(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
21 March 2013 (21.03.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/039937 A1

(51) International Patent Classification:
A01N 49/00 (2006.01) *A01N 27/00* (2006.01)

(21) International Application Number:
PCT/US2012/054701

(22) International Filing Date:
12 September 2012 (12.09.2012)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/533,725 12 September 2011 (12.09.2011) US
61/534,294 13 September 2011 (13.09.2011) US
61/542,739 3 October 2011 (03.10.2011) US
61/543,651 5 October 2011 (05.10.2011) US

(71) Applicant *(for all designated States except US)*: **AGRAQUEST, INC.** [US/US]; 1540 Drew Avenue, Davis, CA 95618 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **JIMENEZ, Desmond, Rito** [US/US]; 216 Toyon Drive, Woodland, CA 95695 (US). **JOO, Daniel, M.** [US/US]; 2402 Anza Avenue, Davis, CA 95616 (US). **MARGOLIS, Jonathan, S.** [US/US]; 1737 Evergreen Court, Davis, CA 95618 (US).

(74) Agent: SAMONEK, Michelle, L.; Agraquest, Inc., 1540 Drew Avenue, Davis, CA 95618 (US).

(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, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, 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, 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, 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, ML, MR, NE, SN, TD, TG).

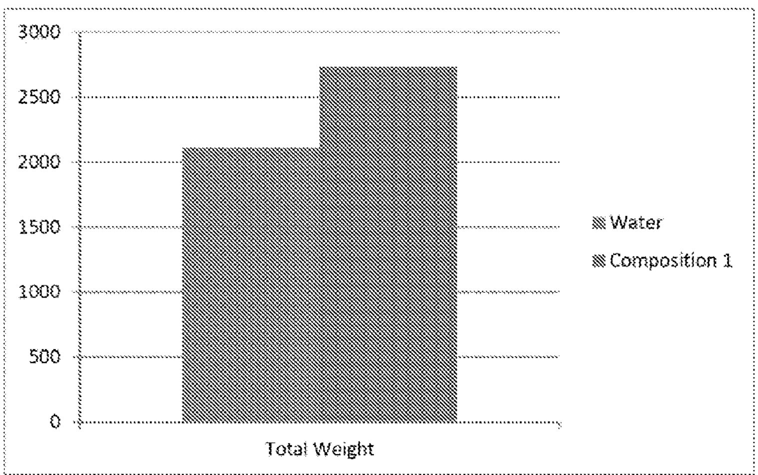
Declarations under Rule 4.17:
— *of inventorship (Rule 4.17(iv))*

Published:
— *with international search report (Art. 21(3))*

[Continued on next page]

(54) Title: METHODS OF ENHANCING HEALTH AND/OR PROMOTING GROWTH OF A PLANT AND/OR OF IMPROVING FRUIT RIPENING

Figure 6



(57) Abstract: The present invention provides methods of enhancing the health of a plant, of promoting the growth of a plant and of improving frail ripening. The methods comprise applying at least one terpene or terpenoid compound to the plant or a plant part, or to the fruit or a plant carrying the fruit, aod/or applying to an area around a plant or plant part or around a fruit.

WO 2013/039937 A1

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

METHODS OF ENHANCING HEALTH AND/OR PROMOTING GROWTH OF A PLANT AND/OR OF IMPROVING FRUIT RIPENING

TECHNICAL FIELD

[0001] This invention relates to the technical field of enhancing the health of a plant and promoting the growth of a plant. The invention also relates to the technical field of improving fruit ripening.

BACKGROUND

[0002] In order to promote plant growth, fertilizers are employed worldwide, based on both inorganic and organic substances. A fertilizer may be a single substance or a composition, and is used to provide nutrients to plants. A major breakthrough in the application of fertilizers was the development of nitrogen-based fertilizer by Justus von Liebig around 1840. Fertilizers, however, can lead to soil acidification and destabilization of nutrient balance in soil, including depletion of minerals and enrichment of salt and heavy metals. In addition, excessive fertilizer use can lead to alteration of soil fauna as well as contaminate surface water and ground water. Further, unhealthful substances such as nitrate may become enriched in plants and fruits.

[0003] Plants generally maintain constant levels of essential mineral nutrients in order to attain optimal growth and development, even though such nutrients are in many soils present in low concentration or accessibility. In this regard plants have evolved adaptive responses, which enable them to grow also on a soil with limited amounts of one or more nutrients. Many nutrients have for instance low solubility or are distributed in an irregular manner in soil. In case of reduced nutrient availability, plants generally trigger physiological and developmental responses aimed at increasing nutrient acquisition which typically lead to a change in plant morphology and metabolism. In addition, plants also have adaptive mechanisms to stimulate growth in the organs that directly participate in nutrient acquisition. It is suspected that interactions between hormone and nutrient-starvation signaling pathways exist. For example in crop protection, there is a continuous need for applications that improve the health of plants. Healthier plants generally result in higher yields and/or a better quality of a plant or its products. In addition, due to their increased vigor, healthier plants show a better resistance to biotic and/or abiotic stress.

[0004] Apart from using chemical fertilizers another existing means of advancing plant growth are plant associated bacteria such as rhizobacteria. Such bacteria are associated with many, if not all plant species. The mechanism behind the effect of plant associated bacteria on plant growth is still open to speculation. Ryu et al. (Proc. Natl. Acad. Sci. U.S.A. [2003] 100, 4927-4932) have suggested that among rhizobacteria, which colonize roots, some strains regulate plant growth via releasing 2, 3-butanediol and/or acetoin.

[0005] There however still remains a need to provide alternative means of advancing the growth of a plant and improving its health.

SUMMARY

[0006] In a first aspect the present invention provides a method of enhancing the health of a plant. The method includes providing one or more terpene or terpenoid compounds, i.e., at least one terpene or terpenoid compound. Further, the method includes using the at least one terpene or terpenoid compound on at least one of a plant, a plant part and an area around a plant or a plant part. In this regard the method may include applying the at least one terpene or terpenoid compound to one of the plant, i.e., the entire plant, and a plant part, i.e., a portion of the entire plant. The method may also include applying the at least one terpene or terpenoid compound to an area around a plant or plant part.

[0007] In a second aspect the present invention provides a method of promoting the growth of a plant. The method includes providing at least one terpene or terpenoid compound. The method further includes using the at least one terpene or terpenoid compound on at least one of a plant, a plant part and an area around a plant or a plant part. In this regard the method may include applying the at least one terpene or terpenoid compound to one of the plant and a plant part. The method may also include applying the at least one terpene or terpenoid compound to an area around a plant or plant part.

[0008] In a third aspect the invention provides a method of improving fruit ripening. The method may include applying at least one terpene or terpenoid compound to one of the fruit and a plant carrying the fruit. In addition or alternatively, the method may further include applying at least one terpene or terpenoid compound to an area around a fruit.

[0009] The area around a plant or plant part, or around a fruit may be or include the locus where the plant is growing, or a part of that locus. The respective area around a plant or plant part may, for example, be or include matter such as soil that is located in the vicinity of the plant or plant part. The respective area around a fruit may for example be or include a portion of a plant on which the fruit is growing, or be or include matter such as soil that is located in the vicinity to the plant or plant part carrying the fruit.

[0010] The present invention also provides methods of using a terpene or terpenoid compound, including a composition that includes the same to promote the growth of a plant, and/or enhance the health of a plant and/or improve fruit ripening.

[0011] The terpene or terpenoid compound may be included in a composition. In one embodiment, a composition that is used in the invention includes an excipient and a composition that is effective in promoting plant growth and/or enhancing plant health and/or improving fruit ripening, such as extracts obtained from *Chenopodium ambrosioides*, or a simulated blend consisting essentially of α-terpinene, p-cymene and limonene not obtained from *Chenopodium ambrosioides* or not obtained from *Chenopodium*. In some embodiments a composition used in the invention consists essentially of an excipient and one or more extracts obtained from *Chenopodium ambrosioides*, or a simulated blend consisting essentially of α-terpinene, p-cymene and limonene. In some embodiments a respective composition consists of an excipient and one or more extracts obtained from *Chenopodium ambrosioides*, or a simulated blend consisting essentially of α-terpinene, p-cymene and limonene. In some embodiments, the simulated blend of the above compositions consists essentially of α-terpinene, p-cymene, limonene and a volume filler. In some embodiments, a respective composition does not contain thymol, carvacol, carvone, carveol and/or nerol. In one embodiment, the simulated blends in the above compositions are not from an extract of *Chenopodium ambrosioides* or from an extract of *Chenopodium*.

[0012] In one embodiment, a composition used in the present invention only includes the essential oil extracts from or based on those found in *Chenopodium ambrosioides* near *ambrosioides*. In one embodiment, a composition used in the present invention only includes a synthetic blend simulating the essential oil extract from or based on those found in *Chenopodium ambrosioides* near *ambrosioides*. In one embodiment, a composition used in the present invention includes a mixture of the essential oil extract and the synthetic blend. In some embodiments, the compositions to be applied to plants are "normalized" by adding specific amounts of synthetic versions of one or more of the terpene or terpenoid compounds found in the natural extract and/or synthetic terpenes so as to produce a composition with a set ratio of the three terpenes, such as the ratio observed in certain standardized or preferred natural extracts from or based on those found in *Chenopodium*. In still other embodiments, the terpene or terpenoid compound or the respective composition used in the methods of the present invention is reconstituted.

[0013] In some embodiments, the simulated blends simulating the *Chenopodium* extract consist essentially of natural analogs of such terpenes from other plant species or other organisms, and/or the synthetic versions of such terpenes. In some embodiments, simulated blends comprise the three substantially pure α-terpinene, p-cymene and limonene, optionally with at least one volume filler that replaces the volume taken up by the minor components normally present in the extract of *Chenopodium ambrosioides* near *ambrosioides*. In some embodiments, the volume filler is vegetable oil or mineral oil. In further embodiments, the simulated blends consist essentially of α-terpinene, p-cymene and limonene, and an oil wherein the α-terpinene, p-cymene and limonene are substantially pure and are not obtained from a Chenopodium extract, and wherein the excipient is not an essential oil. In some embodiments, the limonene is prepared from citrus peels or pines by cold press method.

[0014] The concentration of α-terpinene in a composition used in the present invention, whether as an extract and/or a synthetic version, may range from about 30% to about 70% by weight; the concentration of p-cymene used in a composition, whether as an extract and/or a synthetic version, may range from about 10% to about 30% by weight, and the concentration of limonene in a respective composition, whether as an extract and/or a synthetic version, may range from about 1% to about 20% by weight.

[0015] In some embodiments, the concentration of α-terpinene in a composition, whether as an extract and/or a synthetic version, may range from about 30% to about 50% by weight, including about 35% to about 45% by weight; the concentration of p-cymene in a composition, whether as an extract and/or a synthetic version, may range from about 10% to about 30% by weight, including from about 15% to about 25% by weight, and the concentration of limonene in a composition, whether as an extract and/or a synthetic version, may range from about 2% to about 20% by weight, including from about 5% to about 15% by weight.

[0016] In some embodiments, the concentration of α-terpinene, including at least substantially pure α-terpinene, in a composition may be about 39% by weight; the concentration of p-cymene, e.g., at least substantially pure p-cymene, in a compositions may be about 17% by weight, and the concentration of limonene, e.g. at least substantially pure limonene, in a compositions may be about 12% by weight.

[0017] In some embodiments, the absolute concentration of α-terpinene in a composition is about 36% by weight; the absolute concentration of p-cymene in a composition is about 14.9% by weight, and the absolute concentration of limonene in a composition is about 11.4% by weight.

[0018] In some embodiments, the relative ratio among α-terpinene, p-cymene, and limonene in the compositions is about 35-45 α-terpinene to about 12-20 p-cymene to about 10-15 limonene. Other relative ratios are described in more detail below.

[0019] The present invention also provides the formulation technologies for preparing such compositions of agents for enhancing the health of a plant and/or promoting the growth of a plant and/or improving fruit ripening. In one embodiment, a composition used in the present invention is formulated as an emulsifiable concentrate (EC). In one embodiment, the formulation is a highly concentrated liquid. In one embodiment, the formulation is a spray concentrate. In one embodiment, the formulation is an ultra low volume (ULV) concentrate. In one embodiment, the formulation is a highly diluted liquid or oil solution. In one embodiment the formulation is in an encapsulated form.

[0020] A respective composition can be applied to a plant at any desired time during the life cycle of the plant. In one embodiment a respective composition is applied to one or more plants after germinating. In one embodiment a respective composition is applied to one or more plants before bloom. In one embodiment a respective composition is applied to one or more plants during bloom. In one embodiment a respective composition is applied to one or more plants after bloom. In some embodiments where the plant is a flowering plant (angiosperms) a terpene or terpenoid compound, including a composition according to the present invention, is applied to a plant at any stage, before, during or after the growth of fruit and/or seed. In some embodiments the application occurs at, during or after transplantation of the plant or emergence of the plant. In some embodiments, a composition is applied one or more additional times during the life cycle of the plant.

[0021] The methods and uses according to the present invention can be accomplished by applying to a plant or plant part or an area around a plant or plant part, a fruit, a plant part carrying a fruit or an area around, including proximate to a fruit, a composition that includes a simulated blend of an essential oil extract of *Chenopodium ambrosioides* near *ambrosioides* in which such simulated blend consists essentially of substantially pure α-terpinene, substantially pure p-cymene, and substantially pure limonene, wherein these substantially pure compounds are not obtained from a *Chenopodium* extract. A composition used in the above method may also comprise a carrier and/or volume filler, which may be an oil, such as a vegetable oil. In some embodiments, the carrier and/or volume filler may act as a pesticide. In some embodiments, the carrier and/or volume filler may act as an insecticide. In some embodiments, the composition does not contain thymol, carvacrol, carvone, carveol and/or nerol. In some embodiments the composition does not contain the aforementioned five essential oils and does not contain any other essential oils, except those other essential oils that are present as minor impurities in the substantially pure α-terpinene, p-cymene and limonene. In some embodiments, the composition does not contain essential oils other than α-terpinene, p-cymene and limonene.

[0022] The methods of the present invention include using a composition according to the present invention to enhance the health of a plant, to promote the growth of a plant and/or to improve fruit ripening. The increase in growth, the improved health and/or the intensified fruit ripening is effective for at least about 1 day, for at least about 2 days, for at least about 3 days, for at least about 4 days, for at least about 5 days, for at least about 6 days, for at least about a week, for at least about 8 days, for at least about 9 days, for at least about 10 days, for at least about 11 days, for at least about 12 days, for at least about 2 weeks, for at least about 3 weeks, for at least about a month after application or longer.

[0023] The methods of the present invention include applying the compositions of the present invention at any time during the life cycle of a plant, during one or more stages of a plant's life cycle, or at regular intervals of a plant's life cycle, or continuously throughout the life of the plant. By applying the compositions to plants during growth, before and/or during blossom and/or before and/or during the occurrence of seeds the ameliorating effect on plant health, the strengthening effect on plant growth and/or the stimulating effect on fruit ripening of the extract composition can be maintained for as long as desirable by repeated applications. As an illustrative example, a composition can be applied before, during and/or shortly after the plants are transplanted from one location to another, such as from a greenhouse or hotbed to the field. In another example, the compositions can be applied shortly after seedlings emerge from the soil or other growth media (e.g., vermiculite). As yet another example, a composition can be applied at any time to plants grown hydroponically. A method according to the invention may include applying the composition on a plant, on a plant part, on an area around a plant, including proximate to a plant, on a fruit and/or an area around, including proximate to, a fruit multiple times, for example a preselected number of times during a desired period of time. In some embodiments a respective composition may be applied on plants for multiple times with desired interval period. In one embodiment, such an interval period is about 1 hour, about 5 hours, about 10 hours, about 24 hours, about two days, about 3 days, about 4 days, about 5 days, about 1 week, about 10 days, about two weeks, about three weeks, about 1 month or more.

[0024] In a method or use according to the invention a composition is applied to a plant, to a plant part, to an area around a plant or plant part, to the fruit, to a plant carrying the fruit and/or to an area around a fruit. An area around a fruit, a plant or a plant part may for example be an area within about 2 meters, within about a meter, within about 70 cm, within about 50 cm, within about 25 cm, within about 10 cm or within about 5 cm surrounding the plant, the plant part or the fruit. The composition comprises a terpene or terpenoid compound, such as a monoterpene, a sesquiterpene, a diterpene, a sesterterpene, a triterpene or mixtures thereof. In one embodiment the composition includes α-terpinene, p-cymene and limonene.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] **Figure 1** illustrates the known effectiveness of a blend of α-terpinene, p-cymene and limonene in controlling insects and reducing disease using the example of watermelon vine decline. Pictures were taken approximately 60 days after transplanting. **Fig. 1A, 1B**: effect of a composition having the same terpene ingredients as Composition 1, as described in Example 1 but with slightly different additional ingredients. **Fig. 1C**: effect of neonicitinoid soil application and foliar program. **Fig. 1D**, **1E**: untreated control.

[0026] **Figure 2** depicts the effect of 3 times application of Composition 1, as described in Example 1, (**B**) in comparison to 3 times water (**A**) on fruit set and ripening in comparison to bract.

[0027] **Figure 3** illustrates the effect of Composition 1, as described in Example 1, applied to lima bean plants one, two, or three times (5-d intervals), on the infestation of mites (mites counted 14 DAT3). White bars: total mites; black bars: new growth.

[0028] **Figure 4** depicts the effect of Composition 1, as described in Example 1, applied to lima bean plants one, two, or three times (5-d intervals), on in the presence of twospotted spider mites.

[0029] **Figure 5** depicts untreated tomato palisade cells (**A**, **B**) and tomato palisade cells exposed to Composition 1 three times on a 7 day interval (**C**).

[0030] **Figure 6** represents the total weight of tomato plants after 13 treatments with water or Composition 1.

DETAILED DESCRIPTION

[0031] All publications, patents and patent applications, including any drawings and appendices, herein are incorporated by reference to the same extent as if each individual publication or patent application was specifically and individually indicated to be incorporated by reference.

[0032] The following description includes information that may be useful in understanding the present invention. It is not an admission that any of the information provided herein is prior art or relevant to the presently claimed inventions, or that any publication specifically or implicitly referenced is prior art.

Definitions

[0033] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs.

[0034] As used herein, the term "control" or "controlling" means to kill plant pests; or to inhibit the activity of plant pests (e.g., reduced mobility, appetite and/or reproductive capability); or to repel plant pests from a host or area.

[0035] As used herein, the phrase "active ingredient" refers to an ingredient of one chemical compound, or mixture of several chemical compounds, wherein the ingredient is capable of enhancing the health of a plant, or of promoting the growth of a plant and/or improving fruit ripening.

[0036] As used herein, the term "plant extract" refers to any substance obtained from plants. Plant extracts include but are not limited to aromatic substances, such as phenols or tannins, and alkaloids. Plant extracts are generally obtained from plants by removing the desired substance, usually an active ingredient, from a plant or plant part using a suitable solvent, which is evaporated away, and adjusting the residue to a desired amount, such as a desired or prescribed standard amount of the active substance.

[0037] As used herein, the phrase "normalized extract" refers to a composition formulated so that some or all of at least one of the active substances in a particular plant extract are derived from another source, either synthetic or natural.

[0038] As used herein, the phrase "simulated blend" refers to a composition assembled from synthetically produced compounds and/or compounds derived from one or more plant extracts, which simulates the activity of a plant extract, and in which no compound is obtained from the plant extract whose activity is being simulated.

[0039] As used herein, the phrase "essential oil extract" means the volatile, aromatic oils obtained by steam or hydro-distillation of plant material and may include, but are not restricted to, being primarily composed of terpenes and their oxygenated derivatives. Essential oils can be obtained from, for example, plant parts including, for example, flowers, leaves, seeds, roots, stems, bark, wood, and etc. Plant material that may be used in a method according to the present invention includes plant material derived from the genus *Chenopodium sp.* taken individually or in a group and may include, but is not restricted to, the leaf, flowers, roots, seeds, and stems. As is known by persons skilled in the art, the chemical composition and efficacy of an essential oil extract varies with the phenological age of the plant, percent humidity of the harvested material, the plant parts chosen for extraction, and the method of extraction. Methods well-known in the art can be adapted by a person of ordinary skill in the art to achieve the desired yield and quality of the essential oil extract of the present invention. In one embodiment, the plant material is derived from *Chenopodium ambrosioides*.

