogenous chemicals in treated plants. However, many agronomically important weed species require application of relatively high amounts of glyphosate for effective control. High amounts of glyphosate can lead to undesirable increased selection pressure. Accordingly, glyphosate tolerance is a recognized problem in the field. Moreover, even the seemingly biodegradable glyphosate has been found in ground water.

It is also known to use aqueous solutions of acetic acid in high concentrations for controlling weeds. However, since a substantial part of the acetic acid will evaporate, considerable amounts of acetic acid are needed to provide herbicidal action. Using such high concentrations, the farmer needs special protection equipment. In order to reach the desired effect, it may be required to apply the solution at multiple events. Another disadvantage with the known solution is that its herbicidal ac-

tion is rather slow. Accordingly, weed control operations employing the known aqueous acetic acid solutions are inconvenient, costly, and time-consuming.

Alternative techniques for weed control should be
5 non-toxic for the farmer as well as the end consumer, and should cause no quality changes of the crops.

Moreover, there is an increasing awareness among consumers in the industrial world, and the market for foodstuffs treated only with naturally occurring chemicals is rapidly expanding.
10

Thus, there is a large need for improved herbicidal methods and agents in the near future.

Another relevant problem in the field is that growth
15 of sprouts on tubers, such as potatoes, in storage reduces product yields substantially. Sprouting is unwanted, since it also impairs the quality and the appearance of the commercial products, i.e. potatoes, French fries, potato chips, etc.

Tubers have buds (eyes) on their surface, that, when
20 the conditions are right, grow into new plants. Each such tuber, or tuber piece, must have a bud for a plant to sprout and develop. The buds may, even under conditions favourable to development, remain dormant for more than
25 ten weeks after the tuber is fully-grown.

A variety of treatments of tubers for prevention of sprouting exists, but there is an increasing awareness among consumers in the industrial world, and the market for foodstuffs treated only with naturally occurring
30 chemicals is rapidly expanding. Thus, alternative sprout-inhibiting techniques should be non-toxic and cause no quality changes of the potatoes. There is a large need for improved sprout-inhibiting methods and compositions in the near future.

Summary of the invention

For these and other purposes, it is an object of the present invention to provide a new, non-toxic method and composition for weed control.

5 It is also an object of the present invention to provide a method and a composition for weed control, which are environmentally safe.

It is a further object of the invention to provide a method and a composition for weed control, which are
10 cost-effective and easy to use at an industrial scale.

It is another object of the invention to provide a method and a composition for weed control, which do not negatively affect the quality of plant-derived end products.

15

According to another aspect, it is also an object of the present invention to provide a new, non-toxic method for the inhibition of sprouting of tubers.

It is a further object of the invention to provide a
20 novel use of a non-toxic composition for the inhibition of sprouting of tubers, and a method for producing the same.

It is another an object of the present invention to provide a method and a novel use of a composition for the
25 inhibition of sprouting of tubers, which method and composition are environmentally safe.

It is a further object of the present invention to provide a method and a novel use of a composition for the inhibition of sprouting of tubers, which method and com-
30 position are cost-effective and readily implemented at an industrial scale.

It is another object of the invention to provide a method and a novel use of a composition for the inhibition of sprouting of tubers, which method and composition
35 do not negatively affect the quality of treated tubers.

For these and other objects which will be evident from the following disclosure, the present invention provides a method of killing a plant or retarding its growth, comprising the step of exposing the surface, or
5 part thereof, of said plant to a composition comprising a volatile pH-lowering compound and a carrier substance for said pH-lowering compound, said carrier substance being capable of forming on the surface, or part thereof, of said plant a coating containing said pH-lowering compound
10 upon vaporization of at least part of said composition.

The invention is based on the finding that exposure to a sufficiently acidic environment successfully kills a plant or retards its growth or inhibits sprouting of harvested tubers, such as potatoes.

15 In a preferred embodiment of the method according to the invention, said composition further comprises a volatile medium, such as water.

In one preferred embodiment of the method according to the invention, said composition is capable of main-
20 taining a pH of less than about 5 at the plant surface. In a more preferred embodiment of the method according to the invention, said pH is within the range from about 1 to about 5, such as from about 2 to about 4.

In a preferred embodiment of the method according to
25 the invention, said pH-lowering compound is a buffer or an acid. It is preferred that said acid is a weak acid, preferably an organic acid. It is particularly preferred that said organic acid is an alkanoic acid, preferably containing from 1 to 4 carbon atoms. In the most pre-
30 ferred embodiment of the method according to the invention, said alkanoic acid is formic acid or acetic acid. In another preferred embodiment of the method according to the invention, said buffer is selected from acetates, citrates, and phosphates.

