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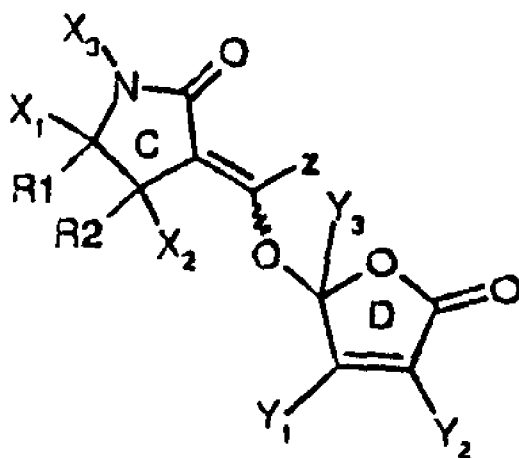
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(54) Title: COMPOSITIONS COMPRISING A STRIGOLACTAME COMPOUND FOR ENHANCED PLANT GROWTH AND YIELD



(I)

(57) Abstract: The present invention relates to strigolactame derivatives of formula (I) that are active on plants and to compositions comprising said derivatives. The present invention also relates to the use of said derivatives or compositions for enhancing the plant growth, yield, vigor and/or mycorrhization and to corresponding methods.

## COMPOSITIONS COMPRISING A STRIGOLACTAME COMPOUND FOR ENHANCED PLANT GROWTH AND YIELD

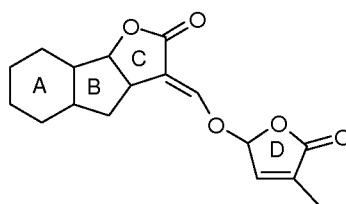
- 5 The present invention relates to strigolactame derivatives that are active on plants and to compositions comprising said derivatives. The present invention also relates to the use of said derivatives or compositions for enhancing the plant growth, yield, vigor and/or mycchorization and to corresponding methods.
- 10 Mycorrhizal symbiosis (or mycchorization) is a common symbiotic relationship between arbuscular mycorrhizal (AM) fungi and plants roots, which is highly beneficial for the plant, its growth, yield and vigor. Fungi of the phylum Glomeromycota (AM fungi) penetrate and colonize plant roots, where they differentiate into highly branched structures known as arbuscules and vesicles. AM fungi help plants to capture nutrients such as phosphorus and micronutrients from the soil. More than 80% of lands plants
- 15 are forming symbiotic associations with AM fungi.

Strigolactones have been identified in the root exudates of a variety of plant species, and have been initially disclosed as compounds capable of stimulating the seed germination of parasitic weed species, especially *Orobanche sp.* and *striga sp.* (Cook et al., 1972, J Am Chem Soc, 94, 6198-6199; Hauck et al., 1992, J Plant Physiol, 139, 474-478; Muller et al., 1992). Later, it has been shown that strigolactones can stimulate the growth of arbuscular mycorrhizae (AM) fungi (WO 2005/077177). More recently, strigolactones have been considered as a new class of plant hormones, exhibiting various biological activities (H. Proust, B. Hoffmann, X. Xie, K. Yoneyama, D. G. Schaefer, K. Yoneyama, F. Nogue, C. Rameau, *Development* 2011, 138, 1531-1539 ; H. Koltai, *New Phytol.* 2011, 190, 545-549 ; E. Foo, N. W. Davies, *Planta* 2011).

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Natural strigolactones generally possess a chemical structure comprising 4 rings A, B, C, D and share the common configuration indicated below, in which rings A and B can comprise double bond(s) or substituents

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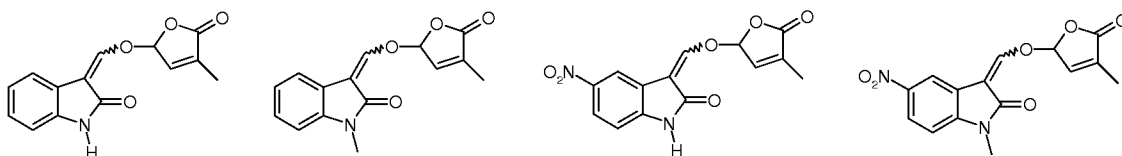


Numerous synthetic strigolactone analogues (A. J. Humphrey, A. M. Galster, M. H. Beale, *Nat. Prod. Rep.* 2006, 23, 592-614 and references cited therein; A. S. Mwakaboko, B. Zwanenburg, *Bioorg. Med. Chem.* 2011, 19, 5006-5011) have been proposed in the last decades to enhance the biological

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activities and to overcome the low stability of natural strigolactones in aqueous medium.