[0040] As used herein, the term "penetrants" refers to chemical compounds that facilitate the transfer of biopesticide into the plant tissues. They can be lipids or detergent (also called surfactant), including but not limited to heavy petroleum oils and distillates, polyol fatty acid esters, polyethoxylated fatty acid esters, polyhydric alcohols, and alkyl phosphates.

[0041] As used herein, the term "safeners" refers to substances added to mixtures of pesticides to limit the formation of undesirable reaction products, e.g., alcohol sulfates, sodium alkyl butane diamate, polyesters of sodium thiobutane dioate, and benzene acetonitrile derivatives.

[0042] As used herein, the term "partially purified" means that the extract is in a form that is relatively free of proteins, nucleic acids, lipids, carbohydrates or other materials naturally associated in a plant.

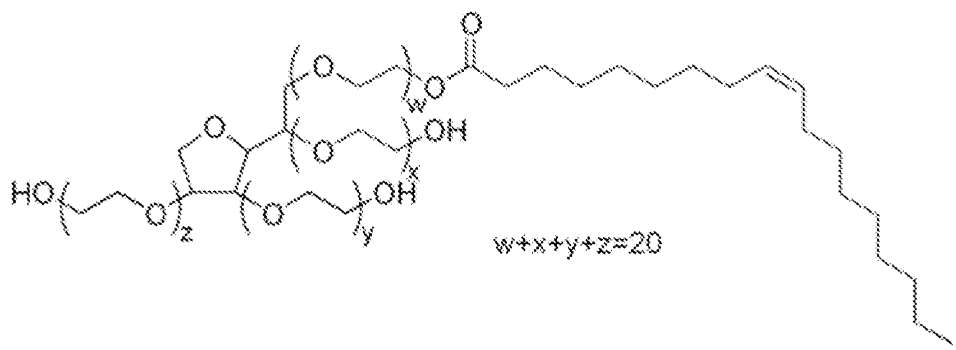
[0043] As used herein, the term "substantially pure" means that a compound or a combination of compounds is generally free of other compounds, as judged by standard analytical techniques. The compound or a combination of compounds may nevertheless contain minor amounts of other compounds, such as less than or equal to about 10% other compounds, less than or equal to about 9% other compounds, less than or equal to about 8% other compounds, less than or equal to about 7% other compounds, less than or equal to about 6% other compounds, less than or equal to about 5% other compounds, less than or equal to about 4% other compounds, less than or equal to about 3% other compounds, less than or equal to about 2%, less than about 1 %, less than about 0.2 %, less than about 0.1 %, less than about 0.05 %, less than about 0.01 % or less than about 0.005 % of other compounds. The term "at least substantially pure" means that a compound or a combination of compounds is generally free of other compounds, as judged by standard analytical techniques. The compound or combination of compounds may contain minor amounts of other compounds, but it may also be entirely free of other compounds, at least as judged by known analytical techniques. In one aspect, substantially pure compounds or at least substantially pure compounds are made synthetically and separated from their starting materials and/or other byproducts. In another aspect, a substantially pure compound or an at least substantially pure compound of interest (i.e., a target compound) is isolated from an organism, such as a plant or a microorganism, such that the isolated compound or compounds only contain minor amounts of non-target compounds.

[0044] As used herein, the term "emulsifier" refers to a substance which stabilises an emulsion, e.g., a surfactant.

[0045] As used herein, the term "surfactant" refers to a substance which serves as a wetting agent that lowers the surface tension of a liquid, allowing easier spreading, and lowers the interfacial tension between two liquids.

[0046] As used herein, the term "spreader/binder", or "spreader-sticker" refers to a substance which improves the performance of many biopesticides/pesticides by making them more resistant to rewetting and run off caused by rain and irrigation water.

[0047] As used herein, the term "Tween™" refers to a group of polysorbate surfactant whose stability and relative non-toxicity allows it to be used as a detergent and emulsifier in a number of domestic, scientific, pharmacological, agricultural applications. It is a polyoxyethylene derivative of sorbitan monolaurate, and is distinguished by length of the polyoxyethylene chain and the fatty acid ester moiety. For example, Tween™ 20 (a.k.a. polysorbate 20) is a chemical compound having the following structure:



[0048] As used herein, the phrase "insect repellent" refers to a substance applied to plant which discourages one or more insects (and arthropods in general) from contacting a plant, such as landing, climbing, or feeding on that plant.

[0049] As used herein, the verb "to comprise" as is used in this description and in the claims and its conjugations are used in its non-limiting sense to mean that items following the word are included, but items not specifically mentioned are not excluded. In addition, reference to an element by the indefinite article "a" or "an" does not exclude the possibility that more than one of the elements are present, unless the context clearly requires that there is one and only one of the elements. The indefinite article "a" or "an" thus usually means "at least one".

[0050] As used herein, the term "solvent" or "carrier" refers to a liquid or gas, or a mixture of two or more types of liquid or gas, that dissolve solid, liquid, or gaseous solute, resulting in a solution. The most common solvent is water. Most other commonly-used solvents are organic (carbon-containing) chemicals.

[0051] As used herein, the phrase "emulsifiable concentrate" refers to a liquid formulation in which the active ingredient(s) has been dissolved in oil or other solvents and an emulsifier has been added so that the formulation can be mixed with water or oil for spraying.

[0052] As used herein, the term "plant" refers to any living organism belonging to the kingdom Plantae (i.e., any genus/species in the Plant Kingdom). This includes familiar organisms such as but not limited to trees, herbs, bushes, grasses, vines, ferns, mosses and green algae. The term refers to both monocotyledonous plants, also called monocots, and dicotyledonous plants, also called dicots. Examples of particular plants include but are not limited to corn, potatoes, roses, apple trees, sunflowers, wheat, rice, bananas, tomatoes, opo, pumpkins, squash, lettuce, cabbage, oak trees, guzmania, geraniums, hibiscus, clematis, poinsettias, sugarcane, taro, duck weed, pine trees, Kentucky blue grass, zoysia, coconut trees, brassica leafy vegetables (e.g., broccoli, broccoli raab, Brussels sprouts, cabbage, Chinese cabbage (Bok Choy and Napa), cauliflower, cavalo, collards, kale, kohlrabi, mustard greens, rape greens, and other brassica leafy vegetable crops), bulb vegetables (e.g., garlic, leek, onion (dry bulb, green, and Welch), shallot, and other bulb vegetable crops), citrus fruits (e.g., grapefruit, lemon, lime, orange, tangerine, citrus hybrids, pummelo, and other citrus fruit crops), cucurbit vegetables (e.g., cucumber, citron melon, edible gourds, gherkin, muskmelons (including hybrids and/or cultivars of cucumis melons), water-melon, cantaloupe, and other cucurbit vegetable crops), fruiting vegetables (including eggplant, ground cherry, pepino, pepper, tomato, tomatillo, and other fruiting vegetable crops), grape, leafy vegetables (e.g., romaine), root/tuber and corm vegetables (e.g., potato), and tree nuts (almond, pecan, pistachio, and walnut), berries (e.g., tomatoes, barberries, currants, elderberryies, gooseberries, honeysuckles, mayapples, nannyberries, Oregon-grapes, see-buckthorns, hackberries, bearberries, lingonberries, strawberries, sea grapes, lackberries, cloudberries, loganberries, raspberries, salmonberries, thimbleberries, and wineberries), cereal crops (e.g., corn, rice, wheat, barley, sorghum, millets, oats, ryes, triticales, buckwheats, fonio, and quinoa), pome fruit (e.g., apples, pears), stone fruits (e.g., coffees, jujubes, mangos, olives, coconuts, oil palms, pistachios, almonds, apricots, cherries, damsons, nectarines, peaches and plums), vine (e.g., table grapes, wine grapes), fibber crops (e.g., hemp, cotton), ornamentals, to name a few. The plant may in some embodiments be a household/domestic plant, a greenhouse plant, an agricultural plant, or a horticultural plant. The plant may in some embodiments be an agricultural, a silvicultural and/or an ornamental plant, i.e., a plant which is commonly used in gardening, e.g., in parks, gardens and on balconies. Examples are turf, geranium, pelargonia, petunia, begonia, and fuchsia, to name just a few among the vast number of ornamentals. The term "plant" is also intended to include any plant propagules.

[0053] As used herein, the term "plant part" refers to any part of a plant including but not limited to the shoot, root, stem, seeds, stipules, leaves, petals, flowers, ovules, bracts, branches, petioles, internodes, bark, wood, tubers, pubescence, tillers, rhizomes, fronds, blades, pollen, stamen, fruit and the like. The two main parts of plants grown in some sort of media, such as soil, are often referred to as the "above-ground" part, also often referred to as the "shoots", and the "below-ground" part, also often referred to as the "roots".

[0054] The term "plant health" is intended to mean a condition of a plant that is determined by several aspects alone or in combination with each other. A first indicator for the condition of the plant is the yield, which is crop and/or fruit yield. The terms "crop" and "fruit" are to be understood as any plant product which is further utilized after harvesting, e.g., fruits in the proper sense, vegetables, nuts, grains, seeds, wood (e.g., in the case of silviculture plants), flowers (e.g., in the case of gardening plants, ornamentals) etc., that is anything of economic value that is produced by the plant. A second indicator for the condition of a plant is the plant vigour. The plant vigour becomes manifest in several aspects, too, some of which are visual appearance, e.g., leaf color, fruit color and aspect, amount of dead basal leaves and/or extent of leaf blades, plant weight, plant height, extent of plant verse (lodging), number, strongness and productivity of tillers or branches, panicles' length, seed set, extent of root system, strongness of roots, extent of nodulation, in particular of rhizobial nodulation, point of time of germination, emergence, crop establishment, flowering, grain maturity and/or senescence, protein content, sugar content and the like.

[0055] The methods of the present invention can be applied to any plant or any part of any plant grown in any type of media used to grow plants (e.g., soil, vermiculite, shredded cardboard, and water) or applied to plants or the parts of plants grown aerially, such as orchids or staghorn ferns. Application may for instance be applied by spraying, atomizing, vaporizing, scattering, dusting, watering, squirting, sprinkling, pouring or fumigating. As already indicated above, application may be carried out at any desired location where the plant of interest is positioned, such as agricultural, horticultural, forest, plantation, orchard, nursery, organically grown crops, turfgrass and urban environments. The application of the one or more terpene or terpenoid compound(s) effects up-regulation/down-regulation of genes involved in defense response pathways, when compared to gene expression in plants that are not being brought in contact with the respective one or more terpene or terpenoid compound(s). In some embodiments the one or more terpene or terpenoid compound(s) effect(s) up-regulation of genes associated with ethylene and jasmonic acid. In some embodiments the one or more terpene or terpenoid compound(s) effect(s) up-regulation of genes encoding Pathogenesis Related Proteins. In some embodiments the one or more terpene or terpenoid compound(s) down-regulate(s) genes associated with photosynthesis. In one embodiment the genes associated with photosynthesis are in one embodiment transiently down regulated.

[0056] The present invention provides methods of using one or more terpene or terpenoid compounds for enhancing the health of a plant, for promoting the growth of a plant and/or for improving fruit ripening. Application of the one or more terpene or terpenoid compounds provides enhanced plant health effects compared to the plant health effects of plants to which the one or more terpene or terpenoid compounds have not been applied. Application of the one or more terpene or terpenoid compounds provides improved growth effects compared to the growth of plants to which the one or more terpene or terpenoid compounds have not been applied. Application of the one or more terpene or terpenoid compounds provides enhanced fruit ripening compared to the growth of plants to which the one or more terpene or terpenoid compounds have not been applied.

[0057] In this context, it is noted that the invention is based on the surprising finding that terpenes or terpenoid compounds have a direct positive effect on plants such as enhancing the health of a plant, promoting the growth of a plant and/or improving fruit ripening. So far, terpene compounds present, for example, in extracts obtained from *Chenopodium ambrosioides*, as well as extracts that include natural terpenes isolated from *Chenopodium*, have been used for controlling established insect or mite infestations on plants. *See*, for example, U.S. Patent Publication Nos. 2003/0091657 and 2009/0030087; International Patent Publication Nos. WO 2001/067868 and WO 2004/006679; William Quarles (1992) Botanical Pesticides from Chenopodium, The IPM Practitioner Volume XIV, Number 2, 11 pages; and Lorenzo Sagrero-Nieves (Mar/Apr 1995) Volatile Constituents from the Leaves of *Chenopodium ambrosioides* L., J. Essent. Oil Res. 7:221-223, each of which is specifically incorporated by reference herein in its entirety. *See also* International Patent Publication No. WO 2010/144919 that discloses natural and/or simulated, synthetic, synergistic pesticidal compositions comprising terpenes, including extracts from *Chenopodium ambrosioides* near *ambrosioides*, and compositions based on those found in *Chenopodium ambrosioides* near *ambrosioides*.

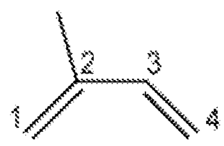
[0058] As used herein, the term "terpene" refers to a large and varied class of hydrocarbons, produced primarily by a wide variety of plants and by some insects. Terpenes, which are largely natural products, are built of isoprenoid and/or isopentenoid units. Some terpenes have a linear aliphatic backbone with methyl substituents defined by the individual isoprene units (see below). Some terpenes are branched aliphatic compounds. Some terpenes include one or more alicyclic moieties. Terpenes are the major components of resin, and or turpentine produced from resin. They are the primary constituents of the essential oils of many types of plants and flowers.

[0059] Terpenes can be classified according to the number of isoprenoid/ isopentenoid units included in the compound. In this regard a hemiterpene, i.e., isoprene or isopentene, has a single isoprenoid/ isopentenoid unit, while a monoterpene such as geraniol, limonene and terpineol, has two isoprenoid/ isopentenoid units, and a sesquiterpene, such as a farnesene or farnesol, includes three isoprenoid/ isopentenoid units. A diterpene such as cafestol, kahweol, cembrene and taxadiene includes four isoprenoid/ isopentenoid units. A sesterterpene such as geranylfarnesol has five isoprenoid/ isopentenoid units, a triterpene such as squalene includes six isoprenoid/ isopentenoid units and a tetraterpene, such as lycopene, gamma-carotene, an alpha- or a beta-carotene, includes eight isoprenoid/ isopentenoid units. Compounds that have more than eight isoprenoid/isopentenoid units can be referred to as polyterpenes.

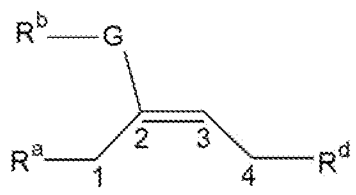
[0060] Terpenoids are likewise built of isoprenoid and/or isopentenoid units. The terms "terpenoid" is used in the art to clarify that the isoprenoid and/or isopentenoid structure underlying terpenes has been modified by oxidation of one or more methyl groups with an oxygen containing functional group (e.g., a hydroxyl, carbonyl, carboxyl or phosphate group), by removal of one or more methyl groups, or by shifting the position of one or more methyl groups. Terpenoids generally include an alicyclic moiety. Typically terpenoids have cyclic, in particular multicyclic structures. Cyclic structures included in a terpenoid may be alicyclic or aromatic structures. These lipids can be found in all classes of living things, and are the largest group of natural products. Accordingly, in some embodiments a terpenoid compound is a cyclic compound that is built by fusion of isoprene units, such as at least one, typically two or more isoprene units. Where only one isoprene unit is included in a ring terpenoid compound, the compound is built by fusion with a further moiety that includes an unsaturated bond, typically a double bond. Such an unsaturated bond may still be present in the ring terpenoid compound. In a ring terpenoid compound the respective isoprenoid unit(s) is/are part of a five- or six-membered ring. In addition, a ring terpenoid compound may include one or more further isoprenoid units that are not integrated into a ring. Several such rings may be fused to a bi-, tri-, tetra- or pentacyclic ring system. Ring terpenoid compounds have structures that differ both in terms of functional groups and side chains as well as in their basic carbon skeletons. Ring terpenoid compounds are produced primarily by a wide variety of plants and are included in e.g., fruits and vegetables, and are main constituents of inter alia odorants, essential oils, balsams, traditional herbal remedies, oleoresins of plants, biogenic metabolites with antimacrofouling and antifungal properties, and provide various classes of compounds such as steroids or cannabinoids.

[0061] Similar to terpenes, terpenoids can be classified according to the number of isoprenoid/isopentenoid units included in the compound. A hemiterpenoid such as prenol or isovaleric acid has a single of isoprenoid/isopentenoid unit. A monoterpenoid has two, a sesquiterpenoid three, a diterpenoid four, a sesterterpenoid five, a triterpenoid six, and a tetraterpenoid eight isoprenoid/isopentenoid units. A polyterpenoid has a higher number than eight isoprenoid/ isopentenoid units.

[0062] The term "isoprenoid" is derived from the name of the unsaturated branched hydrocarbon isoprene 2-methyl-1, 3-butadiene. An isoprenoid compound includes so called 'isoprene units' derived from isoprene:

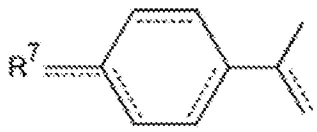


[0063] The integers indicate the numbering of the carbon atoms of isoprene. The same numbering will in the following also be used to address carbon atoms of an isoprene unit of an isoprenoid compound. The term "isoprenoid compound" as used herein refers to any compound that includes at least one isoprenoid unit, or at least two units selected from isoprenoid and isopentenoid units. In some embodiments within the isoprenoid compound one or more isoprene/isoprenoid units (as depicted above) - if present, typically at least two isoprene units - are acyclic moieties. Such an acyclic isoprene unit may include one double bond as follows:



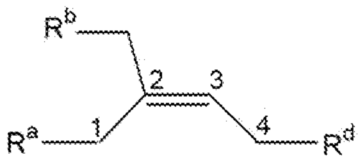
with G being C, Si, O, N, P, S, Se, or a halogen atom. R^a, R^b and R^d are independently selected from the group consisting of H, aliphatic, cycloaliphatic, aromatic, arylaliphatic, and arylcycloaliphatic groups (e.g., hydrocarbyl groups). A respective aliphatic, cycloaliphatic, aromatic, arylaliphatic or arylcycloaliphatic group is typically of a main chain length of 1 to about 10, to about 15 or to about 20 carbon atoms. Each of R^a to R^d may for example include 0 to about 3 heteroatoms (i.e., atoms that differ from carbon) selected from the group N, O, S, Se and Si. Isoprenoid compounds with such acyclic moieties are particularly suitable for the method of the present invention.

[0064] In some embodiments isoprene/isoprenoid units are included in a cyclic moiety, such as a hexacyclic moiety, e.g., a cycloheaxane ring, a cyclohexene ring or a cyclohexadiene ring. In case of a monoterpene, such as a terpinene, cymene or limonene, or a monoterpenoid compound, a monocyclic compound may be of the structure



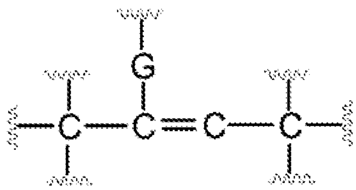
wherein "''" represents a single or a double bond. R^7 may be H, an aliphatic, cycloaliphatic, an aromatic, an arylaliphatic, an arylcycloaliphatic group or a functional group comprising a heteroatom (e.g., N, O, S, Se, halogen or Si) such as a hydroxyl group, a carbonyl group, a carboxyl group, an amino group, an amido group or a phosphate group. In some embodiments a monoterpene or monoterpenoid has a bicyclic structure, such as e.g., pinene.