35 In another preferred embodiment of the method according to the invention, said carrier substance is selected from the group consisting of polysaccharides, pro-

teins, lipids, and waxes, and derivatives thereof. It is preferred that said carrier substance is a polysaccharide or a derivative thereof, preferably of bacterial or plant origin. It is particularly preferred that said polysac-
5 charide is selected from the group consisting of starches, locust bean gum, guar gum, and xanthan gum. In the most preferred embodiment of the method according to the invention, said polysaccharide is starch.

In one preferred embodiment of the method according
10 to the invention, said composition comprises a compound selected from other herbicidal compounds, complexing agents, preservatives, plasticisers, detergents, and softeners.

In a preferred embodiment of the method according to
15 the invention, said composition is an aqueous solution or an aqueous vapour. In another preferred embodiment of the method according to the invention, said composition is made from a concentrate or a wettable powder.

In one preferred embodiment of the method according
20 to the invention, said exposing comprises spraying said plant surface, or part thereof, with said composition.

In a preferred embodiment of the method according to the invention, said plant is a weed. In another preferred embodiment of the method according to the invention, said
25 plant is a potato plant. In a more preferred embodiment of the method according to the invention, said plant parts are the stems, or parts thereof. In another more preferred embodiment of the method according to the invention, said plant surface is a plant foliage surface.

30 In yet another preferred embodiment of the method according to the invention, said step of exposing said plant surface to said composition constitutes a post-emergent application of said composition.

The present invention also provides a herbicidal
35 composition as defined in the method(s) above.

The present invention also provides a novel use of said composition for inhibition of plant growth.

According to another aspect, the present invention also provides a method of inhibiting or delaying sprouting of tubers, comprising the step of exposing said tubers to an environment or a composition comprising acetic acid, said environment being capable of maintaining a pH of less than about 5 at the tuber surface.

In a preferred embodiment of the method according to the invention, said environment is a gas phase or a mist comprising said acetic acid.

In one preferred embodiment of the method according to the invention, said composition is an aqueous vapour or an aerosol.

In a preferred embodiment of the method according to the invention, said tubers are exposed to said composition by spraying or by maintaining the tubers in an atmosphere comprising the composition.

In a more preferred embodiment of the method according to the invention, said tubers are potato tubers.

Furthermore, the present invention provides a method for manufacturing of a sprout-inhibiting or sprout-delaying composition for tubers, comprising the step of incorporating into said composition an amount of acetic acid, such that said composition, when administered to said tubers, is capable of maintaining a pH of less than about 5 at the tuber surface.

The present invention also provides a novel use of acetic acid in a sprout-inhibiting or sprout-delaying composition for tubers, which composition, when administered to said tubers, is capable of maintaining a pH of less than about 5 at the tuber surface.

Detailed description of the invention

The present invention provides a method and a composition that can be used for weed control. The terms "weed" and "weeds" refer widely to any undesirable plant growth, at any stage of a plant's life, from seed through

any stage of a plant's development. Thus, a certain plant may or may not be a weed depending on the particular location and/or time point.

5 The term "weed control" refers to any killing, destroying, inhibiting, retarding or preventing activity directed to weeds. As mentioned above, direct weed control can be mechanical, physical, or chemical.

10 According to the invention, a surface area of the plant, or weed, is contacted with a composition containing a volatile pH-lowering compound and a carrier substance for the pH-lowering compound. As a result, the plant is killed or strongly inhibited. Thus, the composition according to the invention is a herbicide.

15 The term "herbicide" refers to any chemical agent, either organic or inorganic, capable of killing a plant and/or destroying, inhibiting or retarding plant growth, especially of weeds or other undesirable vegetation. The term "herbicidal" refers to anything possessing this property, including chemical agents as well as methods.

20 It is envisioned that killing of a treated plant may be accomplished through a local lowering of the pH at the plant surface and the surrounding area/volume. Even though the exact mechanism of the inhibition is not known, it may be speculated that the pH-lowering effect has to be below the plant epidermis.

25 Lowering of the pH at, and beneath, the plant surface is accomplished through the use of pH-lowering compounds. The pH-lowering compound can pass the skin by diffusion in an aqueous environment, or by gas diffusion if the pH-lowering compound is volatile. Examples of pH-lowering compounds include buffers and acids. Preferred buffers are acetates, citrates, and phosphates. Weak acids are particularly preferred as pH-lowering compounds, since they provide mild treating conditions.

35 The purpose of including the carrier substance in the composition is that, upon vaporization of said composition, a coating is formed on the surface, or part

thereof, of the plant. The coating is containing the pH-lowering compound so as to impart a slow release dimension to the system. It is considered that there will be an enrichment of the volatile pH-lowering compound in the coating, and that the coating slowly is releasing the volatile pH-lowering compound by gas diffusion, thus allowing sufficient time for the volatile pH-lowering compound to penetrate the plant.