In 1981, A. W. Johnson et al. (A. W. Johnson, G. Gowda, A. Hassanali, J. Knox, S. Monaco, Z. Razavi, G. Rosebery J. Chem. Soc., Perkin Trans. 1 1981, 1734-1743.) synthesized from the 4-chloro-2-methylbut-2-en-4-olide and 3-hydroxymethyleneindolin-2-one, (E)-3-(((4-methyl-5-oxo-2,5-dihydrofuran-2-yl)oxy)methylene)indolin-2-one derivative and three analogs in a poor yield (19%).



(E)-3-(((4-methyl-5-oxo-2,5-dihydrofuran-2-yl)oxy)methylene)indolin-2-one derivative and analogs.

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These four compounds have an aromatic cycle fused to a 5-membered heterocyclic group, and are not embraced by the general formula (I) of the compounds according to the invention.

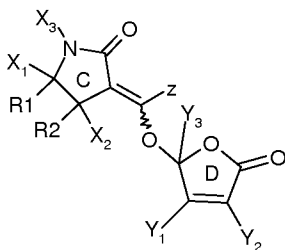
Surprisingly, we have discovered that strigolactame derivatives of formula (I) can enhance plant growth, yield, vigor and/or mycchORIZATION of plants.

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Advantageously, strigolactame derivatives of formula (I) are largely less efficient than strigolactones for promoting the germination of parasitic weed seeds.

Described herein is the invention of new strigolactames of the following formula (I):

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(I)

wherein :

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- X<sub>1</sub>, X<sub>2</sub>, X<sub>3</sub>, Y<sub>1</sub>, Y<sub>2</sub>, Y<sub>3</sub> and Z independently represent a hydrogen atom, a halogen atom, a nitro group, a hydroxy group, a cyano group, an amino group, a sulphenyl group, a sulphinyl group, a sulphonyl group, a formyl group, a acetyl group, a formyloxy group, a formylamino group, a carbamoyl group, a N-hydroxycarbamoyl group, a carbamate group, substituted or non-substituted (hydroxyimino)-C<sub>1</sub>-C<sub>6</sub>-alkyl group, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkyl, substituted or non-substituted tri(C<sub>1</sub>-C<sub>8</sub>-alkyl)silyl-C<sub>1</sub>-C<sub>8</sub>-alkyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-cycloalkyl, substituted or non-substituted tri(C<sub>1</sub>-C<sub>8</sub>-alkyl)silyl-C<sub>1</sub>-C<sub>8</sub>-cycloalkyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkyl having 1 to 5 halogen atoms, substituted or

