The present invention relates to a method for improving the plant growth regulation of crop plants, by applying to the plants a mixture of a plant growth regulator, and cis-jasmone, and to a composition comprising the same.
The present invention relates to a method for improving the plant growth regulation of crop plants, by applying to the crop plants a mixture of a plant growth regulator and czs-jasmone, and to a composition comprising the same.

Plant growth regulators are often used to regulate the growth and development of crop plants. For example, plant growth regulators are used to slow the development of a crop (such as oil seed rape) so that it flowers at a desired time, reduce the height of a crop (such as in cereals) so that it is less susceptible to lodging, increase nitrogen efficiency, regulate flowering and fruit set of a crop (such as fruit trees), and slow turfgrass growth rate to reduce mowing frequency.

There are several different classes of plant growth regulator. Known classes include azoles (such as uniconazole, and paclobutrazol), cyclohexane carboxylates (such as trinexapac-ethyl, and prohexadione-calcium), pyrimidinyl carbinols (such as flurprimidol, and ancymidol), quarternary ammoniums (such as chlormequat-chloride, and mepiquat-chloride), and sulphonyl-amino phenyl-acetamides (such as mefluidide).

Plant growth regulators operate by various modes of action. For example, onium-type plant growth retardants such as chlormequat-chloride and mepiquat-chloride, that possess a positively charged ammonium, phosphonium or sulphonium group, function by blocking the synthesis of gibberellin early in the biosynthetic pathway. Growth retardants comprising a nitrogen-containing heterocycle, such as flurprimidol, paclobutrazol and uniconazole-P, act as inhibitors of monooxygenases that catalyse oxidative steps in gibberellin biosynthesis. Structural mimics of 2-oxoglutaric acid, such as the acylcyclohexanediones trinexapac-ethyl and prohexadione-calcium, interfere with the late steps of gibberellin biosynthesis. Other plant growth regulators, such as mefluidide, inhibit cell division and differentiation.

Plant growth regulators such as trinexapac-ethyl are commonly used on crops to reduce the risk of lodging through stem thickening and shortening, and improved rooting.
In some cases, active ingredients have been shown to be more effective when mixed with other active ingredients compared to when applied individually, and this is referred to as "synergism”, since the combination demonstrates a potency or activity level exceeding that which it would be expected to have based on knowledge of the individual potencies of the components.

WO 1/4 1568 describes that εζ-jasmone can be used as a semiochemical that changes the behaviour of insects and/or the physiology of plants. WO2009/060165 discloses mixtures of plant synergists such as piperonyl butoxide with plant activators such as εζ-jasmone.

WO20 10/063446 relates to methods for improving turfgrass quality by applying to the turfgrass a plant growth regulator and jasmonic acid. WO201 1/063946 relates to a method for improving plant growth regulation and/or enhancing crop plants by applying a mixture of a plant growth regulator and jasmonic acid or salt or ester thereof. Although εζ-jasmone is described in the literature to be a metabolite of jasmonic acid (Koch et al. (1997) Helvetica Chimica Acta 80, p.838-850), neither WO2010/063446 nor WO201 1/063946 discloses cis-jasmone, or suggest that this inactive and volatile metabolite might be useful in promoting or regulating the growth of plants.

The present invention resides in the discovery that plant growth regulators exhibit an improved plant growth regulation effect when applied in combination with εζ-jasmone. It has been found that plant growth regulators, in particular acyclcyclohexanediones, can be used to effectively regulate the growth of crop plants even when growth of the plants has been promoted using εζ-jasmone. In particular, trinexapac-ethyl is surprisingly able to counteract the lodging problem associated with εζ-jasmone induced growth promotion. This is particularly useful because it enables the growth of plants, especially monocots such as cereals, to be promoted without resulting in lodging, and can therefore lead to higher yields. Further, despite the growth promotion effects of εζ-jasmone, it has been found that plant growth regulators are more effective at preventing lodging when applied in combination with εζ-jasmone than when applied alone. Trinexapac-ethyl has also been shown to counteract the growth stimulation of εζ-jasmone in turf. This is also useful because it allows the improvement of turf growth, colour and quality without increasing the need for mowing (reductions in clippings).
According to the present invention, there is provided a method for regulating the growth of crop plants, comprising applying to the plants, plant parts, plant propagation material, or a plant growing locus, a plant growth regulator and cis-jasmine. Suitably, the plant growth regulator and cis-jasmine are each applied in effective amounts. In particular, they may be applied in synergistically effective amounts. In one embodiment, there is provided a method for regulating the growth of crop plants, comprising applying to the plants, plant parts, plant propagation material, or a plant growing locus, a plant growth regulator and cis-jasmine, and no other active ingredient.

The term 'regulating the growth' includes restricting shoot growth, promoting root growth, stunting, and the like.

The term 'plants' refers to all physical parts of a plant, including seeds, seedlings, saplings, roots, tubers, stems, stalks, foliage and fruits.

The term 'plant propagation material' denotes generative parts of the plant, such as seeds, which can be used for the multiplication of the latter, and vegetative material, such as cuttings or tubers, for example potatoes. In particular, it includes seeds (in the strict sense), roots, fruits, tubers, bulbs, rhizomes and parts of plants. Germinated plants and young plants which are to be transplanted after germination or after emergence from the soil, may also be mentioned - these young plants may be protected before transplantation by a total or partial treatment by immersion. Suitably "plant propagation material" is understood to denote seeds.