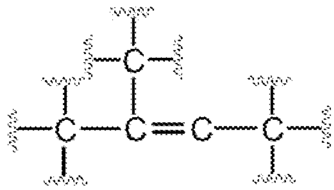
[0065] In this regard the term "isoprenoid unit" as used herein also includes moieties in which the methylene group that is bond to carbon atom No. 2 of isoprene (see above), is replaced by another atom such as Si, O, N, S, Se, a halogen atom or P, or in which the respective side chain of isoprene includes a heteroatom. This fact is indicated by the moiety G in above representation of an isoprenoid unit. In embodiments where moiety G is a methylene group (i.e., unsubstituted carbon, $-CH_2-$), an isoprenoid unit may be depicted as:

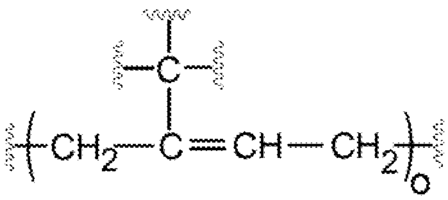


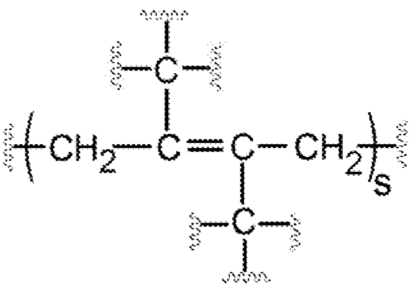
with R^a, R^b and R^d as defined above. As also explained below, the term "isoprenoid unit" refers to any configuration and/or conformation of bonds or centers of the respective unit, alone or when viewed within the entire isoprenoid compound used in the method of the invention.

[0066] Where a plurality of isoprene units is present within a respective isoprenoid compound, they may be directly connected to each other or separated by further moieties. In typical embodiments of the method of the invention, the isoprene units of the isoprenoid compound are directly connected to each other. As a few illustrative examples, an isoprenoid compound may include a structure as represented by one of the four following general formulas (Ia), (Ib), (VIc) and (VId):

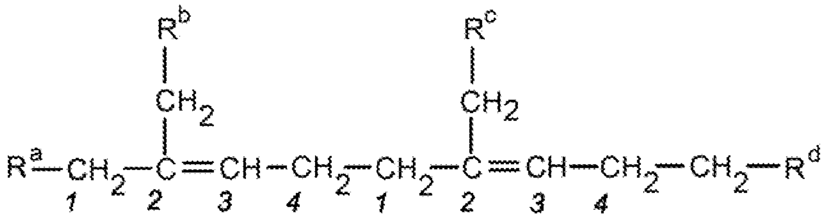
(Ia) 

(Ib) 

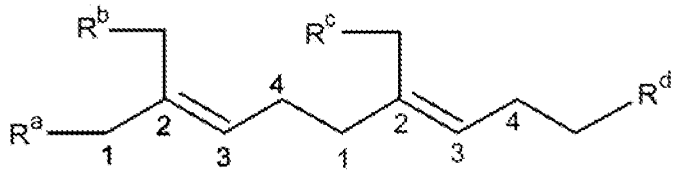
(Ic) 

(Id) 

wherein o and s in formulas (Ic) and (Id), respectively, are an integer from 1 to about 6, such as for example 2, 3, 4 or 5. G in formula (Ia) may be, as indicated above, C, Si, O, N, P, S, Se, or a halogen atom. Where applicable, the respective double bond of an isoprenoid compound may be of the E-(trans-) or the Z-(cis-)configuration. The isoprenoid compound may carry various substituents. As an illustrative example, an isoprenoid compound of two isoprenoid units may include a structure as represented by the following general formulas (Ie) and (If):

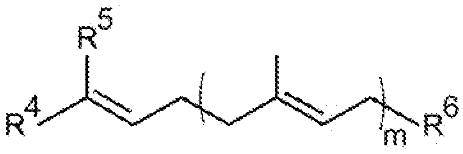
(Ie) 

in which the numberings of the carbon atoms of each isoprenoid unit (cf. above) are indicated in italic letters below the respective carbon atoms of the isoprenoid compound, and:

(If) 

wherein R^a to R^d in formulas (Ie) and (If) may be H, an aliphatic, cycloaliphatic, aromatic, arylaliphatic, or arylcycloaliphatic group (e.g. a hydrocarbyl group) or a functional group. Each of R^a to R^d may for example include 0 to about 3 heteroatoms (i.e., atoms that differ from carbon) selected from the group N, O, S, Se and Si. A respective functional group may be a halogen, hydroxyl-, thiol-, seleno-, carboxyl-, amino-, imino-, amido-, imido-, azido-, diazo-, cyano-, isocyano-, nitro-, nitroso-, sulfo-, sulfido-, sulfonyl-, or silyl-group. If any one or more of R^a to R^d are an aliphatic, cycloaliphatic, aromatic, arylaliphatic, or arylcycloaliphatic moiety, it/they may also include other polar, non-polar, saturated or unsaturated groups, including for example an epoxy group or 0 to about 3 heteroatoms selected from the group N, O, S, Se and Si.

[0067] A respective isoprenoid compound may for example be of the general formula (II):



wherein R^4 to R^6 may be are an independently selected aliphatic, cycloaliphatic, aromatic, arylaliphatic, or arylcycloaliphatic moiety, typically with a main chain of a length of 1 to about 20 carbon atoms. R^4 to R^6 may for example include 0 to about 3, such as one or two, heteroatoms selected from the group N, O, S, Se and Si.

[0068] The term "aliphatic" means, unless otherwise stated, a straight or branched hydrocarbon chain, which may be saturated or mono- or poly-unsaturated and include heteroatoms (see below). An unsaturated aliphatic group contains one or more double and/or triple bonds (alkenyl or alkinyl moieties). The branches of the hydrocarbon chain may include linear chains as well as non-aromatic cyclic elements. The hydrocarbon chain, which may, unless otherwise stated, be of any length, and contain any number of branches. Typically, the hydrocarbon (main) chain includes 1 to 5, to 10, to 15 or to 20 carbon atoms. Examples of alkenyl radicals are straight-chain or branched hydrocarbon radicals which contain one or more double bonds. Alkenyl radicals normally contain about two to about twenty carbon atoms and one or more, for instance two, double bonds, such as about two to about ten carbon atoms, and one double bond. Alkynyl radicals normally contain about two to about twenty carbon atoms and one or more, for example two, triple bonds, such as two to ten carbon atoms, and one triple bond. Examples of alkynyl radicals are straight-chain or branched hydrocarbon radicals which contain one or more triple bonds. Examples of alkyl groups are methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, the n isomers of these radicals, isopropyl, isobutyl, isopentyl, sec-butyl, tert-butyl, neopentyl, 3,3-dimethyl-butyl. Both the main chain as well as the branches may furthermore contain heteroatoms as for instance N, O, S, Se or Si or carbon atoms may be replaced by these heteroatoms.

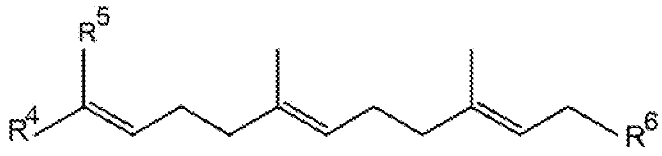
[0069] The term "alicyclic" means, unless otherwise stated, a non-aromatic cyclic moiety (e.g., hydrocarbon moiety), which may be saturated or mono-or poly-unsaturated. The cyclic hydrocarbon moiety may also include fused cyclic ring systems such as decalin and may also be substituted with non-aromatic cyclic as well as chain elements. The main chain of the cyclic hydrocarbon moiety may, unless otherwise stated, be of any length and contain any number of non-aromatic cyclic and chain elements. Typically, the hydrocarbon (main) chain includes 3, 4, 5, 6, 7 or 8 main chain atoms in one cycle. Examples of such moieties include, but are not limited to, cylcopentyl, cyclohexyl, cycloheptyl, or cyclooctyl. Both the cyclic hydrocarbon moiety and, if present, any cyclic and chain substituents may furthermore contain heteroatoms, as for instance N, O, S, Se or Si, or a carbon atom may be replaced by these heteroatoms. The term "alicyclic" also includes cycloalkenyl moieties that are unsaturated cyclic hydrocarbons, which generally contain about three to about eight ring carbon atoms, for example five or six ring carbon atoms. Cycloalkenyl radicals typically have a double bond in the respective ring system. Cycloalkenyl radicals may in turn be substituted.

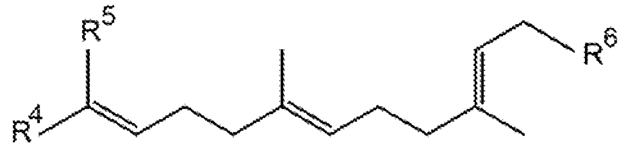
[0070] The term "aromatic" means, unless otherwise stated, a planar cyclic hydrocarbon moiety of conjugated double bonds, which may be a single ring or include multiple fused or covalently linked rings, for example, 2, 3 or 4 fused rings. The term aromatic also includes alkylaryl. Typically, the hydrocarbon (main) chain includes 5, 6, 7 or 8 main chain atoms in one cycle. Examples of such moieties include, but are not limited to, cyclopentadienyl, phenyl, napthalenyl-, [10]annulenyl-(1,3,5,7,9-cyclodecapentaenyl-), [12]annulenyl-, [8]annulenyl-, phenalene (perinaphthene), 1,9-dihydropyrene, chrysene (1,2-benzophenanthrene). An example of an alkylaryl moiety is benzyl. The main chain of the cyclic hydrocarbon moiety may, unless otherwise stated, be of any length and contain any number of heteroatoms, as for instance N, O and S. Examples of such heteroaromatic moeities (which are known to the person skilled in the art) include, but are not limited to, furanyl-, thiophenyl-, naphthyl-, naphthofuranyl-, anthrathiophenyl-, pyridinyl-, pyrrolyl-, quinolinyl, naphtha-quino-linyl-, quinoxalinyl-, indolyl-, benzindolyl-, imidazolyl-, oxazolyl-, oxoninyl-, oxepinyl-, benzoxepinyl-, azepinyl-, thiepinyl-, selenepinyl-, thioninyl-, azecinyl- (azacyclo-deca-pen-ta-enyl-), diazecinyl-, azacyclododeca-1,3,5,7,9,11-hexaene-5,9-diyl-, azozinyl-, diazo-cinyl-, benzazocinyl-, azecinyl-, azaundecinyl-, thia[11]annulenyl-, oxacyclotrideca-2,4,6,8,10,12-hexaenyl- or triazaanthracenyl-moieties.

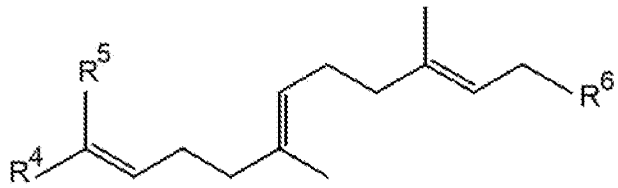
[0071] By the term "arylaliphatic" is meant a hydrocarbon moiety, in which one or more aromatic moieties are substituted with one or more aliphatic groups. Thus the term "arylaliphatic" also includes hydrocarbon moieties, in which two or more aryl groups are connected via one or more aliphatic chain or chains of any length, for instance a methylene group. Typically, the hydrocarbon (main) chain includes 5, 6, 7 or 8 main chain atoms in each ring of the aromatic moiety. Examples of arylaliphatic moieties include, but are not limited, to 1-ethyl-naphthalene, 1,1'-methylenebis-benzene, 9-isopropylanthracene, 1,2,3-trimethyl-benzene, 4-phenyl- 2-buten-1-ol, 7-chloro-3-(1-methylethyl)-quinoline, 3-heptyl-furan, 6-[2-(2,5-diethylphenyl)ethyl]-4-ethyl-quinazoline or, 7,8-dibutyl-5,6-diethyl-iso-quinoline.

[0072] Each of the terms "aliphatic", "alicyclic", "aromatic" and "arylaliphatic" as used herein is meant to include both substituted and unsubstituted forms of the respective moiety. Substituents may be any functional group, as for example, but not limited to, amino, amido, azido, carbonyl, carboxyl, cyano, isocyano, dithiane, halogen, hydroxyl, nitro, organometal, organoboron, seleno, silyl, silano, sulfonyl, thio, thiocyano, trifluoromethyl sulfonyl, p-toluenesulfonyl, bromobenzenesulfonyl, nitrobenzenesulfonyl, and methane-sulfonyl.

[0073] With regard to the configuration of the double bonds included in the isoprenoid compound, these may exist in Z- and/or E-configurations. In the method of the present invention the isoprenoid compound may include either of these configurations. Regardless of the configuration of double bonds included in the isoprenoid compound, carrying out the process according to the present invention results in a cyclisation and formation of a multiple ring compound. As an illustrative example, where in formula (II) m = 2, the following compounds are equally well suited for the purposes of the present invention:







[0074] As already indicated above, the term "isoprenoid compound" as used herein, thus refers to all respective isomers of for instance general formulas (Ia) to (Ie) or general formula (II).

Compositions used in the Present Invention

[0075] A composition used in the present invention includes at least one active ingredient in the form of an isoprenoid and/or isopentenoid compound. In some embodiments, the composition further includes one or more carrier(s)/solvent(s). A respective composition may also include an emulsifier, a spreader and/or a sticking agent, to enable application of the composition to a specific environment.

[0076] In one embodiment, the composition further includes at least one carrier/solvent, at least one adjuvant, wherein the adjuvant is selected from the group consisting of emulsifier, spreader/binder, penetrants, safeners, anticaking agents, and mixture of thereof. In some embodiments the active ingredient present in the composition is a combination of three terpenes, α-terpinene, p-cymene and limonene. The three terpenes in the compositions used in the present invention can be obtained from any source such as, for example, as an extract from *Chenopodium ambrosioides* near *ambrosioides*, which extract has insecticidal and acaricidal activity, as described in detail in U.S. Patent Publication Nos. 2003/0091657 and 2009/0030087;

International Patent Publication Nos. WO 2001/067868 and WO 2004/006679, or as an extract from another plant genus/species that produces such terpenes, or as a compound produced naturally by any organism (i.e., as a compound separate from an extract per se), or produced synthetically (i.e., by a chemical synthesis process). The active ingredients included in an extract from *Chenopodium ambrosioides* near *ambrosioides* have been recognized in the human medicinal pharmacopeia for centuries. Such extract and a simulated blend of such extract, one example of which is set forth as Composition 1 in Example 1, are contact active insecticides that control whiteflies, aphids, mites, thrips and other pests frequently found in high-value agronomic crops.

[0077] The primary mode of action of Composition 1 is based on the effects of emulsified essential oils on the insect exoskeleton, the intersegmental membranes, and chemoreceptors associated with locomotion and plant host identification. Laboratory and field studies suggest that secondary effects of Composition 1 include reduced host plant probing by homoptera, reduced incidence of vectored plant pathogenic viruses, and induction of plant secondary defense response. To understand the effect of Composition 1 as an illustrative example for a composition containing one or more terpene or terpenoid compounds on plant host response the present inventors isolated tomato plants and made repeated applications of Composition 1 using conventional agronomic spray intervals. Transcriptional profiling (Ilumina mRNA seq) was used to compare treated to untreated plants at several different life stages. In one experiment over 37 million 68-bp reads were barcoded to distinguish the reads from each treatment in the experiment. Sequence reads were aligned to the latest mRNA DB published by the International Tomato Genome Sequencing Project. Composition 1 caused significant increases in several key defense response pathways. Genes associated with ethylene and jasmonic acids production were up regulated as were a number of Pathogenesis Related Proteins. Genes associated with photosynthesis were transiently down regulated. QRT-PCR confirmed some, but not all of the RNA-seq observations.

[0078] As an example, the three terpenes α-terpinene, p-cymene and limonene can be from natural extracts obtained from *Chenopodium ambrosioides* near *ambrosioides*, natural analogs of such terpenes as extract from other plant species or other organisms, or synthetic versions of the terpenes, or combination thereof. Thus in one embodiment, the active ingredient in the present invention is the essential oil extract of *Chenopodium ambrosioides* near *ambrosioides*. In another embodiment, the active ingredient is a simulated blend simulating the essential oil extract of *Chenopodium ambrosioides* near *ambrosioides*. In still another example, the active ingredient is a combination of the essential oil extract of *Chenopodium ambrosioides* near *ambrosioides* and the simulated blend.

[0079] As mentioned above, *Chenopodium ambrosioides* near *ambrosioides* plants, methods of preparing, harvesting and storage of such plants, methods of extracting essential oil, and composition of said essential oil, have been described elsewhere. *See*, for example, US Patent Publication Nos. 2003/0091657 and 2009/0030087; International Patent Publication Nos. WO 2001/067868 and WO 2004/006679; and Lorenzo Sagrero-Nieves (Mar/Apr 1995) Volatile Constituents from the Leaves of *Chenopodium ambrosioides* L., J. Essent. Oil Res. 7:221-223, each of which is incorporated by reference in its entirety herein, including all drawings/photographs that are a part thereof. As an example, the isoprenoid/isopentenoid compounds in the extract may be α-terpinene, p-cymene and limonene.

[0080] The essential oil extract of *Chenopodium ambrosioides* near *ambrosioides* consists mainly of α-terpinene, p-cymene, limonene, and of other minor terpene constituents, which may include carvacrol, L-carveol (43% cis+ 54% trans), thymol, and γ-terpinene, which are pesticidal and are present at low levels. Example II of International Patent Publication No. WO 2004/006679 notes that these minor components are likely to have a much greater impact on the activity of the oil than the major components. Even though it has been shown in WO 2010/144919 that the three pesticidally active chemical compounds in the essential oil extract are α-terpinene, p-cymene and limonene and that the minor components are not necessary for this insecticidial activity, all terpene compounds such as α-terpinene, p-cymene, limonene, carvacrol, L-carveol, thymol, and γ-terpinene can be used in the present invention to enhance plant growth and plant health as well as fruit ripening. Any enantiomer of limonene will work in the methods of the present invention, including but not limited to d-limonene.

[0081] Essential oil extracts of *Chenopodium ambrosioides* may contain substantial quantities of the bicyclic monoterpene ascaridole, depending on the cultivar and the growing conditions. Because of concerns over mammalian toxicity of this compound, it might be desirable in certain embodiments to reduce or eliminate ascaridole from a composition used as described herein to enhance worker safety and to minimize ingestion of the compound after application of the product to fruits, vegetables or grains. The *C. ambrosioides* near *ambrosioides* cultivar was originally selected for its relatively low levels of ascaridole. In addition, as ascaridole can be physically removed or chemically converted to another product. Processes for physical removal include molecular distillation or supercritical CO_2 extraction. These methods lead to a near quantitative extraction of ascaridole from the essential oil. Chemical reduction methods have also been employed to convert ascaridole to the corresponding and relatively non-toxic 2,3 cis diol.

[0082] In one example, the concentration of α-terpinene in the extract of *Chenopodium ambrosioides* ranges from about 35% to about 45%, by weight. The concentration of p-cymene in the extract of *Chenopodium ambrosioides* ranges from about 15% to about 25%, by weight. The concentration of limonene in the extract of *Chenopodium ambrosioides* ranges from about 5% to about 15%, by weight. The concentration of minor terpene constituents and impurities in the extract of *Chenopodium ambrosioides* ranges from about 25% to about 35%, by weight. For a non-limiting example, in one extract, the concentrations (by weight) are as follows: 39% α-terpinene, 17% p-cymene, 12% limonene and 32% minor terpene constituents and impurities, by weight.