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non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenocycloalkyl having 1 to 5 halogen atoms, a substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkenyl, substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkynyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylamino, substituted or non-substituted di-C<sub>1</sub>-C<sub>8</sub>-alkylamino, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxy, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkoxy having 1 to 5 halogen atoms, substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkynyloxy, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylsulphenyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylsulphenyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkenyloxy, substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-halogenoalkenyloxy having 1 to 5 halogen atoms, substituted or non-substituted C<sub>3</sub>-C<sub>8</sub>-halogenoalkynyloxy having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbonyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylcarbonyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbamoyl, substituted or non-substituted di-C<sub>1</sub>-C<sub>8</sub>-alkylcarbamoyl, substituted or non-substituted N-C<sub>1</sub>-C<sub>8</sub>-alkyloxycarbamoyl, substituted or non-substituted di-C<sub>1</sub>-C<sub>8</sub>-alkoxy carbamoyl, substituted or non-substituted N-C<sub>1</sub>-C<sub>8</sub>-alkyl-C<sub>1</sub>-C<sub>8</sub>-alkoxy carbamoyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxycarbonyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkoxycarbonyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbonyloxy, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylcarbonyloxy having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbonylamino, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylcarbonylamino having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylaminocarbonyloxy, substituted or non-substituted di-C<sub>1</sub>-C<sub>8</sub>-alkylaminocarbonyloxy, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkyloxycarbonyloxy, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylsulphenyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylsulphenyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylsulphinyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylsulphinyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylsulphonyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylsulphonyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylaminosulfamoyl, substituted or non-substituted di-C<sub>1</sub>-C<sub>8</sub>-alkylaminosulfamoyl, substituted or non-substituted (C<sub>1</sub>-C<sub>6</sub>-alkoxyimino)-C<sub>1</sub>-C<sub>6</sub>-alkyl, substituted or non-substituted (C<sub>1</sub>-C<sub>6</sub>-alkenyloxyimino)-C<sub>1</sub>-C<sub>6</sub>-alkyl, substituted or non-substituted (C<sub>1</sub>-C<sub>6</sub>-alkynyloxyimino)-C<sub>1</sub>-C<sub>6</sub>-alkyl, substituted or non-substituted (benzyloxyimino)-C<sub>1</sub>-C<sub>6</sub>-alkyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxyalkyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkoxyalkyl having 1 to 5 halogen atoms, a substituted or non-substituted arylalkyl substituted or non-substituted benzyloxy, substituted or non-substituted benzylsulphenyl, substituted or non-substituted benzylamino, substituted or non-substituted phenoxy, substituted or non-substituted phenylsulphenyl, substituted or non-substituted phenylamino, a substituted or non-substituted or a 4-, 5-, 6- or 7-membered heterocycle comprising up to 4 heteroatoms selected in the list consisting of N, O, S]

- R<sub>1</sub> and R<sub>2</sub> independently represent a hydrogen atom, a halogen atom, a nitro group, a hydroxy group, a cyano group, an amino group, a sulphenyl group, a sulphinyl group, a sulphonyl group, a formyl group, a formyloxy group, a formylamino group, a carbamoyl group, a N-hydroxycarbamoyl

group, a carbamate group, substituted or non-substituted (hydroxyimino)-C<sub>1</sub>-C<sub>6</sub>-alkyl group, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkyl, substituted or non-substituted tri(C<sub>1</sub>-C<sub>8</sub>-alkyl)silyl-C<sub>1</sub>-C<sub>8</sub>-alkyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-cycloalkyl, substituted or non-substituted tri(C<sub>1</sub>-C<sub>8</sub>-alkyl)silyl-C<sub>1</sub>-C<sub>8</sub>-cycloalkyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenocycloalkyl having 1 to 5 halogen atoms, a

5 substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkenyl, substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkynyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylamino, substituted or non-substituted di-C<sub>1</sub>-C<sub>8</sub>-alkylamino, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxy, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkoxy having 1 to 5 halogen atoms, substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkynyloxy, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylsulphenyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylsulphenyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkenyloxy, substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-halogenoalkenyloxy having 1 to 5 halogen atoms, substituted or non-substituted C<sub>3</sub>-C<sub>8</sub>-halogenoalkynyloxy having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbonyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylcarbonyl having 1 to 5 halogen atoms, substituted