The term 'plant growing locus' is intended to embrace the place on which the plants are growing, where the plant propagation materials of the plants are sown or where the plant propagation materials of the useful plants will be placed into the soil. An example for such a locus is a field, on which crop plants are growing.

There is also provided a method for enhancing crop plants, comprising applying to the plants, plant parts, plant propagation material, or a plant growing locus, a plant growth regulator and cis-jasmine. Suitably, the plant growth regulator and cis-jasmine are each applied in effective amounts. In particular they may be applied in synergistically effective amounts. In one embodiment, there is provided a method for enhancing crop plants, comprising applying
to the plants, plant parts, plant propagation material, or a plant growing locus, a plant growth regulator and czs-jasmone, and no other active ingredient.

'Enhancing crop plants' means improving plant quality and/or plant vigour and/or tolerance to stress factors, any of which may lead to increased yield. In one embodiment, the present invention relates to a method for improving plant yield, comprising applying to the plant, plant part, plant propagation material, or a plant growing locus, a plant growth regulator and czs-jasmone. Such improved yield may be as a result of improved root growth. In a further embodiment, the present invention relates to a method for improving plant vigour and/or plant quality, and/or plant tolerance to stress factors, comprising applying to the plant, plant part, plant propagation material, or a plant growing locus, a plant growth regulator and cis-jasmone.

An improvement in plant vigour means that certain traits are improved qualitatively or quantitatively when compared with the same trait in a control plant which has been grown under the same conditions in the absence of the method of the invention. Such traits include, but are not limited to, early and/or improved germination, improved emergence, the ability to use less seeds, increased root growth, a more developed root system, increased shoot growth, increased tillering, stronger tillers, more productive tillers, increased or improved plant stand, less plant verse (lodging), an increase and/or improvement in plant height, an increase in plant weight (fresh or dry), bigger leaf blades, greener leaf colour, increased pigment content, increased chlorophyll content, increased photosynthetic activity, earlier flowering, homogenous flowering, longer panicles, early grain maturity, increased seed, fruit or pod size, increased pod or ear number, increased seed number per pod or ear, increased seed mass, enhanced seed filling, less dead basal leaves, delay of senescence, improved vitality of the plant and/or less inputs needed (e.g. less fertiliser, water and/or labour needed). A plant with improved vigour may have an increase in any of the aforementioned traits or any combination or two or more of the aforementioned traits. Suitably, the method of the present invention increases plant height, plant weight and/or provides enhanced germination.

An improvement in plant quality means also that certain traits are improved qualitatively or quantitatively when compared with the same trait in a control plant which has been grown under the same conditions in the absence of the method of the invention. Such traits include, but are not limited to, improved visual appearance of the plant (e.g. improved colour, density,
uniformity, compactness), reduced ethylene (reduced production and/or inhibition of 
reception), improved quality of harvested material, e.g. seeds, fruits, leaves, vegetables (such 
improved quality may manifest as improved visual appearance of the harvested material, 
improved carbohydrate content (e.g. increased quantities of sugar and/or starch, improved 
sugar acid ratio, reduction of reducing sugars, increased rate of development of sugar), 
improved protein content, improved oil content and composition, improved nutritional value, 
reduction in anti-nutritional compounds, improved organoleptic properties (e.g. improved 
taste) and/or improved consumer health benefits (e.g. increased levels of vitamins and anti-
oxidants)), improved post-harvest characteristics (e.g. enhanced shelf-life and/or storage 
ability, easier processability, easier extraction of compounds) and/or improved seed quality 
(e.g. for use in following seasons). A plant with improved quality may have an increase in 
y any of the aforementioned traits or any combination or two or more of the aforementioned 
traits.

An improved tolerance to stress factors means that certain traits are improved qualitatively or 
quantitatively when compared with the same trait in a control plant which has been grown 
under the same conditions in the absence of the method of the invention. Such traits include, 
but are not limited to, an increased tolerance and/or resistance to abiotic stress factors which 
cause sub-optimal growing conditions such as drought (e.g. any stress which leads to a lack 
of water content in plants, a lack of water uptake potential or a reduction in the water supply 
to plants), cold exposure, heat exposure, osmotic stress, UV stress, flooding, increased 
salinity (e.g. in the soil), increased mineral exposure, ozone exposure, high light exposure 
and/or limited availability of nutrients (e.g. nitrogen and/or phosphorus nutrients). A plant 
with improved tolerance to stress factors may have an increase in any of the aforementioned 
traits or any combination or two or more of the aforementioned traits. In the case of drought 
and nutrient stress, such improved tolerances may be due to, for example, more efficient 
uptake, use or retention of water and nutrients. Suitably, the method of the present invention 
increases tolerance of plants to drought.