[0083] The concentration of the essential oil extract in the composition to be applied to plants and plant parts, depending on whether it is in the concentrated or diluted (ready-to-spray) form, can be at least about 0.01%, about 0.02%, about 0.03%, about 0.04%, about 0.05%, about 0.06%, about 0.07%, about 0.08%, about 0.09%, about 0.1%, about 0.2%, about 0.3%, about 0.4%, about 0.5%, about 0.6%, about 0.7%, about 0.8%, about 0.9%, about 1%, about 2%, about 3%, about 4%, about 5%, about 6%, about 7%, about 8%, about 9%, about 10%, about 11%, about 12%, about 13%, about 14%, about 15%, about 16%, about 17%, about 18%, about 19%, about 20%, about 21%, about 22%, about 23%, about 24%, about 25%, about 26%, about 27%, about 28%, about 29%, about 30%, about 31%, about 32%, about 33%, about 34%, about 35%, about 36%, about 37%, about 38%, about 39%, about 40%, about 41%, about 42%, about 42%, about 43%, about 44%, about 45%, about 46%, about 47%, about 48%, about 49%, about 50%, about 51%, about 52%, about 53%, about 54%, about 55%, about 56%, about 57%, about 58%, about 59%, about 60%, about 61%, about 62%, about 63%, about 64%, about 65%, about 66%, about 67%, about 68%, about 69%, about 70%, about 71%, about 72%, about 73%, about 74%, about 75%, about 76%, about 77%, about 78%, about 79%, about 80%, about 81%, about 82%, about 83%, about 84%, about 85%, about 86%, about 87%, about 88%, about 89%, about 90%, about 91%, about 92%, about 93%, about 94%, about 95%, about 96%, about 97%, about 98%, about 99%, or about 100%, by weight.

[0084] For example, in some embodiments the final concentration of the extract in the composition to be applied to plants is about 0.05%, or about 0.1%, or about 0.2% or about 0.7%, by weight.

[0085] Formulations containing the essential oil extracts used in the present invention can be prepared by known techniques to form emulsions, aerosols, sprays, or other liquid preparations, dusts, powders or solid preparations. These types of formulations can be prepared, for example, by combining with pesticide dispersible liquid carriers and/or dispersible solid carriers known in the art and optionally with carrier vehicle assistants, e.g., conventional pesticide surface-active agents, including emulsifying agents and/or dispersing agents. The choice of dispersing and emulsifying agents and the amount combined is determined by the nature of the formulation, the intended form of application of the formulation to a specific environment (e.g., plant, animal, soil, building), and the ability of the agent to facilitate the dispersion of the essential oil extract of the present invention while not significantly diminishing the strengthening effect on the health of a plant, on the growth of a plant, and/or on fruit ripening of the essential oil extract (cf. also below).

[0086] In some embodiments a formulation used according to the present invention may be prepared as a microemulsion. Microemulsions are low-viscosity, optically transparent dispersions of two immiscible liquids which are stabilized by at least one ionic or nonionic surfactant. In the case of microemulsions, the particle diameters are in the range from about 5 to about 100 nm, suspended in a continuous phase. The interfacial tension between the two phases is extremely low. The viscosity of many microemulsions of the oil and water type (O/W) is comparable to that of water. In contrast thereto, a "macroemulsion" has a high viscosity. The particle diameter of a macroemulsion is in the range from about 10 to about 100 micrometers. Macroemulsions are milky white in color and, upon heating, tend toward phase separation or toward sedimentation of the dispersed substances. It is believed that the small size of the emulsion droplets of a microemulsion may allow for better transport of the components included therein through plant cell membranes, so that the use of a microemulsion may in some embodiments be advantageous. Further, microemulsions are considered to be infinitely stable, thereby providing improved stability when compared to traditional macroemulsion systems. Therefore, in the context of the present invention the use of a microemulsion formulation of may be particularly suitable for certain applications, for example soil delivery.

[0087] The present invention also provides compositions of simulated terpene blends which simulate the essential oil extract of *Chenopodium ambrosioides* near *ambrosioides*. The simulated terpene blends of the present invention may comprise α-terpinene, p-cymene, and limonene at concentrations that are the same or about the same as their respective concentrations in extracts of *Chenopodium ambrosioides* near *ambrosioides*, wherein such extracts include additional minor terpene ingredients and impurities not present in the simulated blends of the present invention. Greenhouse and field testing unexpectedly demonstrates that there are no material differences in performance and/or plant safety between the simulated terpene blends of the present invention and the extract of *Chenopodium ambrosioides* near *ambrosioides* when used at the same rates or at about the same rates. The present invention also provides the use of a simulated blend of three terpenes, which also successfully mimics the pesticidal/insecticidal effects of extracts of *Chenopodium ambrosioides* near *ambrosioides*.

[0088] In some embodiments the simulated terpene blend of the present invention only includes three active terpene compounds (α-terpinene, p-cymene, and limonene) that when combined with inerts (carrier/solvent, emulsifier, and/or spreader/binder) are sufficient to mimic the pesticidal effects of the extract of *Chenopodium ambrosioides* near *ambrosioides*. Thus, in some embodiments, the terpene blends of the present invention do not contain the minor terpene ingredients and impurities found in the *Chenopodium ambrosioides* near *ambrosioides* extract, such as thymol, carvacrol, carvone, carveol and/or nerol, wherein one or more of such minor terpenes may have insecticidal activity. In one embodiment, the simulated blend does not contain thymol, carvacrol, carvone, carveol and/or nerol. In one embodiment, the terpenes of the simulated terpene blend are not obtained from *Chenopodium ambrosiodes*. In another embodiment, they are not obtained from *Chenopodium*.

[0089] Simulated blends simulating the *Chenopodium* extract can be made according to the present invention by mixing together three at least substantially pure isoprenid compounds, α-terpinene, p-cymene and limonene, optionally with at least one volume filler, for example, vegetable oil (e.g., food grade), or mineral oil that replaces the volume taken up by the minor components normally present in the extract.

[0090] As used herein, the term "vegetable oil" refers to lipid materials derived from plants, which do not contain, or only contain trace amount of fragrances or essential oils, such that the materials are non-volatile, non-scented plant oils. Thus, as used herein, a vegetable oil is not prepared by method of distillations, which are usually utilized to prepare fragrances and/or essential oils. Instead, vegetable oil is typically extracted from plants by chemical extraction and/or physical extraction. Chemical extraction comprises using a chemical agent as a solvent to extract vegetable oils from plant. A common solvent is hexane, which can be derived from petroleum. Another way is physical extraction, which does not use solvent extracts. Physical extraction involves what is known as the "traditional" way by using several different types of mechanical extraction. Expeller-pressed extraction is one type, and there are two other types that are both oil presses: the screw press and the ram press. A vegetable oil can be saturated or unsaturated, and can be edible or inedible. Examples of vegetable oils include, but are not limited to, canola oil, sunflower oil, safflower oil, peanut oil, bean oil, including soybean oil, linseed oil, tung oil, olive oil, corn oil, sesame oil, cumin oil, peanut oil, and castor oil. In one embodiment, vegetable oil is extracted from a whole plant, or from a plant part (e.g., seeds).

[0091] α-terpinene, p-cymene and limonene are publicly available to those skilled in the art, can be produced synthetically using known methods, or can be purified from various plant extracts, as described in more detail below. In addition, all three of these terpenes are commercially available (e.g., Sigma-Aldrich®, Acros Organics, MP Biomedicals, Merck Chemicals). The concentration of each isoprenoid/isopentenoid compound is described below in the composition section. Unless otherwise noted, the percentages provided below reflect the percentage of each terpene present in the simulated blend, and exclude any impurities present in each of these substantially pure compounds. For example, if the simulated blend contains alpha-terpinene that is 90% pure, the percentage shown below reflects the amount of pure alpha-terpinene that is included in the composition, excluding the 10% impurities. Therefore, if such simulated blend constitutes 40% alpha-terpinene, the substantially pure alpha-terpinene used to prepare the blend is about 44%, with 40% alpha-terpinene and 4.4% impurities.

[0092] Methods for synthesizing or purifying the terpenes in the simulated blend are well known to those of skill in the art. Each of the terpene components of the simulated blend may be obtained by chemical synthesis or from a plant extract. For example, α-terpinene may be obtained from acid isomerization of terpinolene. P-cymene may be obtained by disproportionation of dipentene or by dehydration of camphor. In addition, p-cymene may be obtained from limonene, as described in Martin-Luengo, M.A., et al. "Synthesis of P-cymene from Limonene, a Renewable Feedstock," Applied Catalysis B: Environmental (June 24, 2008), 81(3-4), 218-224. The term chemical synthesis, as used herein, includes synthesis using a plant extract as a starting material. For example, as described above, p-cymene may be obtained from limonene. In turn, the limonene starting material may be obtained from a citrus extract. The terpene components of the simulated blend may all be obtained by chemical synthesis or all from one or more non-Chenopodium plant extracts, or some components may be made by chemical synthesis and others obtained from non-Chenopodium plant extracts. In one embodiment, the α-terpinene and the p-cymene are synthetically produced and the limonene is derived from a plant extract.

[0093] Numerous plant species produce terpenes, some of which produce the terpene compounds utilized in the methods of the present invention.

[0094] At least the following plant species produce α-terpinene: *Anethum graceolens, Artemisia argyi, Cuminum cyminum, Elettaria cardomonum, Melaleuca alternifolia, Cardamom spp.* and *Origanum majorana.*

[0095] At least the following plant species produce limonene, including d-limonene: *Anethum graceolens, Anethum sowa, Carum carvi, Citrus, Foeniculum vulgare, Mentha piperita* and *Peppermint.* Limonene may be obtained by steam distillation after alkali treatment of citrus peels and pulp, and also by the fractionation of orange oil.

[0096] At least the following plant species produce p-Cymene: *Coridothymus sativum, Coridothymus captitatus, Cuminum cyminum, Origanum vulgare* and *Thymus vulgaris.*

[0097] For additional information on plants that produce terpene, *see*, for example, Paul Harrewijn et al., *Natural Terpenoids as Messengers: A Multidisciplinary Study of Their*

Production, Biological Functions, and Practical Applications, Published by Springer, 2001 (ISBN 0792368916, 9780792368915); Paul M. Dewick, *Medicinal Natural Products: A Biosynthetic Approach*, Published by John Wiley and Sons, 2009 (ISBN 0470741678, 9780470741672); Ronald Hunter Thomson, *The Chemistry of Natural Products*, Published by Springer, 1993 (ISBN 0751400149, 9780751400144); and Leland J. Cseke et al., *Natural Products from Plants*, Published by CRC Press, 2006, (ISBN 0849329760, 9780849329760), each of which is incorporated by reference herein in its entirety.

[0098] In one embodiment, essential oils, and/or certain fractions of essential oils (e.g., certain terpenes) can be extracted from a plant by distillation. As used herein, "Essential Oil Extract" means the volatile, aromatic oils obtained by steam or hydro-distillation of plant material and may include, but are not restricted to, being primarily composed of terpenes and their oxygenated derivatives. Essential oils can be obtained from, for example, plant parts including, for example, flowers, leaves, seeds, roots, stems, bark, wood, etc. A variety of strategies are available for extracting essential oils from plant material, the choice of which depends on the ability of the method to extract the constituents in the extract of the present invention. Examples of suitable methods for extracting essential oil extracts include, but are not limited to, hydro-distillation, direct steam distillation (Duerbeck, K., et al., (1997), *The Distillation of Essential Oils. Manufacturing and Plant Construction Handbook*, Protrade: Dept. of Foodstuffs and Agricultural Products, Eschborn, Germany, pp. 21-25.), Solvent Extraction, and Microwave Assisted Process (MAPTM) (Belanger et al., (1991) Extraction et Determination de Composes Volatils de L'ail (Allium sativum), Riv. Ital. EPPOS 2: 455-461.). Detailed distillation methods have been described in WO 2001/067868 and WO 2004/006679, which are incorporated by reference in their entireties.

[0099] In one embodiment, a volume filler is added to the terpenes in the simulated blend to replace the minor terpene components of the Chenopodium plant extract. The volume filler is a compound that mixes well with terpenes and creates a good suspension of terpenes, may be inert or have some insecticidal activity, and does not cause phytotoxicity. The excipients described below may serve as both excipients and volume fillers.

[0100] In one aspect of the invention, the concentration of the isoprenoid/isopentenoid compounds in the simulated blend are about the same as their respective concentrations in the extract of *Chenopodium ambrosioides* near *ambrosioides*, and the fraction of volume composed by filler is about the same as that of the minor terpene constituents and impurities in such *Chenopodium* extract. In such embodiment, the relative percentages of the active ingredient (i.e., the three major terpenes) and volume filler (replacing the minor terpene constituents) can vary within certain ranges.

[0101] In one embodiment, the concentration of α-terpinene in the simulated blend ranges from about 30% to about 70%, by weight; the concentration of p-cymene in the simulated blend ranges from about 10% to about 30%, by weight; and the concentration of limonene in the simulated blend ranges from about 1% to about 20%, by weight. For example, the concentration of α-terpinene in the simulated blend ranges from about 32% to about 50%, by weight. The concentration of p-cymene in the simulated blend ranges from about 12.5% to about 20%, by weight. The concentration of limonene in the simulated blend ranges from about 9% to about 15%, by weight. The concentration of volume filler ranges from about 15% to about 47%, by weight. As noted above, the above percentages reflect pure compounds. Use of substantially pure compounds is also contemplated and described herein, and substantially pure compounds, as described above, may have impurities, which would increase the percentage of substantially pure compound in the mixture. For example, the range of concentrations, by weight, of substantially pure terpenes in the simulated blend may range from about 33% to about 78% α-terpinene and from about 11% to about 33% p-cymene and from about 1.1% to about 22% limonene. The other ranges would also increase similarly, and may increase by about 10%, in the case of use of substantially pure compounds. As explained further herein elsewhere, these concentrations represent the concentrations of the terpenes in a concentrated composition that is typically diluted for application to plants and/or the areas around plants or to any other area where control is desired. In one embodiment, the extract is mixed with other components (e.g., carrier, emulsifier, spreader-sticker) to produce a formulated product, wherein the extract is about 1%, about 5%, about 10%, about 15%, about 20%, about 25%, about 30%, about 35%, about 40%, about 45%, about 50%, about 55%, about 60%, about 65%, about 70%, about 75%, about 80%, about 85%, about 90%, or about 95% of the formulated product, by weight. For example, the extract is about 25% of the formulated product, by weight. In such a formulated product, the concentration of α-terpinene ranges from about 8.75% to about 10.25%, by weight;

the concentration of p-cymene ranges from about 3.75% to about 6.25%, by weight; the concentration of limonene ranges from about 1.25% to about 3.75%, by weight.

[0102] In another embodiment, the concentration of each isoprenoid/isopentenoid compound can be higher or lower than the one in the essential oil extract, but roughly maintaining relative ratio to each others as in the essential oil extract. For non-limiting example, the relative ratio of α-terpinene, p-cymene, and limonene is about 39:17:12, or about 40:15:12, or about 36:14.9:11.4, or about 10.175:3.9: 3.05. In some other embodiments, the range of α-terpinene in the relative ratio may be about 30 to about 50, the range of p-cymene in the relative ratio may be about 10 to about 20, and the range of limonene in the relative ratio may be about 5 to about 20; i.e., 30-50:10-20:5-20. Still in some other embodiments, the relative ratio of α-terpinene, p-cymene, and limonene is about 35 to about 45 for α-terpinene, about 12 to about 18 for p-cymene and about 10 to about 15 for limonene. One skilled in the art will be able to determine the actual ratio of each terpene in a blend according to the relative ratios. For example, the synthetic blend can consist of: between about 35% and about 45% by weight of α-terpinene, between about 15% and about 25% by weight of p-cymene, between about 5% and about 15% by weight of limonene, and between about 0% and 99.715% by weight of volume filler wherein the relative ratio among these three terpenes is selected from the group consisting of about 39:17:12, or about 40:15:12, or about 36:14.9:11.4, or about 10.175:3.9:3.05 or about 35-45:12-18:10-15. In addition, no matter what concentrations of α-terpinene, p-cymene, limonene are in a composition, the relative ratio among these three terpenes may be within the ranges set forth above in this paragraph.

[0103] In one embodiment, the relative amounts by weight of the natural and/or synthetic terpenes and of the fillers in the composition are as follows: about 36% α-terpinene, about 15% p-cymene, about 11% limonene and about 33% solvent (e.g., vegetable oil), by weight. The percentages in this embodiment do not total 100% because the terpenes used are substantially pure and contain some impurities. For example, in one embodiment, the alpha-terpinene is 90% pure, the limonene is 95% pure and the cymene is 99% pure. In one embodiment, the impurities are not compounds that are detectable in an extract of *Chenopodium ambrosioides* near *ambrosioides*. In yet another embodiment, the impurities are not thymol, carvacrol, carvone, carveol and/or nerol.

[0104] In another aspect of the invention, the natural and/or synthetic terpenes and fillers in the simulated blend are mixed with other components (e.g., carrier, emulsifier, spreader-sticker, referred to herein collectively as excipients) to produce a formulated product, wherein the substantially pure natural and/or synthetic terpenes and fillers are about 1%, about 5%, about 10%, about 15%, about 20%, about 25%, about 30%, about 35%, about 40%, about 45%, about 50%, about 55%, about 60%, about 65%, about 70%, about 75%, about 80%, about 85%, about 90%, or about 95% of the formulated product, by weight. For example, the substantially pure natural and/or synthetic terpenes and fillers are about 25% of the formulated product, by weight. In one embodiment of such a formulated product containing 25% simulated blend, the simulated blend portion of the composition consists of between about 8% and about 12.5% by weight of α-terpinene, between about 3% and about 5% by weight of p-cymene, between about 2.0% and about 3.75% by weight of limonene, and between about 3.75% to about 11.75% by weight of volume filler. In another embodiment, the concentration of α- terpinene is about 10%, by weight; the concentration of p-cymene is about 3.75%, by weight; the concentration of limonene is about 3%, by weight; and the filler(s) is about 8.25%, by weight. In yet another embodiment, the concentration of α- terpinene is about 9%, by weight; the concentration of p-cymene is about 3.72%, by weight; the concentration of limonene is about 2.85%, by weight; and the filler(s) is about 8.25%, by weight.

[0105] Spray formulations include aqueous solutions, water-soluble powders, emulsifiable concentrates, water miscible liquids/powders (for pesticidal compounds that are soluble in water), wettable powders or water-dispersible powders, flowable/sprayable suspensions or suspension concentrates, and oil solutions. Although sprays are a very popular method of applying pesticides, only a small number of pesticides are sufficiently soluble in water to be formulated into an aqueous solution, water-soluble powder, or water miscible liquid or powder. Therefore, most spray formulations need an organic solvent or a specialized formulation to enable them to be mixed with water for spray application.

[0106] An important spray formulation for the invention is an emulsifiable concentrate. In an emulsifiable concentrate, a concentrated organic solvent based solution of the pesticidal compound (or the pesticidal compound alone if it is a liquid at room temperature) is added to an emulsifier. An emulsifier is a detergent-like (surfactant) material that allows microscopically small oil droplets to be suspended in water to form an emulsion. The concentrate is thereby dispersed evenly throughout an aqueous solution and generally remains suspended for an extended period of time (days).

[0107] Emulsifiers useful in the invention include Tween™ 200, Tween™ 600, sorbitol (polysorbate 80), propylene glycol, polyethylene glycol, ethanol (ethyl alcohol) and methanol (methyl alcohol). Another class of surfactant that can be used as an emulsifier for pesticide formulations is the phosphate esters. Examples of commercially available phosphate ester surfactants include: butyl phosphate, hexyl phosphate, 2-ethylhexyl phosphate, octyl phosphate, decyl phosphate, octyldecyl phosphate, mixed alkyl phosphate, hexyl polyphosphate, and octyl polyphosphate. For example, the emulsifier used is either Tween™ 200, sorbitol 80, propylene glycol, polyethylene glycol, or ethyl alcohol.

[0108] Emulsifiable concentrates are the preferred spray formulation for the pesticidal compounds of the invention since many pesticide compounds are poorly soluble in water and would otherwise settle out in the spray tank after dilution, altering the concentration during spraying.