10 or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbamoyl, substituted or non-substituted di-C<sub>1</sub>-C<sub>8</sub>-alkylcarbamoyl, substituted or non-substituted N-C<sub>1</sub>-C<sub>8</sub>-alkyloxycarbamoyl, substituted or non-substituted di-C<sub>1</sub>-C<sub>8</sub>-alkoxy carbamoyl, substituted or non-substituted N-C<sub>1</sub>-C<sub>8</sub>-alkyl-C<sub>1</sub>-C<sub>8</sub>-alkoxy carbamoyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxy carbonyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkoxy carbonyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbonyloxy, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylcarbonyloxy having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbonylamino, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylcarbonylamino having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylaminocarbonyloxy, substituted or non-substituted di-C<sub>1</sub>-C<sub>8</sub>-alkylaminocarbonyloxy, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkyloxycarbonyloxy, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylsulphenyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylsulphenyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylsulphinyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylsulphinyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylsulphonyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylsulphonyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylaminosulfamoyl, substituted or non-substituted di-C<sub>1</sub>-C<sub>8</sub>-alkylaminosulfamoyl, substituted or non-substituted (C<sub>1</sub>-C<sub>6</sub>-alkoxyimino)-C<sub>1</sub>-C<sub>6</sub>-alkyl, substituted or non-substituted (C<sub>1</sub>-C<sub>6</sub>-alkenyloxyimino)-C<sub>1</sub>-C<sub>6</sub>-alkyl, substituted or non-substituted (C<sub>1</sub>-C<sub>6</sub>-alkynyloxyimino)-C<sub>1</sub>-C<sub>6</sub>-alkyl, substituted or non-substituted (benzyloxyimino)-C<sub>1</sub>-C<sub>6</sub>-alkyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxyalkyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkoxyalkyl having 1 to 5 halogen atoms, substituted or non-substituted benzyloxy, substituted or non-substituted benzylsulphenyl, substituted or non-substituted benzylamino, substituted or non-substituted phenoxy, substituted or non-substituted phenylsulphenyl, substituted or non-substituted phenylamino, a substituted or non-substituted or a 4-, 5-, 6- or 7-membered heterocycle comprising up to 4 heteroatoms selected in the list consisting of N, O, S]; or

35 R<sub>1</sub> and R<sub>2</sub> form a saturated or unsaturated, non-aromatic, substituted or non-substituted 4- to 7-

40 membered carbocycle; or

R<sub>1</sub> and R<sub>2</sub> form a saturated or unsaturated, aromatic or non-aromatic, substituted or non-substituted 4- to 7-membered carbocycle fused to an other saturated or unsaturated, aromatic or non-aromatic, substituted or non-substituted 4- to 7- membered carbocycle;

5 as well as salts, N-oxides, metallic complexes, metalloidic complexes and optically active or geometric isomers thereof;

10 Any of the compounds used in the compositions according to the present invention may also exist in one or more geometric isomeric form depending on the number of double bond within the compound. The invention thus equally relates to any geometric isomer and to any possible mixtures thereof, in any proportion. Geometric isomers can be separated according to any method known per se by the man ordinary skilled in the art.

15 Any of the compounds used in the compositions according to the present invention wherein a substituant represents a hydroxy group, a sulphenyl group or an amino group can exist in a tautomeric form resulting from the shift of the proton of said hydroxy group, sulphenyl group or amino group respectively. Such tautomeric forms are also part of the present invention.

20 According to the invention, the following generic terms are generally used with the following meanings:

- halogen means fluorine, chlorine, bromine or iodine;
- heteroatom can be nitrogen, oxygen or sulphur.

25 Unless indicated otherwise, a group or a substituent that is substituted according to the invention can be substituted by one or more of the following groups or atoms: a halogen atom, a nitro group, a hydroxy group, a cyano group, an amino group, a sulphenyl group, a sulphanyl group, a sulphonyl group, a formyl group, a formyloxy group, a formylamino group, a carbamoyl group, a N-hydroxycarbamoyl group, a carbamate group, substituted or non-substituted (hydroxyimino)-C<sub>1</sub>-C<sub>6</sub>-alkyl group, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkyl, substituted or non-substituted tri(C<sub>1</sub>-C<sub>8</sub>-alkyl)silyl-C<sub>1</sub>-C<sub>8</sub>-alkyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-cycloalkyl, substituted or non-substituted tri(C<sub>1</sub>-C<sub>8</sub>-alkyl)silyl-C<sub>1</sub>-C<sub>8</sub>-cycloalkyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenocycloalkyl having 1 to 5 halogen atoms a C<sub>2</sub>-C<sub>8</sub>-alkenyl, substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkynyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylamino, substituted or non-substituted di-C<sub>1</sub>-C<sub>8</sub>-alkylamino, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxy, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkoxy having 1 to 5 halogen atoms, substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkenyloxy, substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkynyloxy, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylsulphenyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylsulphenyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-halogenoalkenyloxy having 1 to 5 halogen atoms, substituted or non-substituted C<sub>3</sub>-C<sub>8</sub>-alkynyloxy, substituted or non-substituted C<sub>3</sub>-C<sub>8</sub>-halogenoalkynyloxy having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbonyl,