In other words, it is envisioned that the coating will provide a local environment resembling a gas phase containing the volatile pH-lowering compound. The coating is on the one hand considerably slowing down the gas diffusion of the volatile pH-lowering compound to the surrounding atmosphere, on the other hand driving the gas diffusion of the same compound in the direction into the plant.

Another advantage with the carrier substance is that it fixes, or holds in position, the volatile pH-lowering compound at the plant surface.

Thus, lowering of the pH at the plant surface is accomplished through administration of a composition containing a pH-lowering compound and a carrier substance capable of forming a coating, or a film, at the surface.

When a coating is formed on the plant surface, non-volatile pH-lowering compounds can only diffuse through the plant epidermis as long as the coating still contains more water than the inner part of the plant, due to the osmotic pressure. When the coating is dry, this transport is inhibited since the osmotic pressure will act in the opposite direction, driving water out of the plant.

In contrast, volatile pH-lowering compounds can diffuse in vaporized condition through the epidermis and reach the inside. This diffusion is independent of the osmotic pressure and will continue until the gas pressures are equal on both sides of the epidermis.

Thus, lowering of the pH is preferably effected by the use of volatile pH-lowering compounds, such as inor-

ganic or organic acids, buffers, or gases, which in contact with water will generate an acidic environment, e.g. CO₂, SO₂, SO₃ or nitrous gases.

The term "volatile compound" is herein meant to include compounds which are readily vaporisable at a relatively low temperature, i.e. having a low boiling point, or sublimation point, and a high vapour pressure at ambient pressures and temperatures. Thus, volatile compounds are here meant to include all compounds having a higher vapour pressure than 0.1 torr at 0-20°C. In terms of comparison, volatile compounds are here meant to include all compounds being more volatile than, or equally volatile as, butyric acid. (see CRC Handbook of Chemistry and Physics, 54th Ed.).

It is preferred to use volatile pH-lowering compounds, particularly organic acids, together with a carrier to ensure a slow release dimension into the system. The organic acids and the carrier coating should preferably be used as a food or food additive, and registered as such, and should be environmentally safe.

It is even more preferred to use weak volatile organic acids, especially alkanoic acids, e.g. formic, acetic, propionic and butyric acid.

According to the invention, it is preferred that the pH-lowering is accomplished through the use of a composition containing at least 0.1% of a pH-lowering compound by weight, based on the total weight of the composition, preferably at least 1%, more preferably at least 3%, of said pH-lowering compound by weight, based on the total weight of the composition. The concentration can be varied within wide limits depending on the character of the pH-lowering compound, administration route (e.g. gas or liquid), the number of administration events, etc.

The absolute amount of the pH-lowering compound and its concentration in a composition according to the invention may vary and should be selected to provide sufficient killing of the weeds. A person skilled in the art

may readily determine suitable amounts and concentrations. The actual effective amount of the pH-lowering compound may vary with the type and the amount of plants to be treated, and environmental conditions, such as temperature and humidity.

However, the amount of the pH-lowering compound and its concentration in a composition are preferably such that the pH at the plant surface is less than 5. More particularly, the pH at the plant surface is preferably brought to the range from about 1 to about 5, such as from about 2 to about 5, or from about 2 to about 4.

The composition according to the invention contains a carrier substance. The terms "carrier" and "carrier substance" are here meant to include any substance capable of carrying the above-mentioned pH-lowering compound. It is preferred that the carrier is selected such as to provide a controlled release of the pH-lowering compound.

The carrier substance is also capable of forming a coating on the surface of a plant to which the composition is applied. The term "coating" refers to any kind of continuous layer over a surface. Thus, a coating, or a film, could cover the entire plant as well as a particular spot or surface area on a plant. It is preferred that the carrier is selected such that a coating is readily formed on a treated surface upon exposure of the surface to air, i.e. through vaporization of the solute, e.g. water. The thickness of the coating or film thus formed is preferably less than 250 μm , more preferred less than 100 μm , even more preferred between 0.1 μm and 10 μm .

The carrier substance(s) is (are) preferably selected from polysaccharides, proteins, lipids, and waxes, and derivatives thereof. Examples of proteins that may be used include, but are not limited to, gelatine, collagen, and soybean protein. Examples of lipids that may be used include plant lipids, e.g. rapeseed oil, coconut oil, olive oil, and derivatives thereof. Examples of waxes that may be used include synthetic waxes and natural

waxes, including animal waxes, such as beeswax and lanolin, vegetable waxes, such as carnauba and candelilla, as well as mineral and petroleum waxes, such as montan and paraffin.