[0109] Non-limiting examples of conventional carriers that may be used in formulations of the present invention include liquid carriers, including aerosol propellants which are gaseous at normal temperatures and pressures, such as Freon; inert dispersible liquid diluent carriers, including inert organic solvents, such as aromatic hydrocarbons (e.g., benzene, toluene, xylene, alkyl naphthalenes), halogenated especially chlorinated, aromatic hydrocarbons (e.g., chloro-benzenes), cycloalkanes (e.g., cyclohexane), paraffins (e.g., petroleum or mineral oil fractions), chlorinated aliphatic hydrocarbons (e.g., methylene chloride, chloroethylenes), alcohols (e.g., methanol, ethanol, propanol, butanol, glycol), as well as ethers and esters thereof (e.g., glycol monomethyl ether), amines (e.g., ethanolamine), amides (e.g., dimethyl sormamide), sulfoxides (e.g., dimethyl sulfoxide), acetonitrile, ketones (e.g., acetone, methyl ethyl ketone, methyl isobutyl ketone, cyclohexanone), and/or water; as well as inert dispersible finely divided solid carriers such as ground natural minerals (e.g., kaolins, clays, vermiculite, alumina, silica, chalk, i.e., calcium carbonate, talc, attapulgite, montmorillonite, kieselguhr), and ground synthetic minerals (e.g., highly dispersed silicic acid, silicates). More non-limiting examples of suitable carriers/solvents include, but are not limited to, Isopar™ M, THFA™, ethyl lactate, butyl lactate, Soygold™ 1000, M-Pyrol, Propylene glycol, Agsolex™ 12, Agsolex™ BLO, Light mineral oil, Polysolve™ TPM, and Finsolv™ TN. In one embodiment, the solvent in said composition of present invention can be organic solvent, e.g., petroleum distillates or hydrocarbons. In one embodiment, the solvent is vegetable oil. For example, the solvent is canola oil. In another embodiment, the solvent is a methyl ester. For example, the solvent is methyl ester of soybean oil (a.k.a. methyl soyate). Methyl ester of soybean oil can be commercially produced, e.g., Steposol® SB-W. In a further embodiment of present invention, the solvent is mixture of canola oil and Steposol® SB-W. In one embodiment, the concentration of solvent in the composition of present invention is about 0%, at least about 5%, about 10%, about 15%, about 20%, about 25%, about 30%, about 35%, about 40%, about 45%, about 50%, about 55%, about 60%, about 65%, about 70%, about 75%, about 80%, about 85%, about 90%, about 95%, or about 99%, by weight. For example, the concentration of said solvent in a formulated composition of present invention ranges from about 0% to about 99%, by weight, from about 10% to about 50%, or from about 50% to about 99%, or from about 20% to about 50%, or from about 30% to about 50%, or ranges from about 30% to about 40%, by weight.

[0110] In some embodiments of the present invention the carrier is an oil, such as a fixed oil (including vegetable and animal oils) or a mineral oil, but excluding essential oils. In some embodiments of the present invention the carrier and/or volume filler is also an active compound against insects and/or mites. For example, such a carrier and/or volume filler is a vegetable oil. Vegetable oils, saturated or unsaturated, edible or inedible, include, but are not limited to, canola oil, sunflower oil, safflower oil, peanut oil, bean oil, linseed oil, tung oil, and castor oil. The concentration of said solvent in a formulated composition of present invention ranges from about 0% to about 99%, by weight, from about 10% to about 50%, or from about 50% to about 99%, or from about 20% to about 50%, or from about 30% to about 50%, or ranges from about 30% to about 40%, by weight.

[0111] The adjuvant in said composition of present invention can be selected from the group consisting of other additional carriers, spreaders-stickers, surface-active agents, e.g., emulsifiers and/or dispersing agent, penetrants, safeners, anticaking agents, and mixture thereof.

[0112] In one embodiment, the adjuvant comprises at least a second carrier, a spreader, and an emulsifier. In one embodiment, the total concentration of the second carrier, the spreader, and the emulsifier in the composition of present invention is about 0%, at least about 5%, about 10%, about 15%, about 20%, about 25%, about 30%, about 35%, about 36%, about 37%, about 38%, about 39%, about 40%, about 45%, about 50%, about 55%, about 60%, about 65%, about 70%, about 75%, about 80%, about 85%, about 90%, about 95%, or about 99%, by weight. For example, the concentration of said solvent in the composition of present invention ranges from about 0% to about 99%, by weight, from about 10% to about 50%, or from about 50% to about 99%, or from about 20% to about 50%, or from about 30% to about 50%, or ranges from about 30% to about 40%, by weight.

[0113] Non-limiting examples of suitable spreaders and/or sticking agents include, but are not limited to, Latex emulsion, Umbrella™, Adsee™ 775, Witconol™ 14, Toximul™ 858, Latron™ B-1956®, Latron™ CS-7®, Latron™ AG-44M, T-Mulz™ AO-2, T-Mulz™ 1204, Silwet™ L-774, SUSTAIN® (Western Farm Service, Inc.; Miller Chemical & Fertilizer Corp.), Pinetac® (Britz Fertilizers, Inc.), Nufilm P® (Miller Chemical & Fertilizer Corporation), Nufilm 17® (Miller Chemical & Fertilizer Corporation), Sufrix®, Cohere®, Induce®, Picclyte® (e.g., Picclyte A115), Peg600 Argimax 3H®, alpha and beta pinene polymers and co-polymers, PEG 400-DO, Lipopeg 10-S, Maximul 7301, and PEG 600ML®.

[0114] SUSTAIN® is a commercially available spreader/sticker, which comprises polyterpene resin (a proprietary mixture of pinene polymers). The chemical compound pinene is a bicyclic terpene ($C_{10}H_{16}$, 136.24 g/mol) known as a monoterpene. There are two structural isomers found in nature: α-pinene and β-pinene. As the name suggests, both forms are important constituents of pine resin; they are also found in the resins of many other conifers, and more widely in other plants. Both are also used by many insects in their chemical communication system. α-Pinene and β-pinene can be both produced from geranyl pyrophosphate, via cyclisation of linaloyl pyrophosphate followed by loss of a proton from the carbocation equivalent. Methods of producing α-pinene polymers and β-pinene polymers have been described in U.S. Patent Nos. 3,466,271, 4,011,385 and U.S. Patent Publication No. 2009/0209720, and in Barros et al., "Potentially Biodegradable Polymers Based on - or -Pinene and Sugar Derivatives or Styrene, Obtained under Normal Conditions and on Microwave Irradiation," European Journal of Organic Chemistry, Volume 2007 Issue 8, pp. 1357–1363, and Radbil et al., "Preparation of High-Melting Polyterpene Resins from α-Pinene," Russian Journal of Applied Chemistrym, Volume 78, Number 7, pp. 1126-1130. In one embodiment, the biopesticidal composition of the present invention which comprises a simulated terpene blend as described previously (e.g., 25% of a simulated terpene blend, by weight) can further comprise a spreader/sticker, for example SUSTAIN®, wherein the concentration of the spreader ranges from about 1% to about 10%, for example about 5%, by weight.

[0115] Surface-active agents that can be employed with the present invention include, without limitation, emulsifying agents, such as non-ionic and/or anionic emulsifying agents (e.g., polyethylene oxide esters of fatty acids, polyethylene oxide ethers of fatty alcohols, alkyl sulfates, alkyl sulfonates, aryl sulfonates, albumin-hydrolyzates, and especially alkyl arylpolyglycol ethers, magnesium stearate, sodium oleate); and/or dispersing agents such as lignin, sulfite waste liquors, methyl cellulose.

[0116] Emulsifiers that can be used to solubilize the simulated blends of the present invention in water include blends of anionic and non-ionic emulsifiers. Examples of commercial anionic emulsifiers that can be used include, but are not limited to: Rhodacal™ DS-10, Cafax™ DB-45, Stepanol™ DEA, Aerosol™ OT-75, Rhodacal™ A246L, Rhodafac™ RE-610, Rhodapex™ CO-433, Rhodapex™ CO-436, Rhodacal™ CA, Stepanol™ WAC. Examples of commercial non-ionic emulsifiers that can be used include, but are not limited to: Igepal™ CO-887, Macol™ NP-9.5, Igepal™ CO-430, Rhodasurf™ ON-870, Alkamuls™ EL-719, Alkamuls™EL-620, Alkamide™ L9DE, Span™ 80, Tergitol™ TMN-3, Tergitol™ TMN-6, Tergitol™ TMN-10, Morwet™ D425, Tween™ 80, Alkamuls™ PSMO-5, Atlas™ G1086, Tween™ 20, Igepal™ CA-630, Toximul™ R, Toximul™ S, Polystep™ A7, and Polystep™ B1. In one embodiment, the emulsifier in said composition of present invention is Tween™. In one embodiment, the concentration of emulsifier in said composition of present invention is about 5%, about 10%, about 15%, about 20%, about 25%, about 30%, about 35%, about 40%, about 45%, about 50%, about 55%, about 60%, about 65%, about 70%, about 75%, about 80%, about 85%, about 90%, or about 95%, by weight. For example, the concentration of emulsifier in said composition of present invention ranges from about 1% to about 15%, or ranges from about 5% to about 10%, by weight. In one embodiment, the concentration of emulsifier in the composition is about 7.5%, by weight.

[0117] In one embodiment, the spreader-sticker is polyterpene resin, e.g., proprietary mixture of pinene polymers. In one embodiment, the spreader-sticker is Latron™ B-1956® (Dow AgroSciences, LLC), which consists of 77% modified phthalic glycerol alkyd resin and 23% butyl alcohol by weight. In one embodiment, the concentration of Latron™ B-1956® in said composition of present invention is about 5%, about 10%, about 15%, about 20%, about 25%, about 30%, about 35%, about 40%, about 45%, about 50%, about 55%, about 60%, about 65%, about 70%, about 75%, about 80%, about 85%, about 90%, or about 95%, by weight. For example, in some embodiments the concentration of spreader-sticker in said composition of present invention ranges from about 1% to about 15%, or ranges from about 5% to about 10%, by weight. In one embodiment, the concentration of spreader-sticker in the composition is about 7.5%, by weight. In some embodiments, the concentration of spreader-sticker in said composition of present invention is about 5%, about 10%, about 15%, about 20%, about 25%, about 30%, about 35%, about 40%, about 45%, about 50%, about 55%, about 60%, about 65%, about 70%, about 75%, about 80%, about 85%, about 90%, or about 95%, by weight. For example, the concentration of spreader-sticker in said composition of present invention ranges from about 1% to about 15%, or ranges from about 5% to about 10%, by weight. In one embodiment, the concentration of spreader-sticker in the composition is about 7.5%, by weight.

[0118] In one embodiment, the composition of the present invention is diluted with at least one solvent, for example, with water, by the end user before application. The amount of dilution depends upon various factors, including the nature of the plant, e.g., crop.

[0119] The composition can be diluted at least about 1.5 times, about 2 times, about 3 times, about 4 times, about 5 times, about 10 times, about 20 times, about 30 times, about 40 times, about 50 times, about 60 times, about 70 times, about 80 times, about 90 times, about 100 times, about 200 times, about 300 times, about 400 times, about 500 times, about 600 times, about 700 times, about 800 times, about 900 times, about 1000 times, about 1500 times, about 2000 times, about 2500 times, about 3000 times, about 4000 times, about 5000 times, about 6000 times, about 7000 times, about 8000 times, about 9000 times, or about 10000 times. For example, the composition can be diluted between about 1 time and about 50 times. For another example, the composition can be diluted between about 50 times to about 400 times.

[0120] In one embodiment, between about 1 quart and about 10 quarts of a formulation containing 25% of the simulated blend are diluted in 100 gallons of water and applied to an acre. In other embodiments, a formulated composition comprising higher level of active ingredient can be applied at an even lower rate.

[0121] In one specific example in which the formulated simulated blend contains 10% substantially pure alpha-terpinene, 3.75% substantially pure p-cymene and 3% substantially pure limonene, the final concentration of each substantially pure terpene applied upon dilution in 100 gallons of water is as shown in the Table 1 below.

Table 1. Exemplary final concentrations of terpenes after dilution of simulated blend

	Terpinene (density=0.84 g/ml)	p-cymene (density =0.86 g/ml)	d-limonene (density=0.84 g/ml)
1 quart (400x dilution)	0.021%	0.008%	0.006%
2 quart (200x dilution)	0.042%	0.016%	0.013%
5 quart (80x dilution)	0.105%	0.04%	0.0315%

[0122] Regardless of the initial concentration of each terpene in a composition, the final composition applied by the end user to kill, inhibit, prevent and/or repel insect and mite plant pests will comprise the following components: between about 0.017% and about 0.21% by weight of α-terpinene, between about 0.008% and about 0.08% by weight of p-cymene, and between about 0.006% and about 0.063% by weight of limonene. For example, the composition will comprise between about 0.04% and about 0.1% by weight α-terpinene, between about 0.015% and about 0.04% by weight p-cymene, and between about 0.010% and about 0.03% by weight limonene. More examples are the compositions provided in the examples below.

[0123] The concentration of the simulated blend in the composition to be applied to plants and plant parts, depending on whether it is in the concentrated or diluted (ready-to-spray) form, can be at least about 0.01%, about 0.02%, about 0.03%, about 0.04%, about 0.05%, about 0.06%, about 0.07%, about 0.08%, about 0.09%, about 0.1%, about 0.2%, about 0.3%, about 0.4%, about 0.5%, about 0.6%, about 0.7%, about 0.8%, about 0.9%, about 1%, about 2%, about 3%, about 4%, about 5%, about 6%, about 7%, about 8%, about 9%, about 10%, about 11%, about 12%, about 13%, about 14%, about 15%, about 16%, about 17%, about 18%, about 19%, about 20%, about 21%, about 22%, about 23%, about 24%, about 25%, about 26%, about 27%, about 28%, about 29%, about 30%, about 31%, about 32%, about 33%, about 34%, about 35%, about 36%, about 37%, about 38%, about 39%, about 40%, about 41%, about 42%, about 42%, about 43%, about 44%, about 45%, about 46%, about 47%, about 48%, about 49%, about 50%, about 51%, about 52%, about 53%, about 54%, about 55%, about 56%, about 57%, about 58%, about 59%, about 60%, about 61%, about 62%, about 63%, about 64%, about 65%, about 66%, about 67%, about 68%, about 69%, about 70%, about 71%, about 72%, about 73%, about 74%, about 75%, about 76%, about 77%, about 78%, about 79%, about 80%, about 81%, about 82%, about 83%, about 84%, about 85%, about 86%, about 87%, about 88%, about 89%, about

90%, about 91%, about 92%, about 93%, about 94%, about 95%, about 96%, about 97%, about 98%, about 99% or about 100%, by weight.

[0124] The one or more terpene or terpenoid compound(s) or the composition that includes the same may also be prepared for application as a fumigant for both outdoor as well as indoor application, for example in closed environments, such as greenhouses, animal barns or sheds, human domiciles, and other buildings. Persons of skill in the art will appreciate the various methods for preparing such fumigants, for example, as fogging concentrates and smoke generators. A fogging concentrate is generally a liquid formulation for application through a fogging machine to create a fine mist that can be distributed throughout a closed and/or open environment. Such fogging concentrates can be prepared using known techniques to enable application through a fogging machine. Smoke generators, which are generally a powder formulation which is burned to create a smoke fumigant. Such smoke generators can also be prepared using known techniques.

[0125] In a method according to the invention the one or more terpene and/or terpenoid compounds, diluted or undiluted, may be applied in a number of different ways. For small scale application backpack tanks, hand-held wands, spray bottles, or aerosol cans can be utilized. For somewhat larger scale application, tractor drawn rigs with booms, tractor drawn mist blowers, airplanes or helicopters equipped for spraying, or fogging sprayers can all be utilized. Small scale application of solid formulations can be accomplished in a number of different ways, examples of which are: shaking product directly from the container or gravity-application by human powered fertilizer spreader. Large scale application of solid formulations can be accomplished by gravity fed tractor drawn applicators, or similar devices.

[0126] In one embodiment, the one or more terpene and/or terpenoid compounds, such as compositions of a simulated blend of *Chenopodium ambrosioides* near *ambrosioides*, are applied to a plant or a plant part at any time during the life cycle of the plant, during one or more stages of the plant's life cycle, or at regular intervals of the plant's life cycle, or continuously throughout the life of the plant.

[0127] In one embodiment, the one or more terpene and/or terpenoid compounds are applied to a plant before the emergence or appearance of a fruit, of insufficient plant health, and/or slow plant growth. In one embodiment, the one or more terpene and/or terpenoid compounds are applied to a plant during or after the emergence or appearance of a fruit, of insufficient plant health, and/or slow plant growth.

[0128] In some embodiments the compositions can be applied before, during and/or shortly after the plants are transplanted from one location to another, such as from a greenhouse or hotbed to the field. In another example, the compositions can be applied shortly after seedlings emerge from the soil or other growth media (e.g., vermiculite). In yet another example, the compositions can be applied at any time to plants grown hydroponically. Hence, according to the methods of the present invention the compositions can be applied at any desirable time during the life cycle of a plant In some other embodiments, the compositions of the present invention are applied to a plant and/or plant part for two times, during any desired development stages or under any predetermined pest pressure, at an interval of about 1 hour, about 5 hours, about 10 hours, about 24 hours, about two days, about 3 days, about 4 days, about 5 days, about 1 week, about 10 days, about two weeks, about three weeks, about 1 month or more. In some embodiments, the compositions of the present invention are applied to a plant and/or plant part for more than two times, for example, 3 times, 4 times, 5 times, 6 times, 7 times, 8 times, 9 times, 10 times, or more, during any desired development stages or under any predetermined pest pressure, at an interval of about 1 hour, about 5 hours, about 10 hours, about 24 hours, about two days, about 3 days, about 4 days, about 5 days, about 1 week, about 10 days, about two weeks, about three weeks, about 1 month or more. The intervals between each application can vary if it is desired. One skilled in the art will be able to determine the application times and length of interval depending on plant species, plant pest species, and other factors.

[0129] The one or more terpene or terpenoid compound(s), including a corresponding formulated composition can either be applied directly or can be diluted further before application. The diluent depends on the specific treatment to be accomplished, and the method of application. For example, a composition that is to be applied to trees could be diluted further with water to make it easier and more efficient to spray with known spraying techniques. A terpene or terpenoid compound, as well as a composition of the present invention can be diluted by means of a solvent, e.g., water before application, wherein the final composition applied by the end user to inhibit, prevent and/or repel insects will comprise following components: between about 0.020% and 1.70% by weight of α-terpinene, between about 0.008% and 0.65% by weight of p-cymene, and between about 0.005% and 0.500% by weight of limonene. For example, a composition may include between about 0.044% and 0.28% by weight α-terpinene, between about 0.017% and 0.11% by weight p-cymene, and between about 0.013% and 0.086% by weight limonene. As another example, the composition may comprise between about 0.08% and 0.25% by weight α-terpinene, between about 0.035% and 0.080% p-cymene, and between about 0.030% and 0.075% by weight limonene.

[0130] In some embodiments a composition used in the present invention may be diluted with water to a final mixture, wherein the final mixture includes the following components: from about 0.017% to about 0.21% by weight of α-terpinene, from about 0.008% to about 0.08% by weight of p-cymene, and from about 0.007% to about 0.063% by weight of limonene. In another example, the composition may comprise from about 0.02% to about 0.1% by weight α-terpinene, from about 0.008% to about 0.04% by weight p-cymene, and from about 0.006% to about 0.03% by weight limonene.

[0131] In another example, the composition may include from about 0.04% to about 0.1% by weight α-terpinene, from about 0.015% to about 0.04% by weight p-cymene, and from about 0.010% to about 0.03% by weight limonene.

[0132] The respective final mixture may be applied to the surface of a plant, to the surface of a portion of a plant, to a fruit, to the vicinity of a plant, to the vicinity of a fruit, or to an area encompassing the plant or the fruit.