Other crop enhancements include a decrease in plant height, or reduction in tillering, which 
are beneficial features in crops or conditions where it is desirable to have less biomass and 
fewer tillers.
Any or all of the above crop enhancements may lead to an improved yield by improving e.g. plant physiology, plant growth and development and/or plant architecture. In the context of the present invention 'yield' includes, but is not limited to, (i) an increase in biomass production, grain yield (e.g. grain size, grain number, grain density), starch content, oil content and/or protein content, which may result from (a) an increase in the amount produced by the plant per se or (b) an improved ability to harvest plant matter, (ii) an improvement in the composition of the harvested material (e.g. improved sugar acid ratios, improved oil composition, increased nutritional value, reduction of anti-nutritional compounds, increased consumer health benefits) and/or (iii) an increased/facilitated ability to harvest the crop, improved processability of the crop and/or better storage stability/shelf life. Increased yield of an agricultural plant means that, where it is possible to take a quantitative measurement, the yield of a product of the respective plant is increased by a measurable amount over the yield of the same product of the plant produced under the same conditions, but without application of the present invention. According to the present invention, it is preferred that the yield be increased by at least 0.5%, more preferred at least 1%, even more preferred at least 2%, still more preferred at least 4%, preferably 5% or even more.

Any or all of the above crop enhancements may also lead to an improved utilisation of land, i.e. land which was previously unavailable or sub-optimal for cultivation may become available. For example, plants which show an increased ability to survive in drought conditions, may be able to be cultivated in areas of sub-optimal rainfall, e.g. perhaps on the fringe of a desert or even the desert itself.

The term 'synergistically effective amount' indicates the quantity of such compounds which is capable of modifying the effect on the growth of plants, where said effect is greater than the sum of the effects obtained by applying each of the compounds individually.

Cis-jasmone is a volatile component of plants that can act either as an attractant or repellent for various insects, either itself, or by inducing the production of other plant volatiles. Release of cis-jasmone can be induced by damage, for example during feeding by insects, and as such is part of the plant defence against insects. It is produced by metabolism of jasmonic acid or methyl jasmonate. The structure of cis-jasmone is shown in formula (I):
Any plant growth regulator may be used in accordance with the present invention. A complete list of all commercially available plant growth regulators may be obtained from the Pesticide Manual (14th edition, published by the British Crop Protection Council). In one embodiment, the plant growth regulator is selected from the group consisting of trinexapac-ethyl, prohexadione-calcium, paclobutrazol, uniconazole, flurprimidol, mefluidide, mepiquat-chloride, chlormequat-chloride, and a mixture thereof.

Suitably, the plant growth regulator is a gibberellin biosynthesis inhibitor. Suitably, the plant growth regulator is a class A gibberellin biosynthesis inhibitor. Suitably, the plant growth regulator is a class B gibberellin biosynthesis inhibitor. In a preferred embodiment the plant growth regulator is trinexapac-ethyl, prohexadione-calcium or chlormequat-chloride. In one embodiment, the plant growth regulator is trinexapac-ethyl. In one embodiment, the plant growth regulator is prohexadione-calcium. In one embodiment, the plant growth regulator is chlormequat-chloride. In one embodiment, the plant growth regulator is paclobutrazol. In one embodiment, the plant growth regulator is flurprimidol.

In one embodiment, the plant growth regulator is an acylcyclohexanedione.

If desired, it is possible to use more than one plant growth regulator in combination, in accordance with the present invention, such as mixtures of trinexapac-ethyl and paclobutrazol.

In the present invention, the mixture ratio of plant growth regulator to czs-jasmone at which the growth regulation effect is synergistic lies within the range from about 1:1000 to about 1000:1 by weight. Suitably, the mixture ratio of plant growth regulator to czs-jasmone is from about 1:100 to about 100:1 by weight. More suitably, the mixture ratio of plant growth regulator to czs-jasmone is from about 10:1 to about 1:10 by weight. For example, when the
plant growth regulator is trinexapac-ethyl, a mixture ratio of trinexapac-ethyl to czs-jasmone from about 5:1 to about 1:5 by weight is preferred, with a mixture ratio from 1:1 to 1:3 more preferred.

The rate of application of the compounds of the present invention may vary within wide limits and depends upon the nature of the soil, the method of application, the target insect pest to be controlled, the prevailing climatic conditions, and other factors governed by the method of application and the time of application. The compounds of the present invention are generally applied at a rate of 0.001 to 4 kg/ha, especially from 0.005 to 1 kg/ha, in particular of 0.01 to 0.5 kg/ha. Suitably, the plant growth regulator is applied at a rate from about 50 to about 300 g ai/ha, and czs-jasmone is applied at a rate from about 100 to about 500 g ai/ha. A particularly preferred rate of czs-jasmone is 300 g ai/ha.

The method of the present invention may be applied to any crop plants, in particular monocotyledons such as cereals (wheat, millet, sorghum, rye, triticale, oats, barley, teff, spelt, buckwheat, fonio and quinoa), rice, maize (corn), and/or sugar cane; or dicotyledon crops such as beet (such as sugar beet or fodder beet); fruits (such as pomes, stone fruits or soft fruits, for example apples, pears, plums, peaches, almonds, cherries, strawberries, raspberries or blackberries); leguminous plants (such as beans, lentils, peas or soybeans); oil plants (such as rape, mustard, poppy, olives, sunflowers, coconut, castor oil plants, cocoa beans or groundnuts); cucumber plants (such as marrows, cucumbers or melons); fibre plants (such as cotton, flax, hemp or jute); citrus fruit (such as oranges, lemons, grapefruit or mandarins); vegetables (such as spinach, lettuce, cabbages, carrots, tomatoes, potatoes, cucurbits or paprika); lauraceae (such as avocados, cinnamon or camphor); tobacco; nuts; coffee; tea; vines; hops; durian; bananas; natural rubber plants; turfgrasses; and ornamentals (such as flowers, shrubs, broad-leaved trees or evergreens, for example conifers). This list does not represent any limitation.