5 It is particularly preferred that the carrier is a polysaccharide or a derivative thereof. Among suitable polysaccharides, the following groups can be mentioned: hemicelluloses (e.g. arabinoxylans, glucomannans), plant gums (e.g. guar gum, locust bean gum), cellulose and derivatives thereof (e.g. ethyl celluloses, carboxymethyl
10 celluloses), starch and starch derivatives (e.g. hydroxyethyl starch), microbial polysaccharides (e.g. xanthan gum, curdlan, pullulan, dextran), algal polysaccharides (e.g. agar, carragenans, alginic acid), chitin, and
15 chitosan, and derivatives thereof. Polysaccharides are preferably selected from plant polysaccharides and bacterial polysaccharides, such as starches and guar gum, locust bean gum, and xanthan gum. Preferred polysaccharides contain more than 10 monosaccharide units, preferably
20 more than 20 monosaccharide units, more preferably more than 50 monosaccharide units.

The concentration of a particular polysaccharide used in the composition may vary within broad limits. The compositions may contain up to about 20% by weight of a
25 polysaccharide based on the weight of the solution. It is preferred that the solution does not contain more than about 8% by weight, preferably not more than 5% by weight of the polysaccharide, and it is particularly preferred to use a polysaccharide concentration in the order of 0.5
30 to 8% by weight, preferably around 5% by weight. The concentration can be varied depending on the character of the polysaccharide, administration route, the number of administration events, etc.

A preferred composition comprises 1-3% acetic acid
35 and 4-6% starch, preferably approximately 2% acetic acid and approximately 5% starch.

Thus, both the carrier concentration and the concentration of the pH-lowering compound can be varied extensively, as described above. Since the outcome depends on their relative presence, it is preferred that the concentration of carrier is selected with the concentration of the pH-lowering compound in mind, and vice versa.

The viscosity of the applied composition may readily be varied by adjustment of the concentrations of the constituents. The viscosity has importance for the adherence of the composition to the plant surface as well as the thickness and other properties of the coating. A thicker coating may maintain the acidic atmosphere for a longer period of time and/or otherwise improve the acidic properties of the resulting coating. If the viscosity is increased considerably, the composition may be administered using high pressure devices.

Optionally, the composition may, in addition to the volatile pH-lowering compound and the carrier substance, contain a volatile medium, which is readily vaporisable. The purpose of the volatile medium is to provide an environment in which the two other substances can be delivered or diluted. For example, the medium may be a solvent. Preferred media are preferably acceptable as food or food additives, and registered as such, and should be environmentally safe and biodegradable. A particularly preferred medium is water.

Thus, a preferred composition comprises a volatile pH-lowering compound, such as formic acid or acetic acid, a carrier substance, such as starch or a derivative thereof, and a volatile medium, such as water. Upon application to a plant surface, the medium is vaporized, leaving a coating, or a film, formed by the carrier substance comprising sufficient amounts of the volatile pH-lowering compound to cause a lowering of the pH, e.g. to less than 5, at the plant surface.

The composition according to the present invention optionally contains conventional additives, such as com-

plexing agents, preservatives, plasticisers, detergents, etc. It is preferred to include detergents or other surface-active agents in the composition according to the invention. The amount thereof is preferably such that adherence of the composition to the plant surface is facilitated. The specific amount is readily determined by a person skilled in the art.

Compositions according to the invention may be formulated as, or prepared from, solutions, suspensions, emulsions, vapours, aerosols, spray mists, emulsifiable concentrates, flowable liquid concentrates, or wettable powders, which are readily diluted with water, other suitable solvent or oil carrier. The compositions may also be formulated in suspension concentrates, microemulsions, and the like.

It is preferred that the composition is an aqueous solution. Thus, a water-soluble polysaccharide is preferred to use in such a solution. Aqueous solutions of volatile organic acids, such as formic and acetic acid, may be bound in polysaccharide, protein, or other carriers and exert its herbicidal action(s) over long periods of time through gas diffusion mechanisms.

Compositions according to the invention may be applied to the weeds in any conventional way, including pre-emergence (application to soil before plant emergence) or post-emergence (application to plant foliage). It is particularly preferred to employ post-emergent application, i.e. application to plant foliage or any plant parts situated above the ground. However post-emergent application is within the scope of the invention, it is not favourable when it is raining.

The composition according to the invention is preferably used as a herbicide, i.e. to kill plants and retard or inhibit undesirable plant growth. The composition according to the invention is advantageously used for destruction of vegetation before seeding in the practice of reduced tillage or no tillage, or for destruction of an-

nual grasses in preparation for seeding perennial grasses in pasture grounds. Other uses include fire prevention, elimination of vegetation which may inhibit infrastructure, destruction of plants that are hosts for insects and plant diseases, as well as killing of poisonous or allergen-bearing plants.