[0133] In some embodiments application of the one or more terpenes or terpenoids lasts for at least 2 hours, at least 5 hours, at least 10 hours, at least 15 hours or at least 1 day, such as for at least 2 days, for at least 3 days or at least 4 days, or at least 5 days, or at least 6 days. In one embodiment the application of the one or more terpenes or terpenoids lasts for at least 1 week, for at least 8 days, or at least 9 days, or at least 10 days, or at least 11 days, or at least 12 days, or at least 13 days, or at least 2 weeks, or at least 3 weeks, or at least one month or longer.

[0134] In some embodiments the terpene or terpenoid compound(s) may be applied in combination with one or more nutrients (fertilizers) and/or one or more herbicides. A respective nutrient and/or herbicide may be applied separately from the terpene or terpenoid compound, at the same point or points of time. Thus the skilled artisan will appreciate that the instant invention may be further formulated to provide various dissolution rates and/or be prepared in combination with nutrients (fertilizers) or herbicides.

[0135] In some embodiments, a plant in a method according to the invention grows in a field, such as a grower's field or a farmer's field. In some embodiments, a plant in a method according to the invention grows in a hotbed, growth chamber, arboretum, solarium, on a window sill of home or office, or in a greenhouse. In other words, the methods of the present invention are useful in enhancing plant growth, plant health and/or fruit ripening wherever plants are grown and for whatever purpose the plants are cultivated, whether the plants be grown in pots, hydroponically or in a field in large-scale monoculture farming operations.

[0136] In some embodiments, the isoprenoid and/or isopentenoid compounds, including compositions of the present invention, can be applied together, either mixed or separated but in consequences, or in rotations, with one or more plant pest repellent(s) to achieve inhibition, prevention, and/or repellency against broader plant pests species spectrum, and/or synergistic effects against specific plant pest species or to synergistically enhance plant growth and/or plant health and/or fruit ripening. Such repellents may include, but are not limited to, 2-ethyl-1,3-hexanediol; N-octyl bicycloheptene dicarboximide; N,N-diethyl-M-toluamide; 2,3:4,5-Bis (2-butylene) tetrahydro-2-furaldehyde; Di-n-propyl isocinchomeronate; 2-hydroxyethyl-n-octyl sulfide; N-(cyanomethyl)-4-(trifluoromethyl)-3-pyridine-carboxamide (e.g., Flonicamid, FMC BELEAF™® 50 SG INSECTICIDE), pymetrozine (e.g., Fulfill®), and plant insect repellents described in U.S. Patent Nos.: 4,769,242; 4,869,896; 4,943,563; 5,221,535; 5,372,817; 5,429,817; 5,559,078; 5,591,435; 5,661,181; 5,674,517; 5,711,953; 5,756,113; 6,559,175; 6,646,011; 6,844,369; 6,949,680; 7,381,431; 7,425,595; each of which is incorporated by reference in its entirety herein, including all drawings/photographs that are a part thereof.

[0137] In other embodiments, the compositions of the present invention can be applied together, either mixed or separated but in consequences, or in rotations, with at least one fertilizer, nutrient, mineral, auxin, growth stimulant and the like, referred to below as plant health compositions, to synergistically enhance plant health and/or growth and/or fruit ripening. A plant health composition/compound is a composition/compound comprising one or more natural or synthetic chemical substances, or biological organisms, capable of maintaining and/or promoting plant health. Such a composition/compound can improve plant health, vigor, productivity, quality of flowers and fruits, and/or stimulate, maintain, or enhance plant resistance to biotic and/or abiotic stressors/pressures.

[0138] Traditional plant health compositions and/or compounds include, but are not limited to, plant growth regulators (aka plant growth stimulators, plant growth regulating compositions, plant growth regulating agents, plant growth regulants) and plant activating agents (aka plant activators, plant potentiators, pest-combating agents). The plant health composition in the present invention can be either natural or synthetic.

[0139] Plant growth regulators include, but are not limited to, fertilizers, herbicides, plant hormones, bacterial inoculants and derivatives thereof.

[0140] Fertilizer is a composition that typically provides, in varying proportions, the three major plant nutrients: nitrogen, phosphorus, potassium known shorthand as N-P-K); or the secondary plant nutrients (calcium, sulfur, magnesium), or trace elements (or micronutrients) with a role in plant or animal nutrition: boron, chlorine, manganese, iron, zinc, copper, molybdenum and (in some countries) selenium. Fertilizers can be either organic or non-organic. Naturally occurring organic fertilizers include, but are not limited to, manure, worm castings, peat moss, seaweed, sewage and guano. Cover crops are also grown to enrich soil as a green manure through nitrogen fixation from the atmosphere by bacterial nodules on roots; as well as phosphorus (through nutrient mobilization) content of soils. Processed organic fertilizers from natural sources include compost (from green waste), bloodmeal and bone meal (from organic meat production facilities), and seaweed extracts (alginates and others). Fertilizers also can be divided into macronutrients and micronutrients based on their concentrations in plant dry matter. The macronutrients are consumed in larger quantities and normally present as a whole number or tenths of percentages in plant tissues (on a dry matter weight basis), including the three primary ingredients of nitrogen (N), phosphorus (P), and potassium (K), (known as N-P-K fertilizers or compound fertilizers when elements are mixed intentionally). There are many micronutrients, required in concentrations ranging from 5 to 100 parts per million (ppm) by mass. Plant micronutrients include iron (Fe), manganese (Mn), boron (B), copper (Cu), molybdenum (Mo), nickel (Ni), chlorine (Cl), and zinc (Zn).

[0141] Plant hormones a (aka phytohormones) and derivatives thereof include, but are not limited to, abscisic acid, auxins, cytokinins, gibberellins, brassinolides, salicylic acid, jasmonates, plant peptide hormones, polyamines, nitric oxide and strigolactones.

[0142] Plant activating agents are natural or synthetic substances that can stimulate, maintain, or enhance plant resistance to biotic and/or abiotic stressors/pressures, which include, but are not limited to, acibenzolar, probenazole, isotianil, salicyclic acid, azelaic acid, hymexazol, brassinolide, forchlorfenuron, benzothiadiazole (e.g., ACTIGARD® 50WG), 2,3 butanediol, microbes or elicitors derived from microbes. More plant activating agents are described in U.S. Patent Nos. 6,849,576; 5,950,361; 6,884,759; 5,554,576; 6,100,092; 6,207,882; 6,355,860; 5,241,296; 6,369,296; 5,527,783; and 6,987,130.

[0143] Microbes, or chemical compounds and peptides/proteins (e.g., elicitors) derived from microbes, can also be used as plant activating agents. Non-limiting exemplary elicitors are: branched-β-glucans, chitin oligomers, pectolytic enzymes, elicitor activity independent from enzyme activity (e.g. endoxylanase, elicitins, PaNie), *avr* gene products (e.g., AVR4, AVR9), viral proteins (e.g., vial coat protein, Harpins), flagellin, protein or peptide toxin (e.g., victorin), glycoproteins, glycopeptide fragments of invertase, syringolids, Nod factors (lipochitooligo-saccharides), FACs (fatty acid amino acid conjugates), ergosterol, bacterial toxins (e.g., coronatine), and sphinganine analogue mycotoxins (e.g., fumonisin B1). More elicitors are described in Howe et al., *Plant Immunity to Insect Herbivores,* Annual Review of Plant Biology, 2008, vol. 59, pp. 41-66; Stergiopoulos, *Fungal Effector Proteins* Annual Review of Phytopathology, 2009, vol. 47, pp. 233-263; and Bent et al., *Elicitors, Effectors, and R Genes: The New Paragigm and a Lifetime Supply of Questions*, Annual Review of Plant Biology, 2007, vol. 45, pp. 399-436.

[0144] More non-limiting exemplary plant health compositions/compounds are described in U.S. Pat. Nos.: 4,751,226; 4,889,551; 4,456,467; 5,763,366; 4,219,351; 4,394,151; 4,913,725; RE33976; 4,959,093; 6,645,916; 4,152,429; 4,462,821; 4,704,160; 3,979,201; 4,505,736; 4,422,865; 5,919,448; 4,431,442; 4,824,473; 4,185,990; 5,837,653; 4,701,207; 4,717,732; 4,716,174; 4,720,502; 4,717,734; 6,261,996; 4,701,463; 4,728,657; 4,636,514; 4,717,733; 4,731,372; 5,168,059; 4,261,730; 5,861,360; 4,066,435; 4,210,439; 5,006,148; 4,906,280; 4,160,660; 4,439,224; 5,123,951; 4,094,664; 4,902,815; 4,036,629; 4,534,785;

4,212,664; 4,880,622; 4,144,047; 4,336,060; 4,308,054; 4,515,618; 4,525,200; 4,579,582; 5,554,580; 4,840,660; 4,268,299; 4,534,786; 5,589,438; 4,596,595; 5,468,720; 6,083,882; 6,306,797; 4,226,615; 4,509,973; RE29439; 4,025,331; 6,242,381; 4,326,878; 4,259,104; 5,518,994; 5,446,013; 3,713,805; 4,75,5213; 4,397,678; 4,762,549; 6,984,609; 4,808,207; 4,943,310; 4,481,026; 7,270,823; 4,592,772; 5,346,879; 5,627,134; 4,439,225; 4,931,082; 4,554,010; 4,057,413; 4,072,495; 4,364,768; 7,544,821; 5,523,275; 5,525,576; 7,404,959; 4,619,685; 4,157,255; 5,688,745; 6,569,809; 4,606,756; 4,537,623; 5,965,488; 4,243,405; 4,978,386; 5,654,255; 5,849,666; 7,078,369; 6,884,758; 5,076,833; 6,649,568; 4,954,157; 4,519,163; 4,154,596; 4,246,020; 4,356,022; 4,093,664; 4,808,209; 4,726,835; 4,879,291; 4,776,874; 4,892,576; 4,859,231; 4,130,409; 4,530,715; 4,936,907; 4,964,894; 4,921,529; 4,494,982; 5,228,899; 4,992,093; 4,059431; 4,765,823; 4,059,432; 4,969,948; 6,750,222; 4,171,213; 5,668,082; 4,672,112; 4,067,722; 4,732,605; 5,481,034; 5,015,283; 4,812,159; 3,905,799; 4,371,388; 4,427,436; 4,293,331; 3,979,204; 5,436,225; 6,727,205; 4,148,624; 4,737,498; 3,938,983; 5,656,571; 4,863,505; 4,227,918; 4,595,406; 4,976,771; 4,857,545; 4,999,043; 3,960,539; 5,617,671; 3,912,492; 4,217,129; 4,170,462; 4,486,219; 5,801,123; 5,211,738; 4,067,721; 5,854,179; 4,285,722; 5,510,321; 6,114,284; 4,588,435; 7,005,298; 4,504,304; 4,451,281; 3,940,414; 5,925,596; 6,331,506; 4,391,629; 5,006,153; 4,857,649; 5,922,646; 5,922,599; 5,709,871; 4,741,768; 4,723,984; 4,752,321; 5,741,521; 5,700,760; 4,888,048; 4,113,463; 5,086,187; 4,711,658; 4,960,453; 4,846,883; 4,959,097; 5,371,065; 4,620,867; 5,154,751; 4,090,862; 6,906,006; 4,292,072; 4,349,377; 4,586,947; 4,239,528; 6,284,711; 4,043,792; 6,939,831; 5,030,270; 4,844,730; 6,410,483; 5,922,648; 6,069,114; 6,861,389; 4,806,143; 4,886,544; 4,923,502; 6,071,860; 5,131,940; 4,193,788; RE31550; 4,127,402; 4,799,950; 4,963,180; 4,337,080; 4,637,828; 4,525,203; 4,391,628; 4,908,353; 4,560,738; 4,685,957; 5,637,554; 5,312,740; 3,985,541; 4,770,692; 4,787,930; 4,240,823; 5,428,002; 6,458,746; 3,989,525; 5,902,772; 4,588,821; 4,681,900; 5,679,621; 6,995,015; 5,110,345; 5,332,717; 5,222,595; 5,351,831; 4,904,296; 4,104,052; 4,622,064; 4,902,332; 4,747,869; 5,053,072; 5,186,736; 4,349,378; 5,223,017; 4,889,946; 5,323,906; 5,529,976; 4,946,493; 4,961,775; 5,253,759; 4,311,514; 4,380,626; 5,635,451; 4,975,112; 5,658,854; 6,410,482; 7,479,471; 5,015,284; 4,925,480; 4,638,004; 4,124,369; 5,039,334; 5,090,992; 5,710,104; 4,909,832; 4,744,817; 4,764,202; 4,668,274; 4,547,214; 4,808,213; 4,507,140;

4,904,298; 6,316,388; 6,265,217; 5,869,424; 5,110,344; 4,330,322; 5,292,533; 4,047,923; 4,764,624; 4,560,403; 4,557,754; 5,346,068; 4,770,688; 5,073,185; 4,973,690; 4,772,309; 4,911,746; 4,594,094; 4,518,415; 4,786,312; 7,198,811; 6,376,425; 4,895,589; 4,960,456; 4,897,107; 4,891,057; 4,102,667; 5,763,495; 4,606,753; 4,602,929 4,740,231; 4,812,165; 5,324,710; 5,701,699; 6,465,394; 5,783,516; 4,334,909; 5,466,460; 5,559,218; 4,678,496; 5,679,620; 5,977,023; 7,326,826; 4,729,783; 4,377,407; 4,602,938; 5,211,736; 5,106,409; 4,802,909; 4,871,387; 4,846,873; 4,936,892; 5,714,436; 6,239,071; 4,507,141; 4,936,901; 5,026,418; 4,734,126; 4,999,046; 4,554,017; 4,554,007; 4,943,311; 4,401,458; 5,419,079; 4,789,394; 4,871,389; 5,198,254; 5,747,421; 5,073,187; 5,258,360; 4,153,442; 4,808,722; 4,565,875; 5,298,480; 4,233,056; 4,849,007; 5,112,386; 5,221,316; 5,470,819; 4,614,534; 4,615,725; 5,496,794; 4,772,310; 4,640,706; 4,894,083; 6,767,865; 5,022,916; 4,797,152; 4,957,535; 4,880,457; 4,735,651; 5,160,364; 4,647,302; 4,818,271; 5,710,103; 6,508,869; 5,858,921; 4,599,448; 4,938,791; 4,491,466; 4,812,162; 7,427,650; 4,684,396; 4,201,565; 4,636,247; 4,925,482; 4,486,218; 6,570,068; 5,045,108; 4,336,059; 4,983,208; 4,954,162; 4,921,528; 4,826,531; 4,661,145; 4,935,049; 4,515,619; 4,810,283; 4,988,382; 4,584,008; 4,227,915; 4,875,922; 4,988,383; 4,886,545; 5,602,076; 4,229,442; 4,525,201; 5,034,052; 5,104,443; 3,620,919; 4,164,405; 5,703,016; 5,102,443; 4,618,360; 6,569,808; 4,919,704; 4,584,013; 4,775,406; 5,631,208; 4,909,835; 4,178,166; 4,183,742; 6,225,260; 5,318,945; 4,623,382; 5,053,073; 4,693,745; 4,875,930; 5,696,053; 4,221,584; 4,975,459; 4,601,746; 4,185,991; 4,871,390; 4,863,503; 5,073,184; 5,262,389; 5,061,311; 4,966,622; 6,228,808; 5,057,146; 4,849,009; 4,939,278; 4,481,365; 4,333,758; 4,741,754; 4,411,685; 4,455,162; 7,291,199; 5,252,542; 4,470,840; 4,227,911; 4,959,093; and 5,123,951. Each of the patents, patent publications cited here is incorporated by reference in its entirety herein, including all drawings/photographs that are a part thereof.

[0145] Bacterial inoculants are compositions comprising beneficial bacteria that are used to inoculate soil, often at the time of planting. Such bacterial inoculants include nitrogen-fixing bacteria or rhizobia bacteria. *Bradyrhizobia japonicum* is commonly used for soybean inoculation and *Bradyrhizobia* sp. (Vigna) or (Arachis) for peanuts. Other rhizobia are used with other crops: *Rhizobium leguminosarum* for peas, lentils and beans and alfalfa and clover and *Rhizobium loti*, *Rhizobium leguminosarum* and *Bradyryizobium* spp. for various legumes.

In one embodiment, the compositions of the present invention are applied to a plant that has been planted in soil treated with a bacterial inoculant or that derives from a seed treated with a bacterial inoculant.

[0146] Compositions of the present invention may also be applied to plants, plant parts or plant loci in combination with or in rotation with fungicides, especially fungicides that also have plant health effects, such as strobilurins and, in particular, pyraclostrobin (also known as F500). Other strobilurins include, but are not limited to, azoxystrobin, dimoxystrobin, enestroburin, fluoxastrobin, kresoxim-methyl, metominostrobin, picoxystrobin, pyraclostrobin, pyroxastrobin, trifloxystrobin, orysastrobin, methyl (2-chloro-5-[1-(3-methylbenzyloxyimino)-ethyl]benzyl)-carbamate, methyl (2-chloro-5-[1-(6-methylpyrid in-2-ylmethoxyimino)ethyl]benzyl)carbamate, methyl 2-(ortho-(2,5-dimethylphenyloxymethylene) phenyl)-3-methoxyacrylate; 2-(2-(6-(3-chloro-2-methyl-phenoxy)-5-fluoro-pyrimidin-4-yloxy)phenyl)-2-methoxyimino-N-methyl-acetamide 3-methoxy-2-(2-(N-(4-methoxyphenyl)-cyclopropanecarboximidoylsulfanylmethyl)-phenyl)-acrylic acid methyl ester.

[0147] Compositions of the present invention may be applied to plants, plant parts or plant loci in combination with or in rotation with insecticides. Suitable insecticides include neonicotinoid insecticides such as 1-(6-chloro-3-pyridylmethyl)-N-nitroimidazolidin-2-ylideneamine (imidacloprid), 3-(6-chloro-3-pyridylmethyl)-1,3-thiazolidin-2-ylidenecyanamide (thiacloprid), 1-(2-chloro-1,3-thiazol-5-ylmethyl)-3-methyl-2-nitroguanidine (clothianidin), nitempyran, N.sup.1-[(6-chloro-3-pyridyl)methyl]-N.sup.2-cyano-N.sup.1-methylacetamid-ine(acetamiprid), 3-(2-chloro-1,3-thiazol-5-ylmethyl)-5-methyl-1,3,5-oxadiazinan-4-ylidene(-nitro)amine (thiamethoxam) and 1-methyl-2-nitro-3-(tetrahydro-3-furylmethyl)guanidine (dinotefuran).

[0148] The following examples are given for purely illustrative and non-limiting purposes of the present invention.

EXAMPLES

Example 1

[0149] A study was conducted to determine whether primary metabolic changes were detectable in young tomato plants, *Lycopersicon esculentum* cv. "Florida Lanai," subjected to three applications of Composition 1 on a five day interval.

Table 2 - Composition 1

Compound in wt %	Total 100%
α-Terpinene	10
p-Cymene	3.75
limonene	3
Total terpene in wt %	16.75
Canola oil (volume filler) in wt %	8.25
Canola oil (carrier)	37.5
Steposol SB-W® (carrier)	25
Tween 80 (emulsifier)	7.5
SUSTAIN®	5.0

[0150] Note that the terpenes provided in the chart are substantially pure. The α-Terpinene is 90% pure, the p-cymene 99% pure and the limonene 95% pure.

[0151] Two sets of plants were grown in a greenhouse in four inch square pots and were treated identically with the exception of treatment of one set of plants with Composition 1 and one set with water. Plants were caged and managed to protect them from insect infestation. A 2% v/v dilution of Composition 1 was applied to plants at a rate equivalent to a field rate of 100 gallons per acre with the first spray occurring seven weeks from planting, the second spray occurring five days after the first spray and the third spray occurring five days after the second spray. Sampling of new and old growth from treated and control plants occurred the day after the third spray application.