Suitably the crop plants are monocotyledonous plants. More suitably, the crop plants are cereals, in particular wheat, barley or rye. In one embodiment, the cereal crop is wheat. In a further embodiment, the cereal crop is barley. In a further embodiment, the crop plants are rye plants. In a further embodiment, the crop plants are rice plants. In a further embodiment, the crop plants are sugar cane plants. In further embodiment, the crop plants are corn plants. In a further embodiment, the crop is turfgrass.
The term turfgrass as used herein refers to any grass species from the family Gramineae. For example the grass species may belong to the genera Agropyron, Agrostis, Axonopus, Bromus, Buchloe, Cynodon, Eremochloa, Festuca, Lolium, Paspalum, Pennisetum, Phleum, Poa, Stenotaphrum or Zoysia. Turfgrass may include more than one grass species.

In a preferred embodiment of the present invention the turfgrass is bentgrass. However, the present invention can be practiced with all turfgrasses, including cool season turfgrass and warm season turfgrass.

Cool season turfgrasses include, for example: Bluegrasses (Poa L.), such as Kentucky Bluegrass (Poa pratensis L.), Rough Bluegrass (Poa trivialis L.), Canada Bluegrass (Poa compressa L.) and Annual Bluegrass (Poa annua L.); Bentgrasses (Agrostis L.), such as Creeping Bentgrass (Agrostis palustris Huds.), Colonial Bentgrass (Agrostis tenius Sibth.), Velvet Bentgrass (Agrostis canina L.) and Redtop (Agrostis alba L.); Fescues (Festuca L.), such as Creeping Red Fescue (Festuca rubra L.), Chewings Fescue (Festuca rubra var. commutata Gaud.), Sheep Fescue (Festuca ovina L.), Hard Fescue (Festuca longifolia), Tall Fescue (Festuca arundinacea Schreb.), Meadow Fescue (Festuca elatior L.); Ryegrasses (Lolium L.), such as Perennial Ryegrass (Lolium perenne L.), Annual (Italian) Ryegrass (Lolium multiflorum Lam.); Wheatgrasses (Agropyron Gaertn.), such as Fairway Wheatgrass (Agropyron cristatum (L.) Gaertn.), Western Wheatgrass (Agropyron smithii Rydb.); Smooth Brome (Bromus inermis Leyss.); and Timothy (Phleum L.).

Warm season turfgrasses include, for example Bermudagrasses (Cynodon L. C. Rich), Zoysiagrasses (Zoysia Willd.), St. Augustinegrass (Stenotaphrum secundatum (Walt.) Kuntze), Centipedegrass (Eremochloa ophiuroides (Munro.) Hack.), Carpetgrass (Axonopus Beauv.), Bahiagrass (Paspalum notatum Flugge.), Kikuyugrass (Pennisetum clandestinum Hochst. ex Chiov.), Buffalo grass (Buchloe dactyloides (Nutt.) Engelm.), Centipedegrass (Eremochloa spp) and Seashore paspalum (Paspalum vaginatum swartz).

Suitably the crop plants are dicotyledonous plants. In one embodiment, the crop plants are oil seed rape plants.
Crops include those that have been rendered tolerant to herbicides like bromoxynil or classes of herbicides (such as HPPD inhibitors, ALS inhibitors (for example primisulfuron, prosulfuron and trifloxysulfuron), EPSPS (5-enol-pyrovyl-shikimate-3-phosphate-synthase) inhibitors, GS (glutamine synthetase) inhibitors or PPO (protoporphyrinogen-oxidase) inhibitors) as a result of conventional methods of breeding or genetic engineering. An example of a crop that has been rendered tolerant to imidazolinones, e.g. imazamox, by conventional methods of breeding (mutagenesis) is Clearfield® summer rape (Canola). Examples of crops that have been rendered tolerant to herbicides or classes of herbicides by genetic engineering methods include glyphosate- and glufosinate-resistant maize varieties commercially available under the trade names RoundupReady®, Herculex I® and LibertyLink®. Crops also includes plants that have been transformed by the use of recombinant DNA techniques so that they are capable of synthesising one or more selectively acting toxins, such as are known, for example, from toxin-producing bacteria, especially those of the genus Bacillus. Crops also includes plants which have been transformed by the use of recombinant DNA techniques so that they are capable of synthesising antipathogenic substances having a selective action, such as, for example, the so-called "pathogenesis-related proteins". Examples of such antipathogenic substances and transgenic plants capable of synthesising such antipathogenic substances are known, for example, from EP-A-0 392 225, WO 95/33818, and EP-A-0 353 191. The methods of producing such transgenic plants are generally known to the person skilled in the art and are described, for example, in the publications mentioned above.