In particular, the composition according to the invention is useful for clearing fields from undesirable vegetation as a preparation for new crops. It is also useful for clearing fields from undesirable vegetation as a preparation for harvest, such as clearing potato plants immediately prior to harvest of the potatoes.

Surprisingly, treatment of plants with the method according to the present invention effectively kills them using substantially lower amounts of the pH-lowering compound compared to when using previously known compositions. For example, this may mean acid concentrations lower than 50%, particularly lower than 24%, more particularly lower than 12%, by weight.

20

According to another aspect, the present invention provides a method and a novel use of a composition for the inhibition of sprouting of tubers. The terms "sprout" and "sprouting" refer to any new or young growth that arises from the rhizome portion of a plant, i.e. all kinds of formation of shoots, buds, sprouts, and the like.

According to the invention, the tubers, or at least certain potential sprouting areas of the tubers, are exposed to an environment capable of maintaining a pH of less than about 5 at the tuber surface.

The expression "potential sprouting area" refers to an area where new or young growth, i.e. shoots, buds, sprouts, and the like, if any, is predestined to arise. This new or young growth is often referred to as primary growth. Primary growth is restricted to the youngest part of the plant, the tips of roots and shoots, where the

apical meristems are situated. On the stem, such a potential point of shooting is commonly situated at a node and referred to as an axillary bud or a terminal bud. Many plants, such as tubers, produce an underground lateral stem, known as a rhizome, from which new shoots can arise. The shoots, or sprouts, arise from nodes, or eyes, situated at the rhizome.

The term "sprout-inhibiting" refers in general to anything that inhibits, suppresses, prevents, arrests or slows down the growth of any new or young growth, i.e. shoots, buds, sprouts, and the like. Thus, the term "sprout-inhibiting compound" refers to any compound possessing this property.

Lowering of the pH at the tuber surface, and beneath the skin, may be accomplished through the use of pH-lowering compounds. The pH-lowering compound can pass the skin by diffusion in an aqueous environment, or by gas diffusion if the pH-lowering compound is volatile. Examples of pH-lowering compounds include buffers and acids. Preferred buffers are acetates, citrates, and phosphates. Weak acids are particularly preferred as pH-lowering compounds, since they provide mild treating conditions.

Thus, lowering of the pH at the tuber surface may be accomplished through exposure of the tuber to a pH-lowering atmosphere, preferably for a prolonged period of time (hours or days). As an example, the tubers and a pH-lowering compound in gaseous, liquid or solid phase can be kept in a sealed container. Preferably, the pH is regulated by the use of acetic acid in a suitable form and concentration.

In the sprout-inhibiting or -delaying method according to the invention, it is preferred that the tubers are exposed to an environment capable of maintaining a pH of less than about 5 at the tuber surface. Preferably, the pH is maintained below 2,5, preferably below 2. Without being limited thereto, the environment will not maintain the pH below 1.

Thus, lowering of the pH at the tuber surface is preferably effected by the use of volatile pH-lowering compounds, such as inorganic or organic acids, buffers, or gases, which in contact with water will generate an acidic environment, e.g. CO₂, SO₂, SO₃ or nitrous gases.

According to the invention, it is preferred that the pH-lowering at the tuber surface is accomplished through the use of a composition containing at least 50% of a pH-lowering compound by volume, based on the total volume of the composition, preferably at least 75%, more preferably at least 90%, of said pH-lowering compound by volume, based on the total volume of the composition. The concentration can be varied within wide limits depending on the character of the pH-lowering compound, administration route (e.g. gas or liquid), the number of administration events, time of exposure to the composition, etc.

The absolute amount of the pH-lowering compound and its concentration in a composition according to the invention may vary and should be selected to provide sufficient inhibition of tuber sprouting. A person skilled in the art may readily determine suitable amounts and concentrations. The actual effective amount of the pH-lowering compound may vary with the amount of tubers to be treated, and environmental conditions, such as temperature and humidity.

The sprout-inhibiting composition according to the invention may contain a carrier substance, or matrix. Optionally, the composition may contain a suitable buffer.

The sprout-inhibiting composition according to the present invention optionally contains conventional additives, such as colouring agents, complexing agents, preservatives, plasticisers, detergents, softeners, etc. It is also possible to include anti-microbial agents and/or anti-fungal agents in the composition.

It is preferred that the sprout-inhibiting composition is an aqueous solution of acetic acid. Sprout-inhibiting compositions according to the invention may be

applied to the tubers in any conventional way, including spraying and exposing the tubers to a gaseous atmosphere thereof.