[0152] The collected leaves from each set of plants were harvested and pooled for mRNA extraction and transcriptome sequencing. 9.3 million 50bp reads were collected from the Composition 1-treated plants and 11.4 million 50bp reads were collected from the water-treated plants. The DNA sequence reads were aligned using Bowtie (Langmead et al., *Genome Biol.*, 2009) to 33,926 predicted genes provided by the international tomato genome sequencing project. The reads that were mapped to genes were normalized using RPKM (Montazavi et al., *Nat. Methods*, 2008). The P-values were determined using DEGseq (Wong et al., *Bioinformatics* 2009). P-value of less than 0.001 with a normalized fold change of +/- 1.5 were used to identify significant hits. Utilizing these cut-off parameters generated 786 upregulated genes and 1232 downregulated genes. While a number of different classes of genes were differentially expressed, many of the genes involved in plant defense, such as genes for signaling compounds, such as ethylene and jasmonic acid, and pathogenesis-related genes responsible for the production of proteins associated with systemic acquired resistance, were upregulated and many photosynthetic genes were downregulated. Tables 3 and 4 summarize the upregulation of certain genes. Table 5 summarizes the down-regulation of photosynthetic genes.

Table 3

Properties	Gene	Fold Change (FC)
ET producers	1- synthase	17.4
	2- synthase	1.72
	3 - oxidase	1.79
	4 - oxidase	1.50
JA producers	1 - esterase	2.51
	2 - esterase	2.49

Table 4

Family	Gene	Fold Change
PR	1 - Pathogenesis related protein	7.59
PR	2 - Pathogenesis-related protein	6.98
PR	3 - Pathogenesis-related protein	8.57
PR	4 - Pathogenesis-related leaf protein	7.85
PR	5 -Pathogenesis-related protein	2.80

Table 5

Properties	Gene	Fold change (FC)
Chlorophyll binding	chlorophyll a-b binding protein	20.96
	chlorophyll a-b binding protein	10.26
	type I polypeptide	4.48
	light inducible protein	2.93
	(at least 25 more down-regulated)	
Photosynthesis reaction center	photosystem II protein	12.05
	photosystem I protein	2.40
	photosystem I protein	2.34
	photosystem I protein	2.20
	(at least 15 more down-regulated)	

[0153] qRT-PCR was used to confirm the differentially expressed genes previously determined by RNA-seq analysis. For each target gene, two primers and an internal, fluorescently labeled TaqMan probe (5' end, reporter dye FAM (6-carboxyfluorescein), 3' end, quencher dye TAMRA (6-carboxytetramethylrhodamine) was designed using default parameters of Primer Express software 2.0 (Applied Biosystems). TaqMan PCR systems were validated using defined protocols (Leutenegger et al., 1999). Total RNA was extracted using ABI chemistry and cDNA was synthesized from 20 uL I DNase (RNase-free DNase I, Invitrogen) digested total RNA. Each PCR reaction contained 20 X primer and probes for the respective TaqMan system. The samples were placed in 384-well plates and amplified in an automated fluorometer (ABI PRISM 7900 HTA FAST, Applied Biosystems). The manufacturer's standard amplification conditions were used. Fluorescent signals were collected during the annealing period and CT values extracted with a threshold of 0.04 and baseline values of 3–15. 18S rRNA gene was used as a positive control. Final quantification was performed using the comparative CT method (ΔΔCT, User Bulletin No. 2, Applied Biosystems) and is reported as relative transcription or the *n*-fold difference relative to a calibrator cDNA (i.e., transcript levels of plants treated with water). The relative linear amount of target molecules relative to the calibrator was calculated by $2^{-\Delta\Delta CT}$. Therefore, all gene transcription is expressed as an *n*-fold difference relative to the calibrator. Transcript accumulation was considered to be significantly different from the calibrator (water level for any specific target gene) if the 95% confidence intervals of the mean did not overlap the mean level of the calibrator. This experiment confirmed downregulation of various photosynthetic genes, as summarized in Table 6, below.

Table 6

	Genes	FC (RNA-seq)	FC (qRT-PCR)
Downregulated			
1	transcription factor	-6.55	-10.27
2	lyase	-3.44	-3.94
3	photosynthesis reaction center	-1.97	-22.94
4	chlorophyll a/b binding protein	-32.47	-40.5
5	peroxidase	-10.79	-24.93

[0154] However, the results were inconclusive as to upregulated genes, potentially because of design and technical issues commonly found in qRT-PCR technique. Therefore, instead of troubleshooting the qRT-PCR further, another RNA-seq analysis, described in Example 2, was performed to validate the initial result.

Example 2

[0155] A slightly different experiment was conducted to test metabolic changes at several different time points after one treatment with Composition 1. Eight sets of six young flowering tomato plants were grown in the greenhouse in one gallon pots. Plants were caged and managed to isolate them from insect infestation. Each set was treated one time with water or with a 2% v/v dilution of Composition 1 applied at a rate equivalent to a field rate of 100 GPA. (Note that Composition 1 is typically applied at a 0.5% to 2% dilution (which is equivalent to a rate of 2 quarts per 100 gallons to a rate of 2 gallons per 100 gallons.) Samples from the various sets were harvested 20 hours before treatment (referred to in tables below as 0 hour), 4 hours after treatment, 28 hours after treatment, and 52 hours after treatment.

[0156] Harvested leaf tissue from each plant set was pooled, as shown in Table 7 below, to minimize interplant variability, and mRNA extraction and transcriptome sequencing conducted on the pooled leaf tissue. Two flow cells were used to generate over 37 million 68-bp reads that were barcoded to distinguish the reads from each treatment in the experiment. The sequence reads were then aligned to the then-current mRNA database published by the International Tomato Genome Sequencing Project (as of late 2010) using Bowtie. *See* Langmead, B., et al., "Ultrafast and Memory-Efficient Alignment of Short DNA Sequences to the Human Genome," Genome Biology, 2009, 10(3):R25, Epub 2009 Mar 4.

Table 7

SEQ ID	**reads aligned**	**% aligned**	**total reads**	**approx. tomato mRNA DB coverage**	**Treatment**	**Cages**
AQ-1	1939037	49.61	3908679	6.99	None	A&F
AQ-2	2025002	57.12	3544876	6.34	None	G&B
AQ-3	2472802	56.37	4386634	7.85	4HAT with Composition 1	C&E
AQ-4	2282433	57.77	3950998	7.07	4HAT with water	D&H
AQ-5	2406902	52.24	4607153	8.24	28HAT with Composition 1	A&F
AQ-6	2425570	52.94	4581529	8.20	28HAT with water	G&B
AQ-7	1526791	48.40	3154733	5.65	52HAT with Composition 1	C&E
AQ-8	4842957	53.41	9067621	16.23	52HAT with water	D&H
	19921494	53.48	37202223			

[0157] Note in the table that AQ-8 had many more reads than AQ-7. This was due to a dilution error but did not affect the downstream analysis, which took the dilution error into account.

[0158] The number of reads aligned to genes were counted, normalized and searched for differentially expressed genes (DEGs) using DESeq, according to the method described in Anders, S. and Huber, W., "Differential Expression Analysis for Sequence Count Data," Genome Biology, 2010, 11(10): R106, Epub. 2010 Oct. 27.

[0159] Table 8 summarizes the number of DEGs that are statistically significant (adjusted pvalue or padj <=0.05) between samples treated with Composition 1 or water at various sampling points before and after treatment.

Table 8

	0 hr	4 hr	28 hr	52 hr
# of DEGs	120	87	77	114

[0160] It was expected to see fewer numbers of DEGs at 0 hr compared to other time points because the plants from cages AF and BG were similarly treated and grown. The presence of so many DEGs at time point 0 hr suggested that there was quite a bit of noise at least for those sets of plants (AF and BG). Note from Table 1 that plants from cages AF (treated) and GB (untreated) were used for the 0 hr and 28 hr time point calculation while plants from cages CE (treated) and DH (untreated) were used for the 4 hr and 52 hr time point calculations. When scanning the identity of DEGs at the 28 hr time point, there were no photosynthetic genes that were downregulated and no plant defense related genes that were upregulated, in contrast to the results observed in the first RNA-seq experiment (described in Example 1). In addition, there were only three out of 77 genes upregulated at the 28 hr time point, which also seemed quite unusual.

[0161] The pattern of DEGs at 4 hr and 52 hr were much more similar to the observations from the first RNA-seq experiment described in Example 1. See Table 9, below.

Table 9

	4 hour		52 hour	
	Down	Up	Down	Up
DEG	30	57	37	77
Photosynthetic Genes	16	0	2	0
Defense: PR	0	7	0	31
Defense: Others	0	18	0	15

[0162] About half or 16 of the genes that were downregulated at 4 hr were photosynthetic genes. However, this number reduced drastically to two at 52 hr. On the other hand, seven pathogenesis related (PR) and 18 plant defense related genes were upregulated at 4 hr. At 52 hr, the number of PR genes increased dramatically to 31. There was an initial uptick of plant defense genes at 4 hr, but the plant shifted into high gear by the 52 hr time point, especially as to the PR genes. Another striking observation was that no photosynthetic genes were upregulated and no plant defense related genes were downregulated at either of the 4 and 52 hour time points. A list of the gene categories of overexpressed genes at 4 and 52 hours after treatment is provided in Table 10, below. The abbreviation FC in Tables 10 and 11 refers to fold change.

Table 10

FC at 4 HAT	FC at 52 HAT	Gene Category
62.9	**inf**	**PR**
31.1	**inf**	**PR**
10.0	**inf**	**PR**
n.e.	**16.4**	**PR**
n.e.	**15.8**	**PR**
n.e.	**15.1**	**PR**
n.e.	**inf**	**viral induced**

FC at 4 HAT	FC at 52 HAT	Gene Category
n.e.	44.8	viral induced
13.2	21.0	viral induced
15.7	31.6	defense
15.6	10.2	defense
n.e.	9.0	defense
n.e.	6.1	defense
10.9	5.2	defense
n.e.	10.9	hormone
n.e.	8.3	hormone
17.1	*n.e.*	hormone
9.9	*n.e.*	hormone

[0163] A list of the gene categories of underexpressed genes at 4 and 52 hours after treatment is provided in Table 11, below.

Table 11

FC at 4 HAT	FC at 52 HAT	Gene Category
-11.8	-6.3	photosynthesis
inf	*n.e.*	photosynthesis
-13.7	*n.e.*	photosynthesis
-12.0	*n.e.*	photosynthesis
-11.8	*n.e.*	photosynthesis
-11.7	*n.e.*	photosynthesis
-11.3	*n.e.*	cell wall
n.e.	-9.2	cell wall

FC at 4 HAT	FC at 52 HAT	Gene Category
inf	*n.e.*	cell growth
-16.7	*n.e.*	cell growth

Conclusions

1. Plants in cages AF and BG (time points 0 hr and 28 hr) may be anomalous.

2. Photosynthetic genes are downregulated initially but most revert to norm by 52 hr time point.

3. Plant defense genes are upregulated at 4 hr and even more plant defense genes, specifically PR genes, become highly expressed at 52 hr.

Example 3

[0164] Two sets of plants grown in the greenhouse in one gallon plants were treated with Composition 1 or water on the following schedule.

Table 12

Treatment	Spray Date
1	4/5
2	4/12
3	4/19
4	5/3
5	5/17
6	5/24
7	5/31
8	6/7
9	6/18
10	6/26
11	7/6
12	7/17
13	7/28

[0165] The two sets of plants were compared for differences in plant growth, fruit ripening and fruit set. Differences in these properties were observed after the treatments, with the Composition 1-treated plants appearing more robust and healthy, having more fruit and having more ripe fruit more quickly. Specific results follow. Total weight of water-treated plants was 2107.492 g while total weight of Composition 1-treated plants was 2735.748 g.

[0166] Figure 6 represents the total weight of tomato plants after 13 treatments with water or Composition 1. The column on the left shows weight of water-treated plants while the column on the right represents weight of Composition 1-treated plants.

[0167] Following is a summary of total number of fruit produced by water-treated and Composition 1-treated plants after the last treatment.

Table 13

Water-Treated	
Sum of Fruit #	143

Table 14
Composition 1-Treated

Sum of Fruit #	195

[0168] Composition 1 also seemed to accelerate ripening of fruit. Figure 2A shows plants treated about seven or eight times with water. Only seven or so of the pictured fruit were starting to redden at this point. In other words, none of these fruit were a bright red or fully ripe. Figure 2B shows plants treated about seven or eight times with Composition 1. About 11 fruit on these plants were bright red.

[0169] Measurements, taken after the final treatment, of average fruit weight, average fruit diameter and fruit color index of fruit from Composition 1-treated and water-treated plants were very similar.

[0170] While the invention has been described in connection with specific embodiments thereof, it will be understood that it is capable of further modifications and this application is intended to cover any variations, uses, or adaptations of the invention following, in general, the principles of the invention and including such departures from the present disclosure as come within known or customary practice within the art to which the invention pertains and as may be applied to the essential features hereinbefore set forth and as follows in the scope of the appended claims.

CLAIMS

What is claimed is:

1. A method of enhancing the health of a plant, wherein the method comprises applying at least one terpene or terpenoid compound to the plant or a plant part and/or applying to an area around a plant or plant part.

2. A method of promoting the growth of a plant, wherein the method comprises applying at least one terpene or terpenoid compound to the plant or a plant part and/or applying to an area around a plant.

3. A method of improving fruit ripening comprising applying at least one terpene or terpenoid compound to the fruit or a plant carrying the fruit and/or applying to an area around a fruit.

4. The method of any of claims 1 to 3, wherein the at least one terpene or terpenoid compound is an aliphatic or a cyclic compound.

5. The method of any of claims 1-4, wherein the at least one terpene or terpenoid compound is selected from the group consisting of a monoterpene, a sesquiterpene, a diterpene, a sesterterpene, a triterpene and mixtures thereof.

6. The method of claim 5, wherein the at least one monoterpene or terpeoid compound is selected from the group of geraniol, limonene, terpinene, p-cymene, limonene, carvacrol, carveol, nerol, thymol and carvone and mixtures thereof.

7. The method of claim 6, wherein the terpinene is selected from group consisting of alpha-terpinene, beta-terpinene and gamma-terpinene.

8. The method of claim 5, wherein the sequiterpene is selected from the group of farnesene and farnesol.

9. The method of claim 5, wherein the diterpene is selected from the group consisting of cafestol, kahweol, cembrene, and taxadiene.

10. The method of claim 5, wherein the sesterterpene is geranylfarnesol.

11. The method of claim 5, wherein the triterpene is squalene.

12. The method of claim 5, wherein the at least one terpene compound is a mixture of α-terpinene, p-cymene and limonene.

13. The method of any of claims 5 to 7 or claim 12, wherein the at least one terpene compound is present in a composition comprising a simulated blend of an essential oil extract of Chenopodium ambrosioides near ambrosioides.

14. The method of claim or 13, wherein the simulated blend consists essentially of (i) substantially pure α-terpinene, p-cymene and limonene, wherein each of the substantially pure α-terpinene, p-cymene and limonene is not obtained from a Chenopodium extract and (ii) a carrier.

15. The method of claim 13 or 14, wherein the α-terpinene and p-cymene are synthetically produced and the limonene is obtained from a plant other than Chenopodium.

16. The method of any of claims 13 to 15, wherein the carrier is a vegetable oil.

17. The method of any of claims 13 to 16, wherein the composition is diluted before application and wherein the simulated blend in such composition after dilution consists essentially of about 0.010% to about 0.21% by weight of α-terpinene, about 0.004% to about 0.08% by weight of p-cymene, and about 0.003% to about 0.063% by weight of limonene.

18. The method of any of claims 13 to 17, wherein the composition is diluted before application and wherein the simulated blend in such composition after dilution consists essentially of about 0.02% to about 0.08% by weight of α-terpinene, from about 0.008% to about 0.032% by weight of p-cymene, and from about 0.006% to about 0.026% by weight of limonene.

19. The method of any of the preceding claims, wherein the at least one terpene or terpenoid compound effects up-regulation/down-regulation of genes involved in defense response pathways in comparison to plants which are not treated with the at least one terpene or terpenoid compound.

20. The method of claim 19, wherein the at least one terpene or terpenoid compound effects up-regulation of genes associated with ethylene and jasmonic acid.

21. The method of claim 19, wherein the at least one terpene or terpenoid compound effects up-regulation of genes encoding Pathogenesis Related Proteins.

22. The method of claim 19, wherein the at least one terpene or terpenoid compound down-regulates genes associated with photosynthesis.

23. The method of claim 22, wherein the genes associated with photosynthesis are transiently down regulated.

24. The method of any of the preceding claims in which the plant is selected from the group consisting of trees, herbs, bushes, grasses, vines, ferns, mosses and green algae, monocotyledonous plants, and dicotyledonous plants.

25. The method of claim 24, wherein the plant is selected from the group consisting of corn, potatoes, roses, apple trees, sunflowers, wheat, rice, bananas, tomatoes, opo, pumpkins, squash, lettuce, cabbage, oak trees, guzmania, geraniums, hibiscus, clematis, poinsettias, sugarcane, taro, duck weed, pine trees, Kentucky blue grass, zoysia, coconut trees, brassica leafy vegetables (e.g., broccoli, broccoli raab, Brussels sprouts, cabbage, Chinese cabbage (Bok Choy and Napa), cauliflower, cavalo, collards, kale, kohlrabi, mustard greens, rape greens, and other brassica leafy vegetable crops), bulb vegetables (e.g., garlic, leek, onion (dry bulb, green, and Welch), shallot, and other bulb vegetable crops), citrus fruits (e.g., grapefruit, lemon, lime, orange, tangerine, citrus hybrids, pummelo, and other citrus fruit crops), cucurbit vegetables (e.g., cucumber, citron melon, edible gourds, gherkin, muskmelons (including hybrids and/or cultivars of cucumis melons), water-melon, cantaloupe, and other cucurbit vegetable crops), fruiting vegetables (including eggplant, ground cherry, pepino, pepper, tomato, tomatillo, and other fruiting vegetable crops), grape, leafy vegetables (e.g., romaine), root/tuber and corm vegetables (e.g. potato), and tree nuts (almond, pecan, pistachio, and walnut), berries (e.g., tomatoes, barberries, currants, elderberryies, gooseberries, honeysuckles, mayapples, nannyberries, Oregon-grapes, see-buckthorns, hackberries, bearberries, lingonberries, strawberries, sea grapes, blackberries, cloudberries, loganberries, raspberries, salmonberries, thimbleberries, and wineberries), cereal crops (e.g., corn, rice, wheat, barley, sorghum, millets, oats, ryes, triticales, buckwheats, fonio, and quinoa), pome fruit (e.g., apples, pears), stone fruits (e.g., coffees, jujubes, mangos, olives, coconuts, oil palms, pistachios, almonds, apricots, cherries, damsons, nectarines, peaches and plums), vine (e.g., table grapes, wine grapes), fibber crops (e.g., hemp, cotton), and ornamentals.