The plant growth regulator and czs-jasmone of the present invention may be applied either simultaneously or sequentially in any order. If administered sequentially, the components may be administered in any order in a suitable timescale, for example, with no longer than 1 month, no longer than 1 week, or no longer than 24 hours between the time of administering the first component and the time of administering the last component. Suitably, the components are administered within a timescale of a few hours, such as one hour. If the plant growth regulator and czs-jasmone components are administered simultaneously, they may be administered separately or as a tank mix or as a pre-formulated mixture. In one embodiment the mixture or composition of the present invention may be applied to the crop plants as a seed treatment prior to planting.
When the method of the present invention refers to the application to crop plants of a co-
formulated composition, the composition comprises both plant growth regulator and cis-
jasmones. The compounds may be homogeneously mixed together with other formulation
components necessary to make the desired formulation type, as is known to those skilled in
the art.

In one embodiment of the present invention, the plant growth regulator and cis-jasmones, are
applied in the form of a composition comprising an agriculturally acceptable carrier.

In one aspect of the present invention, there is provided a composition comprising a plant
growth regulator and cis-jasmones, and optionally an agriculturally acceptable carrier. In one
aspect of the present invention, there is provided a composition comprising a plant growth
regulator, cis-jasmones, and optionally an agriculturally acceptable carrier, but no other active
ingredient. In a further aspect of the invention, there is provided a composition consisting
essentially of a plant growth regulator, cis-jasmones, and at least one agriculturally acceptable
carrier. In a further aspect of the invention, there is provided a composition consisting
essentially of a plant growth regulator, cis-jasmones, and an agriculturally acceptable carrier.
In a further aspect of the invention, there is provided a composition comprising (i) active
ingredients consisting of a plant growth regulator and cis-jasmones, and (ii) an agriculturally
acceptable carrier. In a further aspect of the invention, there is provided a composition
consisting of a plant growth regulator, cis-jasmones, and an agriculturally acceptable carrier.
In a further aspect of the invention, there is provided a composition consisting of a plant
growth regulator and cis-jasmones. Suitably, the plant growth regulator is trinexapac-ethyl.

The compounds of the present invention may be used in unmodified form, but are generally
formulated into compositions using formulation adjuvants, such as carriers, solvents and
surface-active substances. The formulations can be in various physical forms, for example
dusting powders, gels, wettable powders, water-dispersible granules, water-dispersible
tabs, effervescent compressed tablets, emulsifiable concentrates, microemulsifiable
concentrates, oil-in-water emulsions, oil flowables, aqueous dispersions, oil dispersions,
suspoemulsions, capsule suspensions, emulsifiable granules, soluble liquids, water-soluble
concentrates (with water or a water-miscible organic solvent as carrier), or impregnated
polymer films. Such formulations can either be used directly or are diluted prior to use.
Diluted formulations can be prepared, for example, with water, liquid fertilizers, micro-
nutrients, biological organisms, oil or solvents. These formulations may contain as little as about 0.5% to as much as about 95% or more by weight of active ingredient. The optimum amount for any given compound will depend on formulation, application equipment and nature of the plants to be controlled.

Wettable powders are in the form of finely divided particles which disperse readily in water or other liquid carriers. The particles contain the active ingredient retained in a solid matrix. Typical solid matrices include fuller’s earth, kaolin clays, silicas and other readily wet organic or inorganic solids. Wettable powders normally contain about 5% to about 95% of the active ingredient plus a small amount of wetting, dispersing or emulsifying agent.

Emulsifiable concentrates are homogeneous liquid compositions dispersible in water or other liquid and may consist entirely of the active compound with a liquid or solid emulsifying agent, or may also contain a liquid carrier, such as xylene, heavy aromatic naphthas, isophorone and other non-volatile organic solvents. In use, these concentrates are dispersed in water or other liquid and normally applied as a spray to the area to be treated. The amount of active ingredient may range from about 0.5% to about 95% of the concentrate.

Granular formulations include both extrudates and relatively coarse particles and are usually applied without dilution to the area in which suppression of vegetation is desired. Typical carriers for granular formulations include fertiliser, sand, fuller’s earth, attapulgite clay, bentonite clays, montmorillonite clay, vermiculite, perlite, calcium carbonate, brick, pumice, pyrophyllite, kaolin, dolomite, plaster, wood flour, ground corn cobs, ground peanut hulls, sugars, sodium chloride, sodium sulphate, sodium silicate, sodium borate, magnesia, mica, iron oxide, zinc oxide, titanium oxide, antimony oxide, cryolite, gypsum, diatomaceous earth, calcium sulphate and other organic or inorganic materials which absorb or which can be coated with the active compound. Particularly suitable is a fertiliser granule carrier. Granular formulations normally contain about 5% to about 25% active ingredients which may include surface-active agents such as heavy aromatic naphthas, kerosene and other petroleum fractions, or vegetable oils; and/or stickers such as dextrins, glue or synthetic resins. The granular substrate material can be one of the typical carriers mentioned above and/or can be a fertiliser material e.g. urea/formaldehyde fertilisers, ammonium, liquid nitrogen, urea, potassium chloride, ammonium compounds, phosphorus compounds, sulphur, similar plant nutrients and micronutrients and mixtures or combinations thereof. The plant growth
regulator and cis-jasnone may be homogeneously distributed throughout the granule or may be spray impregnated or absorbed onto the granule substrate after the granules are formed.