5 The sprout-inhibiting composition according to the invention is preferably used for the treatment of potatoes in storage. After a dormant period of 1-3 months after harvesting, potatoes are inclined to sprout even in cold storage. The sprouting starts with cell divisions below the "eyes", resulting in enzymatic breakdown of the potato starch with formation of reducing sugars. The mechanism initiating the sprouting is largely unknown. Once a sprout has developed, the treatment according to the present invention will not stop the further development of the sprout.

15 Surprisingly, treatment of potatoes with the method according to the present invention effectively stops the sprouting of potatoes for prolonged periods of time. Inhibition of sprouting can be maintained for at least up to 6 months using the present invention.

20 In summary, the present invention provides a novel composition, and use thereof, for weed control. The composition comprises a volatile pH-lowering compound and a carrier substance for said pH-lowering compound, and optionally a volatile medium, such as water. The carrier substance is selected such that it is capable of forming a coating, or a film, on the surface of a plant, or plant part, upon drying or vaporization of the composition. The thus formed coating comprises the pH-lowering compound in an amount sufficient to kill or inhibit the treated plant. In the method according to the invention, a plant surface is exposed to the composition according to the invention.

35 According to another aspect, the present invention moreover provides the use of a sprout-inhibiting composition for tubers. The composition comprises a pH-lowering compound, preferably acetic acid, and optionally a car-

rier substance for the pH-lowering compound. In the method according to the invention, the tubers are exposed to an environment capable of maintaining a pH of less than about 5 at the tuber surface where it is inclined to sprout, i.e. at the potential budding points.

The present invention will be further described below by non-limiting examples.

10 Examples

Example 1

Aqueous solutions of 2% (w/v) maize starch containing various concentrations (12%, 6%, 3% and 1% (w/v)) of acetic acid and 0.05% of a neutral detergent are prepared. As a comparison, aqueous solutions of acetic acid in various concentrations and 0.05% of a neutral detergent are prepared.

The solutions are sprayed on the upper side of leaves of the following plant types: dandelion (*Taraxacum vulgare*), goosefoot (*Chenopodium album*), quackgrass (*Agropyron repens*), and red clover (*Trifolium pratense*), which are grown at 18°C. The plants are observed 4, 8, 24, and 48 hours following the administration of the solutions.

The effects of the treatments are shown in Tables I-IV. The effect is graded with the signs -, +, ++, and +++, where - means that the leaves are unaffected, and +++ means that all leaves are dead.

Table I. Effect on *Taraxacum vulgare*

Composition of solution	Time following treatment			
	4 h	8 h	24 h	48 h
12% Acetic acid	+	++	+++	+++
12% Acetic acid, 2% maize starch	++	+++	+++	+++
6% Acetic acid	-	+	++	+++
6% Acetic acid, 2% maize starch	+	++	+++	+++
3% Acetic acid	-	+	+	++
3% Acetic acid, 2% maize starch	+	++	+++	+++
1% Acetic acid	-	-	-	+
1% Acetic acid, 2% maize starch	+	+	+++	+++

Table II. Effect on *Chenopodium album*

Composition of solution	Time following treatment			
	4 h	8 h	24 h	48 h
12% Acetic acid	+	++	+++	+++
12% Acetic acid, 2% maize starch	++	+++	+++	+++
6% Acetic acid	-	+	++	+++
6% Acetic acid, 2% maize starch	+	++	+++	+++
3% Acetic acid	-	+	+	++
3% Acetic acid, 2% maize starch	+	+++	+++	+++
1% Acetic acid	-	-	-	+
1% Acetic acid, 2% maize starch	+	++	+++	+++

Table III. Effect on *Agropyron repens*

Composition of solution	Time following treatment			
	4 h	8 h	24 h	48 h
12% Acetic acid	+	++	+++	+++
12% Acetic acid, 2% maize starch	++	+++	+++	+++
6% Acetic acid	-	+	++	++
6% Acetic acid, 2% maize starch	+	++	+++	+++
3% Acetic acid	-	+	+	++
3% Acetic acid, 2% maize starch	+	+++	+++	+++
1% Acetic acid	-	-	-	+
1% Acetic acid, 2% maize starch	+	++	++	+++

Table IV. Effect on *Trifolium pratense*

Composition of solution	Time following treatment			
	4 h	8 h	24 h	48 h
12% Acetic acid	+	++	+++	+++
12% Acetic acid, 2% maize starch	++	+++	+++	+++
6% Acetic acid	-	+	++	++
6% Acetic acid, 2% maize starch	+	++	+++	+++
3% Acetic acid	-	+	+	++
3% Acetic acid, 2% maize starch	+	+++	+++	+++
1% Acetic acid	-	-	-	+
1% Acetic acid, 2% maize starch	+	++	++	+++

It is apparent from the experimental results that, for a given acid concentration, the compositions according to the invention are more effective in terms of speed, or killing time, and have an improved final outcome, especially at lower acid concentrations. Moreover, it can be seen that, after a given period of time, the compositions according to the invention are more effective in terms of killing. This is particularly apparent at lower acid concentrations.