FIGURE 1 (prior art)

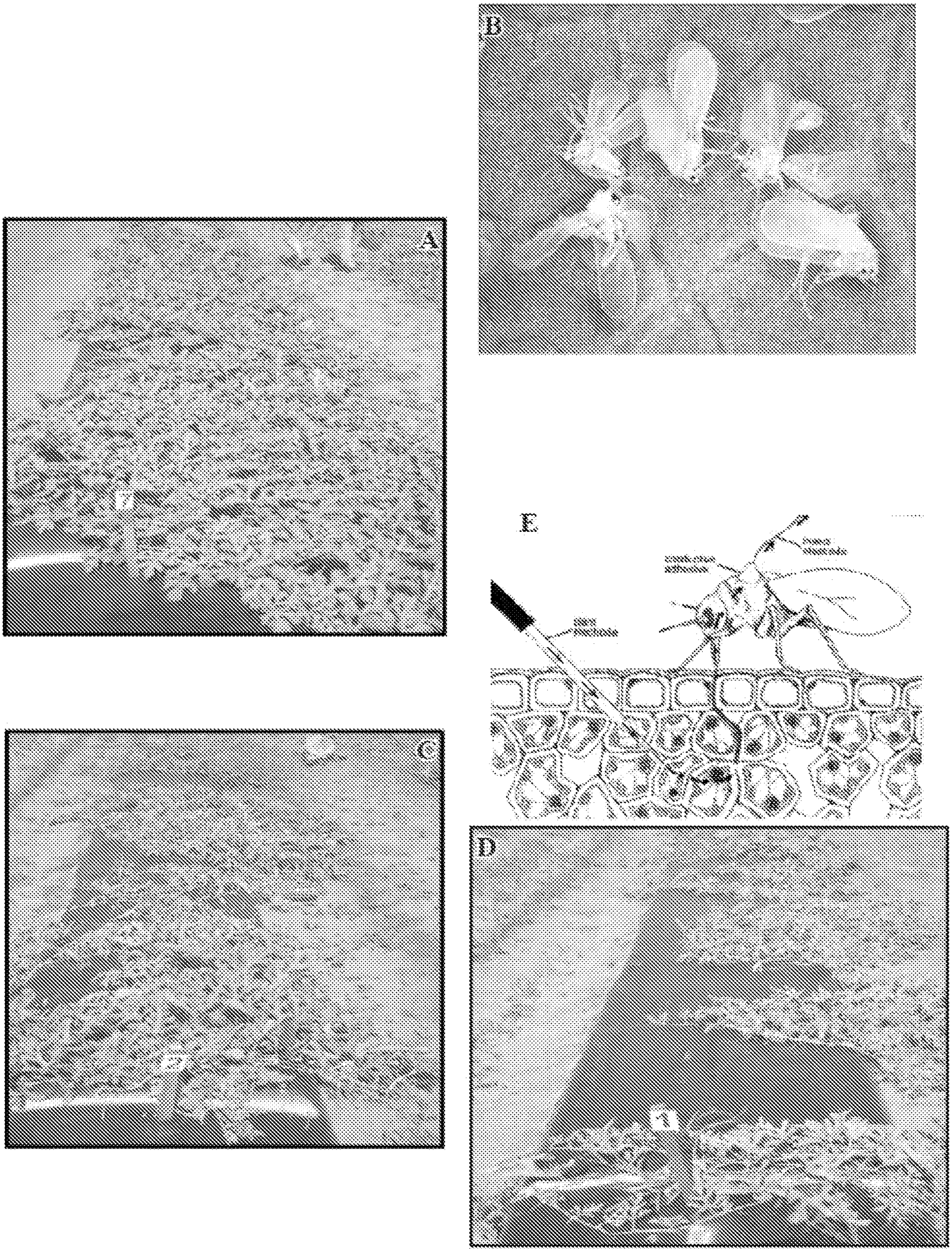


FIGURE 2A

FIGURE 2B

FIGURE 3

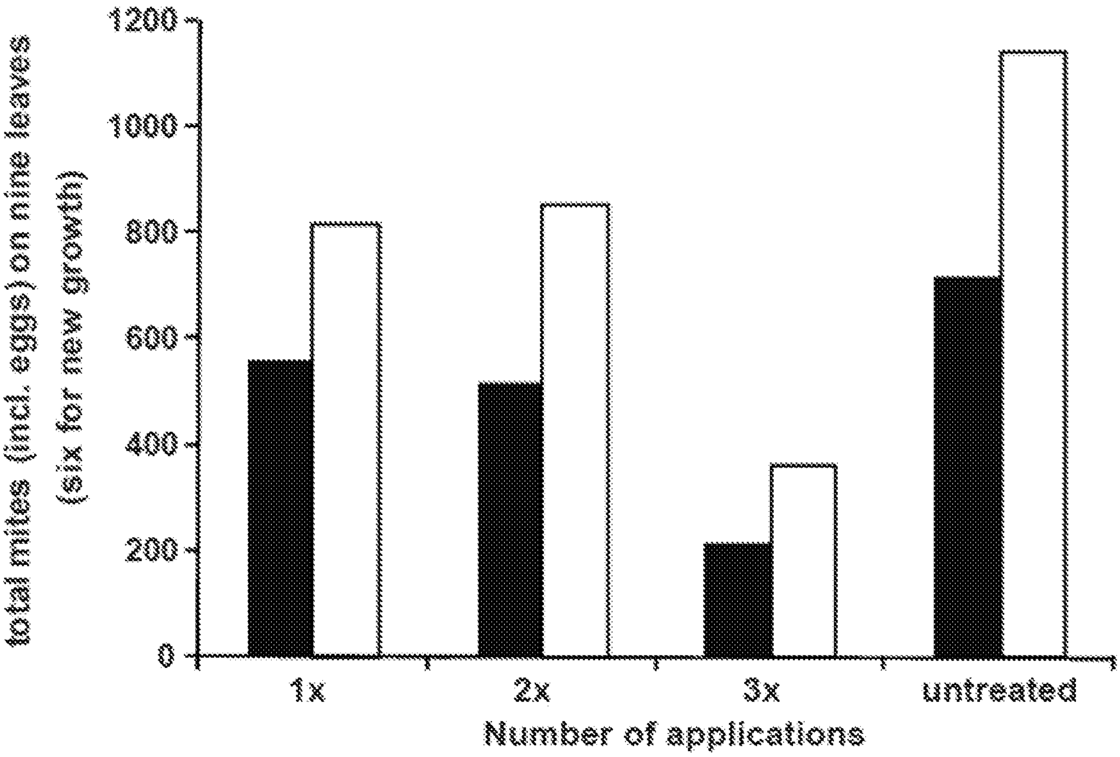

1200
1000
800
600
400
200
0
total mites (incl. eggs) on nine leaves
(six for new growth)
1x
2x
3x
untreated
Number of applications

FIGURE 4

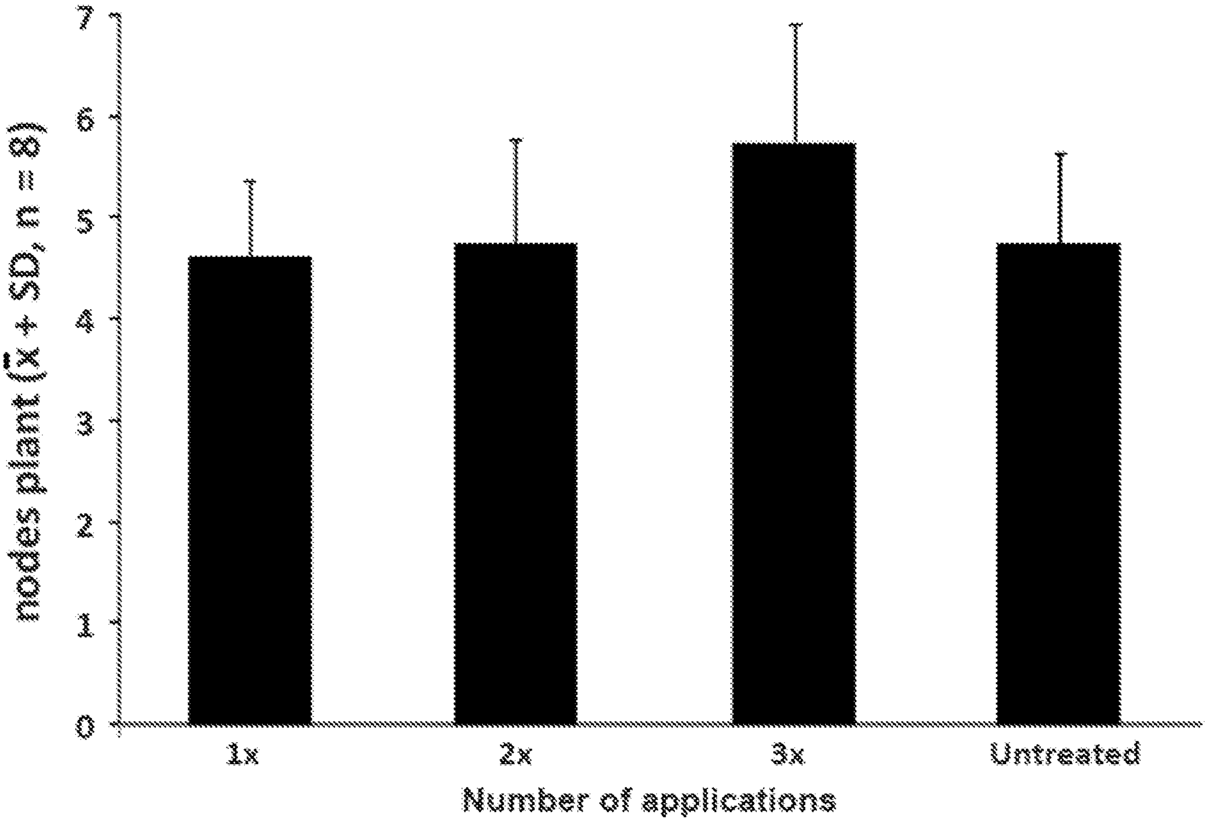

nodes plant (x̄ + SD, n = 8)
7
6
5
4
3
2
1
0
1x
2x
3x
Untreated
Number of applications

FIGURE 5A

FIGURE 5B

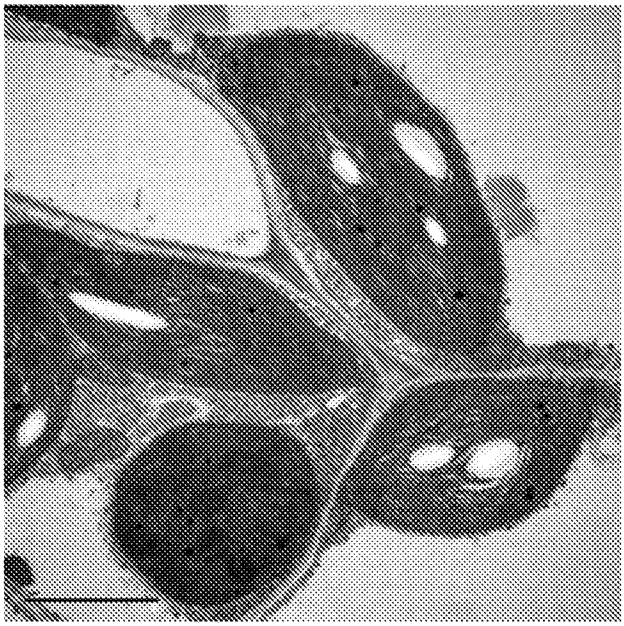


FIGURE 5C

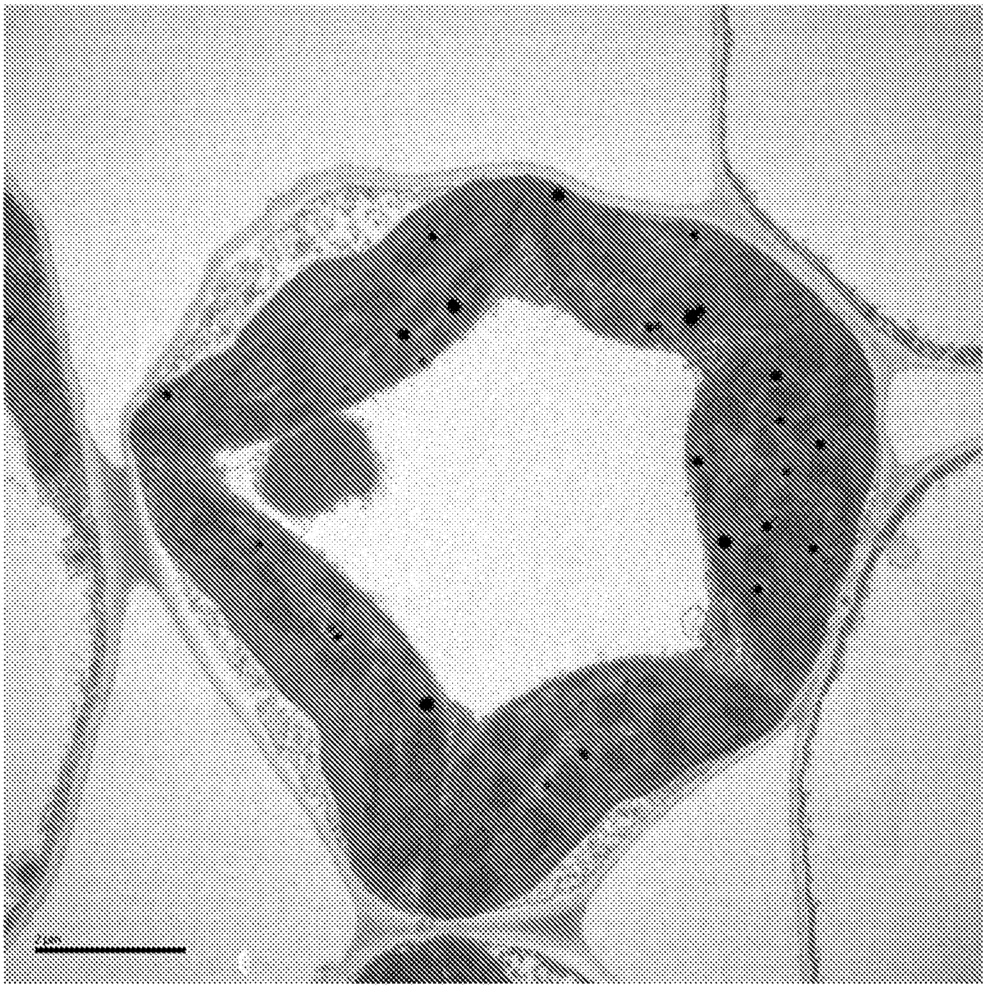
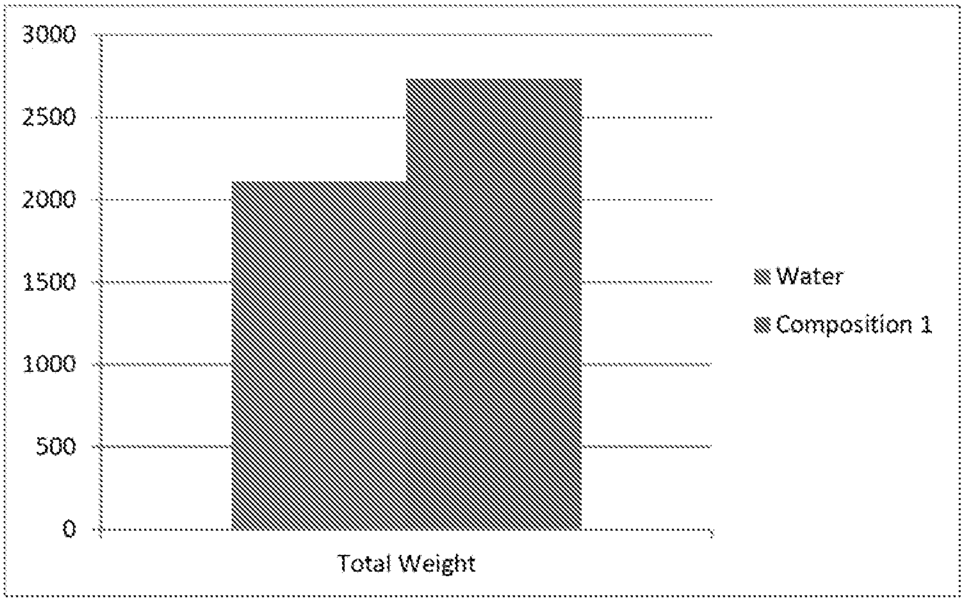


Figure 6


3000
2500
2000
1500
1000
500
0
Total Weight
Water
Composition 1

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/054701

A. CLASSIFICATION OF SUBJECT MATTER
INV. A01N49/00 A01N27/00
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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2008/146444 A1 (FABRI JON O [US] ET AL) 19 June 2008 (2008-06-19) paragraph [0001] paragraphs [0011] - [0013] paragraphs [0035] - [0046] paragraphs [0066] - [0070] example 1 claims 1-3 -----	1,2,4-6, 8-11,13, 16,24,25
X	WO 03/020024 A2 (XIMED GROUP PLC [US]; FRANKLIN LANNY U [US]) 13 March 2003 (2003-03-13) page 12, line 20 - page 14, line 22 page 21, line 14 - page 22, line 3 examples 2,5, 13 ----- -/--	1,2,4-6, 8-11,13, 24,25

[X] Further documents are listed in the continuation of Box C.

[X] 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	Date of mailing of the international search report
1 February 2013	12/02/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Hateley, Martin

2

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2004/006679 A2 (CODENA INC [CA]; CHIASSON HELENE [CA]) 22 January 2004 (2004-01-22) page 4, lines 9-19 page 11, lines 4-13 page 12, line 13 - page 13, line 17 pages 49-50 claims 1-6, 14-18 -----	1,2,4-7, 12-15, 17,18, 24,25
X	WO 2010/144919 A1 (AGRAQUEST INC [US]; JIMENEZ DESMOND [US]; JANSSEN GISELLE [US]; LONG D) 16 December 2010 (2010-12-16) page 1, lines 5-10 page 5, line 21 - page 6, line 25 page 9, lines 18-23 example 3; table 5 -----	1,2,4-7, 12-15, 17,18, 24,25
X	WO 01/67868 A2 (URGEL DELISLE & ASSOCIES INC [CA]; CHIASSON HELENE [CA]) 20 September 2001 (2001-09-20) page 4, line 18 - page 7, line 14 page 9, lines 23-31 example 8; table 10 -----	1,2,4-7, 12-15, 17,18, 24,25
X	EP 0 063 194 A1 (IWAMURA JUNICHI [JP]; DAIGAKU GAKKO HOJIN KINKI [JP]; KOMAI KOICHIRO [) 27 October 1982 (1982-10-27) page 1, lines 1-3 page 2, lines 1-13 page 4, line 23 - page 5, line 28 -----	3
A	BAPAT V A ET AL: "Ripening of fleshy fruit: Molecular insight and the role of ethylene", BIOTECHNOLOGY ADVANCES, ELSEVIER PUBLISHING, BARKING, GB, vol. 28, no. 1, 1 January 2010 (2010-01-01), pages 94-107, XP026796005, ISSN: 0734-9750 [retrieved on 2009-10-20] the whole document -----	3

2

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2012/054701

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 2008146444	A1	19-06-2008	NONE			
WO 03020024	A2	13-03-2003	BR	0212163	A	07-12-2004
			EP	1420640	A2	26-05-2004
			MX	PA04001906	A	07-03-2005
			NZ	531492	A	30-11-2007
			US	2004248764	A1	09-12-2004
			WO	03020024	A2	13-03-2003
WO 2004006679	A2	22-01-2004	AU	2003246476	A1	02-02-2004
			CA	2491880	A1	22-01-2004
			EP	1521530	A2	13-04-2005
			JP	2005536495	A	02-12-2005
			MX	NL05000006	A	01-09-2005
			US	2003091657	A1	15-05-2003
			US	2005013885	A1	20-01-2005
			US	2009030087	A1	29-01-2009
			WO	2004006679	A2	22-01-2004
WO 2010144919	A1	16-12-2010	AR	077099	A1	03-08-2011
			CA	2764208	A1	16-12-2010
			EP	2440061	A1	18-04-2012
			US	2010316738	A1	16-12-2010
			WO	2010144919	A1	16-12-2010
WO 0167868	A2	20-09-2001	AU	4215501	A	24-09-2001
			AU	2001242155	B2	02-06-2005
			CA	2403333	A1	20-09-2001
			CN	1469710	A	21-01-2004
			EP	1301079	A2	16-04-2003
			IL	151786	A	17-06-2007
			MX	PA02009135	A	05-04-2004
			NZ	521666	A	24-09-2004
			WO	0167868	A2	20-09-2001
EP 0063194	A1	27-10-1982	AU	549746	B2	13-02-1986
			AU	8225382	A	07-10-1982
			CA	1170855	A1	17-07-1984
			DE	3169861	D1	15-05-1985
			EP	0063194	A1	27-10-1982
			ES	8302023	A1	01-04-1983
			JP	57165302	A	12-10-1982
			JP	59024123	B	07-06-1984
			NZ	200176	A	31-05-1984
			US	4449997	A	22-05-1984