Encapsulated granules are generally porous granules with porous membranes sealing the granule pore openings, retaining the active species in liquid form inside the granule pores. Granules typically range from 1 millimetre to 1 centimetre, preferably 1 to 2 millimetres in diameter. Granules are formed by extrusion, agglomeration or prilling, or are naturally occurring. Examples of such materials are vermiculite, sintered clay, kaolin, attapulgite clay, sawdust and granular carbon. Shell or membrane materials include natural and synthetic rubbers, cellulosic materials, styrene-butadiene copolymers, polyacrylonitriles, polyacrylates, polyesters, polyamides, polyureas, polyurethanes and starch xanthates.

Dusts are free-flowing admixtures of the active ingredient with finely divided solids such as talc, clays, flours and other organic and inorganic solids which act as dispersants and carriers.

Microcapsules are typically droplets or granules of the active material enclosed in an inert porous shell which allows escape of the enclosed material to the surroundings at controlled rates. Encapsulated droplets are typically about 1 to 50 microns in diameter. The enclosed liquid typically constitutes about 50 to 95% of the weight of the capsule and may include solvent in addition to the active compound.

Other useful formulations for plant growth regulation applications include simple solutions of the active ingredients in a solvent in which it is completely soluble at the desired concentration, such as acetone, alkylated naphthalenes, xylene and other organic solvents. Pressurised sprayers, wherein the active ingredient is dispersed in finely-divided form as a result of vaporisation of a low boiling dispersant solvent carrier, may also be used.

Many of the formulations described above include wetting, dispersing or emulsifying agents. Examples are alkyl and alkylaryl sulphonates and sulphates and their salts, polyhydric alcohols; polyethoxylated alcohols, esters and fatty amines. These agents, when used, normally comprise from 0.1% to 15% by weight of the formulation.

Suitable agricultural adjuvants and carriers, either formulated together and/or added separately, that are useful in formulating the compositions of the invention in the formulation
types described above are well known to those skilled in the art. Suitable examples of the
different classes are found in the non-limiting list below.

Liquid carriers that can be employed include water, toluene, xylene, petroleum naphtha, crop
oils, AMS; acetone, methyl ethyl ketone, cyclohexanone, acetic anhydride, acetonitrile,
acetophenone, amyl acetate, 2-butane, chlorobenzene, cyclohexane, cyclohexanol, alkyl
acetates, diacetonalcohol, 1,2-dichloropropane, diethanolamine, p-diethylbenzene, diethylene
glycol, diethylene glycol abietate, diethylene glycol butyl ether, diethylene glycol ethyl ether,
diethylene glycol methyl ether, N,N-dimethyl formamide, dimethyl sulfoxide, 1,4-dioxane,
dipropylene glycol, dipropylene glycol methyl ether, dipropylene glycol dibenzoate,
diproxitol, alkyl pyrrolidinone, ethyl acetate, 2-ethyl hexanol, ethylene carbonate, 1,1,1-
trichloroethane, 2-heptanone, alpha pinene, d-limonene, ethylene glycol, ethylene glycol
butyl ether, ethylene glycol methyl ether, gamma-butyrolactone, glycerol, glycerol diacetate,
glycerol monoacetate, glycerol triacetate, hexadecane, hexylene glycol, isoamyl acetate,
isobornyl acetate, isoctane, isophorone, isopropyl benzene, isopropyl myristate, lactic acid,
laurylamine, mesityl oxide, methoxy-propanol, methyl isoamyl ketone, methyl isobutyl
ketone, methyl laurate, methyl octanoate, methyl oleate, methylene chloride, m-xylene, n-
hexane, n-octylamine, octadecanoic acid, octyl amine acetate, oleic acid, oleylamine, o-
xylene, phenol, polyethylene glycol (PEG400), propionic acid, propylene glycol, propylene
glycol monomethyl ether, p-xylene, toluene, triethyl phosphate, triethylene glycol, xylene
sulfonic acid, paraffin, mineral oil, trichloroethylene, perchloroethylene, ethyl acetate, amyl
acetate, butyl acetate, methanol, ethanol, isopropanol, and higher molecular weight alcohols
such as amyl alcohol, tetrahydrofurfuryl alcohol, hexanol, octanol, etc. ethylene glycol,
propylene glycol, glycerine, N-methyl-2-pyrrolidinone, and the like. Water is generally the
carrier of choice for the dilution of concentrates.

Suitable solid carriers include talc, titanium dioxide, pyrophyllite clay, silica, attapulgite clay,
kieselguhr, chalk, diatomaceous earth, lime, calcium carbonate, bentonite clay, fuller's earth,
fertiliser, cotton seed hulls, wheat flour, soybean flour, pumice, wood flour, walnut shell
flour, lignin and the like.