Example 2

Aqueous solutions are prepared containing 5% (w/v) potato starch and 6% and 10%, respectively, of acetic acid. The solutions are administered to different sections of a potato field. The following day, the vast majority of the treated plants are dead. The potatoes are harvested employing traditional techniques.

Example 3

Aqueous solutions of 1.5% (w/v) guar gum containing various concentrations (1-6% (w/v)) of formic acid and 0.07% of a neutral detergent are prepared. As a comparison, aqueous solutions of formic acid in various concentrations and 0.07% of a neutral detergent are prepared.

The solutions are sprinkled on the leaves of the following plant types: dandelion (*Taraxacum vulgare*), goosefoot (*Chenopodium album*), quackgrass (*Agropyron repens*), and red clover (*Trifolium pratense*), which are
5 grown at 18°C. The plants are observed 4, 8, 24, and 48 hours following the administration of the solutions.

The solutions containing guar gum are considerably more effective in killing the treated plants than the solutions with corresponding acid concentrations lacking
10 guar gum.

Example 4

Aqueous solutions are prepared containing 1% (w/v) potato starch and 1%, 3%, and 5%, respectively, of acetic
15 acid. The solutions are administered to various weeds growing in a garden gravel path. The following day, the weeds are dead. All tested solutions are effective.

Example 5

20 An aqueous solution is prepared containing 5% (w/v) potato starch and 2% of acetic acid. The solution is administered to various weeds. The solution is herbicidally active.

Example 6

25 1 kg of potatoes (Bintje) is treated with an aqueous solution of acetic acid (10%) containing locust bean gum (1%). The treatment is made by spraying the potatoes (0.1 litre/m²) using an airless spray at a pressure of 100
30 bars.

The potatoes are allowed to dry and are stored as described above. No sprouting of the treated potatoes is observed over a period of 6 months.

Example 7

1 kg of potatoes (Bintje) is exposed to an atmosphere of gaseous acetic acid, whereby sprouting is prevented.

5

Example 8

1 kg of potatoes (Bintje) is exposed to a mist of acetic acid, whereby sprouting is prevented.

10 Example 9

A wide beaker containing 1 litre of aqueous acetic acid (50, 75, and 100% vol/vol, respectively) is placed on the bottom of a plastic container with a volume of 25 litres. pH-paper strips are placed in the ceiling of the container, and the container is sealed. An atmosphere of acetic acid is generated in the container by allowing the aqueous acetic acid to evaporate into gaseous phase within the container.

Following 4 h of exposure to this atmosphere, the pH-paper strips are collected and visually inspected. All three acetic acid concentrations tested generate a pH response in the range of from 1 to 2, in the region closer to 1.

25 Example 10

Samples consisting of 20 medium-sized potatoes (Bintje), which have been stored at 8-12°C for two months are subjected to various atmospheres of aqueous acetic acid for different periods of time (1-5 days).

30 A wide beaker containing 1 litre of aqueous acetic acid (0-100% vol/vol) is placed on the bottom of a plastic container with a volume of 25 litres. The container is sealed, and an atmosphere of acetic acid is generated by allowing the aqueous acetic acid to evaporate into gaseous phase for 24 h within the container.

35 Following generation of this atmosphere, a basket containing the potatoes is introduced to the container,

and the container is resealed for a period of time (1-5 days). The baskets contain sufficient air holes to allow the potatoes to be exposed to the gaseous acetic acid environment.

- 5 Following this treatment, the baskets are removed from the containers, and the potatoes are stored in the dark at 8°C. After one month, the potatoes are visually inspected for sprouts. The results are shown in Table V.

Table V. Effect on Bintje potatoes

Composition % acetic acid (vol/vol) in water	Treatment time (days)	% sprouting potatoes after 1 month
0	1	100
0	2	100
0	3	100
0	4	100
0	5	100
50	1	90
50	2	75
50	3	50
50	4	25
50	5	0
75	1	75
75	2	25
75	3	0
75	4	0
75	5	0
100	1	0
100	2	0
100	3	0
100	4	0
100	5	0

CLAIMS

1. A method of killing a plant or retarding its growth, comprising the step of exposing the surface, or
5 part thereof, of said plant to a composition comprising a volatile pH-lowering compound and a carrier substance for said pH-lowering compound, said carrier substance being capable of forming on the surface, or part thereof, of said plant a coating containing said pH-lowering compound
10 upon vaporization of at least part of said composition.