A broad range of surface-active agents are advantageously employed in both said liquid and
solid compositions, especially those designed to be diluted with carrier before application.
The surface-active agents can be anionic, cationic, non-ionic or polymeric in character and
can be employed as emulsifying agents, wetting agents, suspending agents or for other purposes. Typical surface active agents include salts of alkyl sulfates, such as diethanolammonium lauryl sulphate; alkylaryl sulfonate salts, such as calcium dodecylbenzenesulfonate; alkylphenol-alkylene oxide addition products, such as nonylphenol-C.sub. 18 ethoxylate; alcohol-alkylene oxide addition products, such as tridecyl alcohol-C.sub. 16 ethoxylate; soaps, such as sodium stearate; alkylnaphthalenesulfonate salts, such as sodium dibutyl naphthalenesulfonate; dialkyl esters of sulfosuccinate salts, such as sodium di(2-ethylhexyl) sulfosuccinate; sorbitol esters, such as sorbitol oleate; quaternary amines, such as lauryl trimethylammonium chloride; polyethylene glycol esters of fatty acids, such as polyethylene glycol stearate; block copolymers of ethylene oxide and propylene oxide; and salts of mono and dialkyl phosphate esters.

Other adjuvants commonly utilized in agricultural compositions include crystallisation inhibitors, viscosity modifiers, suspending agents, spray droplet modifiers, pigments, antioxidants, foaming agents, light-blocking agents, compatibilizing agents, antifoam agents, sequestering agents, neutralising agents and buffers, corrosion inhibitors, dyes, odorants, spreading agents, penetration aids, micronutrients, emollients, lubricants, sticking agents, and the like. The compositions can also be formulated with liquid fertilizers or solid, particulate fertiliser carriers such as ammonium nitrate, urea and the like.

According to the present invention, there is provided the use of a composition comprising an effective amount of a plant growth regulator and czs-jasmone, for regulating the growth of crop plants, as described above.

According to the present invention, there is provided a plant growth regulating composition, comprising a plant growth regulator and czs-jasmone at a weight ratio from about 100:1 to about 1:100. Suitably, the weight ratio is from 10:1 to 1:10. In a further embodiment, the plant growth regulator and czs-jasmone are present in a synergistically effective amount. In an alternative embodiment, the plant growth regulator is trinexapac-ethyl.

Compositions of the present invention may contain from about 0.001% to about 99% by weight active ingredients. Suitably, the composition contains from about 0.001% to about 50% by weight active ingredients. More suitably, the composition contains from about 0.001% to about 10% by weight active ingredients. More suitably, the composition contains
from about 0.001% to about 1% by weight active ingredients. If the formulation is in the form of a concentrate, requiring dilution with water before use, it will contain a higher amount of active ingredients than a composition that is ready to use without dilution.

The following examples further exemplify the present invention. Although the invention has been described with reference to preferred embodiments and examples thereof, the scope of the present invention is not limited only to those described embodiments.
EXAMPLES

Example 1

A glasshouse trial was set up to compare growth regulation effects of trinexapac-ethyl, cis-jasmone, and mixtures of trinexapac-ethyl and cis-jasmone at various rates, on summer barley (Pasadena) and winter rye (Rekrut).

Table 1 describes the treatments made. Each treatment was applied as a spray to the leaves of the plant at plant growth stage 30 (start of stem elongation). Assessments of lodging were made 30 days after application; the results are expressed as percentage lodging in Table 2.

### TABLE 1: Treatment list

<table>
<thead>
<tr>
<th>Treatment Number</th>
<th>Treatment description</th>
<th>Treatment details</th>
<th>Rate (g AI / ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Check (untreated)</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>2</td>
<td>Trinexapac-ethyl (TXP) only</td>
<td>Moddus®</td>
<td>200</td>
</tr>
<tr>
<td>3</td>
<td>TXP</td>
<td>Moddus®</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>Cis-jasmone (CJN) only</td>
<td>Cis-jasmone</td>
<td>300</td>
</tr>
<tr>
<td>5</td>
<td>CJN</td>
<td>Cis-jasmone</td>
<td>150</td>
</tr>
<tr>
<td>6</td>
<td>TXP + CJN</td>
<td>Moddus® + Cis-jasmone</td>
<td>200+300</td>
</tr>
<tr>
<td>7</td>
<td>TXP + CJN</td>
<td>Moddus® + Cis-jasmone</td>
<td>100+300</td>
</tr>
<tr>
<td>8</td>
<td>TXP + CJN</td>
<td>Moddus® + Cis-jasmone</td>
<td>200+150</td>
</tr>
<tr>
<td>9</td>
<td>TXP + CJN</td>
<td>Moddus® + Cis-jasmone</td>
<td>100+150</td>
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</tbody>
</table>

### TABLE 2: Results

<table>
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<tr>
<th>Treatment Number</th>
<th>% lodging 30 DAA</th>
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</thead>
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<tr>
<td></td>
<td>Summary barley</td>
</tr>
<tr>
<td>1</td>
<td>32.2</td>
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Comparing treatments 4 and 5 to treatment 1, the results show that czs-jasmone alone significantly increases lodging. One would expect that the addition of trinexapac-ethyl would reduce the level of lodging, due to its known plant growth regulation properties. However, surprisingly, despite the growth promoting effects of \( \text{cis} \)-jasmone, the presence of trinexapac-ethyl significantly reduced lodging. At some rates lodging was completely absent (treatments 6 and 7); at other rates it was similar (treatment 9) or lower (treatment 8) than with trinexapac-ethyl alone.

In addition, the plants treated with a mixture of TXP and CJN exhibited very good plant stand at late crop development (when the ears are visible) compared to the untreated check and solo treatments. Further, the plants had more roots, and were visually healthy and vital.

**Example 2 - Barley**

A trial was setup in Switzerland to compare growth regulation effects of trinexapac-ethyl, \( \text{cis} \)-jasmone, and mixtures of trinexapac-ethyl and \( \text{cis} \)-jasmone on barley.

Table 3 describes the treatments made, and results obtained. Assessments of plant height were made 21 days after application.

**TABLE 3: Treatment list and results**

<table>
<thead>
<tr>
<th>Treatment Number</th>
<th>Treatment description</th>
<th>Treatment details</th>
<th>Rate (g AI / ha)</th>
<th>Plant height (cm) 21DAA</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Check (untreated)</td>
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<td>n/a</td>
<td>89</td>
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</table>
The results show that mixtures of trinexapac-ethyl and cis-jasmone unexpectedly exhibited a synergistic effect in reducing plant height of barley.

Example 3 - Turf

A study was conducted on *Poa annua* golf course fairway, to compare the effects of treatment with cis-jasmone alone, trinexapac-ethyl alone, and combinations of cis-jasmone and trinexapac-ethyl. Clipping weights were measured at regular intervals. The results are shown in Table 4.

<table>
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<tr>
<th>Treatment Number</th>
<th>Treatment Details</th>
<th>Rate g ai/ha</th>
<th>Treatment Description</th>
<th>4-6 June</th>
<th>10-17 June</th>
<th>17-24 June</th>
<th>24-30 June</th>
<th>3-8 July</th>
<th>Cumulative Clipping total g</th>
</tr>
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<tbody>
<tr>
<td>1.</td>
<td>Check (untreated)</td>
<td>NA</td>
<td>NA</td>
<td>21.5 ab</td>
<td>12.1 a</td>
<td>13.8 b</td>
<td>11.95 bc</td>
<td>15.7 a</td>
<td>194 bc</td>
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<td>2.</td>
<td>TXP 96</td>
<td>3 applications on a 4 week schedule</td>
<td>18.1 de</td>
<td>9.27 d</td>
<td>11.35 bc</td>
<td>10.71 bc</td>
<td>18.2 a</td>
<td>173 def</td>
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</tr>
<tr>
<td>3.</td>
<td>Cis-jasmone (CJN)</td>
<td>50</td>
<td>3 applications on a 4 week schedule</td>
<td>21.7 a</td>
<td>12.8 a</td>
<td>17.69 a</td>
<td>14.7 a</td>
<td>19.2 a</td>
<td>213.5 a</td>
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</table>
The results show that *cis*-jastone increased clipping weights, and that surprisingly the combination treatment of TXP + *cis*-jasnone significantly reduced clipping weights when compared to the untreated control. This demonstrates that trinexapac-ethyl counteracts the growth stimulation of *cis*-jasnone in turf.
CLAMS

1. A method for regulating the growth of crop plants, comprising applying to the plants a plant growth regulator and cis-jasmone.

2. A method according to claim 1, wherein no other active ingredient is applied.

3. A method according to claim 1 or 2, wherein the plant growth regulator and cis-jasmone are applied in an effective amount.

4. A method according to any of claims 1 to 3, wherein the plant growth regulator is selected from the group consisting of trinexapac-ethyl, prohexadione-calcium, paclobutrazol, uniconazole, flurprimidol, mefluidide, mepiquat-chloride, chlormequat-chloride, and a mixture thereof.

5. A method according to claim 4, wherein the plant growth regulator is trinexapac-ethyl.

6. A method according to claim 4, wherein the plant growth regulator is paclobutrazol.

7. A method according to claim 1, wherein the crop plants are monocotyledonous plants.

8. A method according to claim 7, wherein the crop plants are selected from the group consisting of cereals, rice, maize, sugar cane and turfgrass.

9. A method according to claim 1, wherein the plant growth regulator and cis-jasmone are applied to the plant in a weight ratio from about 10:1 to about 1:10.

10. A method according to claim 1, wherein the plant growth regulator is applied at a rate from about 50 to about 300 g ai/ha.

11. A method according to claim 1, wherein the cis-jasmone is applied at a rate from about 100 to about 500 g ai/ha.

13. A composition according to claim 12, comprising (i) active ingredients consisting of a plant growth regulator and *cis*-jasmone, and (ii) an agriculturally acceptable carrier.

14. A composition according to claim 12 or 13, wherein the plant growth regulator is trinexapac-ethyl.

15. A composition according to any of claims 12 to 14, wherein the plant growth regulator and *cis*-jasmone are in weight ratio from 10:1 to 1:10.

16. Use of a composition comprising an effective amount of a plant growth regulator and *cis*-jasmone, for regulating the growth of crop plants.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

INV. A01P21/00 A01N37/42 A01N43/653 A01N43/54 A01N47/02
A01N43/40 A01N33/12 A01N35/06

B. FIELDS SEARCHED

Electronic database consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal , CHEM ABS Data, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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* 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 establishes the publication date of another citation or other special reason (as specified)

O* document referring to an oral disclosure, use, exhibition or other means

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A* document member of the same patent family

Date of actual completion of the international search: 15 October 2012

Date of mailing of the international search report: 23/10/2012

Name and mailing address of the ISA:

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, 340-3016
Fax: (+31-70) 340-3016

Authorized officer:
Davi es, Maxwell

Form PCT/ISA/210 (second sheet) (April 2005)
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