2. A method according to claim 1, wherein said composition further comprises a volatile medium, such as water.

3. A method according to claim 1 or 2, wherein said
15 composition is capable of maintaining a pH of less than about 5 at the plant surface.

4. A method according to claim 3, wherein said pH is within the range from about 1 to about 5, such as from about 2 to about 4.

20 5. A method according to any one of the preceding claims, wherein said pH-lowering compound is a buffer or an acid.

6. A method according to claim 5, wherein said acid is a weak acid.

25 7. A method according to claim 6, wherein said weak acid is an organic acid.

8. A method according to claim 7, wherein said organic acid is an alkanoic acid.

30 9. A method according to claim 8, wherein said alkanoic acid contains from 1 to 4 carbon atoms.

10. A method according to claim 9, wherein said alkanoic acid is formic acid or acetic acid.

11. A method according to claim 5, wherein said buffer is selected from acetates, citrates, and phosphates.

35 12. A method according to any one of the preceding claims, wherein said carrier substance is selected from

the group consisting of polysaccharides, proteins, lipids, and waxes, and derivatives thereof.

13. A method according to claim 12, wherein said carrier substance is a polysaccharide or a derivative thereof.

14. A method according to claim 13, wherein said polysaccharide is of bacterial or plant origin.

15. A method according to claim 14, wherein said polysaccharide is selected from the group consisting of starches, locust bean gum, guar gum, and xanthan gum.

16. A method according to claim 15, wherein said polysaccharide is starch.

17. A method according to any one of the preceding claims, wherein said composition comprises a compound selected from other herbicidal compounds, complexing agents, preservatives, plasticisers, detergents, and softeners.

18. A method according to any one of the preceding claims, wherein said composition is an aqueous solution or an aqueous vapour.

19. A method according to any one of claims 1 to 17, wherein said composition is made from a concentrate or a wettable powder.

20. A method according to any one of claims 1 to 17, wherein said exposing comprises spraying said plant surface, or part thereof, with said composition.

21. A method according to any one of claims 1-20, wherein said plant is a weed.

22. A method according to any one of claims 1-20, wherein said plant is a potato plant.

23. A method according to claims 21 or 22, wherein said plant parts are the stems, or parts thereof.

24. A method according to any one of claims 1-20, wherein said plant surface is a plant foliage surface.

25. A method according to any one of claims 1-24, wherein said step of exposing said plant surface to said

composition constitutes a post-emergent application of said composition.

26. A herbicidal composition as defined in any one of claims 1 to 19.

5 27. Use of a composition according to claim 26 for inhibition of plant growth.

28. A method of inhibiting or delaying sprouting of tubers, comprising the step of exposing said tubers to an environment or a composition comprising acetic acid, said
10 environment being capable of maintaining a pH of less than about 5 at the tuber surface.

29. A method according to claim 28, wherein said environment is a gas phase comprising said acetic acid.

30. A method according to claim 28, wherein said en-
15 vironment is a mist comprising said acetic acid.

31. A method according to claim 28, wherein said composition is an aqueous vapour or an aerosol.

32. A method according to any one of claims 28 to 31, wherein said tubers are exposed to said composition
20 by spraying.

33. A method according to any one of claims 28 to 31, wherein said tubers are exposed to said composition by maintaining the tubers in an atmosphere comprising the composition.

25 34. A method according to any one of claims 28 to 33, wherein said tubers are potato tubers.

35. A method for manufacturing of a sprout-inhibiting or sprout-delaying composition for tubers, comprising the step of incorporating into said composition an
30 amount of acetic acid, such that said composition, when administrated to said tubers, is capable of maintaining a pH of less than about 5 at the tuber surface.

36. Use of acetic acid in a sprout-inhibiting or sprout-delaying composition for tubers, which composition, when administrated to said tubers, is capable of
35 maintaining a pH of less than about 5 at the tuber surface.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 02/01644

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: A01N 37/02, A01N 43/16, A01N 25/26, A01N 25/08, A23B 7/10

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: A01N

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)

EPO-INTERNAL, WPI DATA, PAJ, CHEM.ABS DATA

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	--	1-25,27-36
X	STN International, File CAPLUS, CAPLUS accession no. 2001:173838, Document no. 134:203785, Gunei Chemical Industry Co., Ltd.: "Vinegar-based plant activators and their use in crop cultivation"; JP,A2,2001061344, 20010313	1-36
X	DE 19645130 A1 (TEMEN GMBH), 7 May 1998 (07.05.98)	1-27
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☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"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

22 November 2002

Date of mailing of the international search report

11-12-2002

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 02/01644

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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International application No.

PCT/SE 02/01644

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