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substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylcarbonyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbonyl, substituted or non-substituted di-C<sub>1</sub>-C<sub>8</sub>-alkylcarbonyl, substituted or non-substituted N-C<sub>1</sub>-C<sub>8</sub>-alkoxy carbonyl, substituted or non-substituted di-C<sub>1</sub>-C<sub>8</sub>-alkoxy carbonyl, substituted or non-substituted N-C<sub>1</sub>-C<sub>8</sub>-alkyl-C<sub>1</sub>-C<sub>8</sub>-alkoxy carbonyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxy carbonyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkoxy carbonyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbonyloxy, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylcarbonyloxy having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbonylamino, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylcarbonylamino having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylaminocarbonyloxy, substituted or non-substituted di-C<sub>1</sub>-C<sub>8</sub>-alkylaminocarbonyloxy, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxy carbonyloxy, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylsulphenyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylsulphenyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylsulphinyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylsulphinyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylsulphonyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylsulphonyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylaminosulfamoyl, substituted or non-substituted di-C<sub>1</sub>-C<sub>8</sub>-alkylaminosulfamoyl, substituted or non-substituted (C<sub>1</sub>-C<sub>6</sub>-alkoxyimino)-C<sub>1</sub>-C<sub>6</sub>-alkyl, substituted or non-substituted (C<sub>1</sub>-C<sub>6</sub>-alkenyloxyimino)-C<sub>1</sub>-C<sub>6</sub>-alkyl, substituted or non-substituted (C<sub>1</sub>-C<sub>6</sub>-alkynyloxyimino)-C<sub>1</sub>-C<sub>6</sub>-alkyl, substituted or non-substituted (benzyloxyimino)-C<sub>1</sub>-C<sub>6</sub>-alkyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxyalkyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkoxyalkyl having 1 to 5 halogen atoms, substituted or non-substituted benzyloxy, substituted or non-substituted benzylsulphenyl, substituted or non-substituted benzylamino, substituted or non-substituted phenoxy, substituted or non-substituted phenylsulphenyl, substituted or non-substituted phenylamino, a substituted or non-substituted or a 4-, 5-, 6- or 7-membered heterocycle comprising up to 4 heteroatoms selected in the list consisting of N, O, S.

Preferred compounds of formula (I) according to the invention are those wherein X<sub>1</sub>, X<sub>2</sub>, Y<sub>1</sub>, Y<sub>2</sub>, Y<sub>3</sub> and Z independently represent a hydrogen atom, a halogen atom, a nitro group, a hydroxy group, a cyano group, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-haloalkyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxy, or a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-haloalkoxy.

More preferred compounds of formula (I) according to the invention are those wherein X<sub>1</sub>, X<sub>2</sub>, Y<sub>1</sub>, Y<sub>3</sub> and Z represent a hydrogen atom.

Other more preferred compounds of formula (I) are those wherein Y<sub>2</sub> represents a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkyl, or a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-haloalkyl.

Other preferred compounds of formula (I) according to the invention are those wherein X<sub>3</sub> represents hydrogen atom, a formyl group, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkyl having 1 to 5 halogen atoms, a substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-

alkenyl, a substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkynyl, a substituted or non-substituted arylalkyl, acetyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbonyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylcarbonyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxycarbonyl,

5 More preferred compounds of formula (I) according to the invention are those wherein X<sub>3</sub> represents hydrogen atom, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkyl, a substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkenyl, a substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkynyl, a substituted or non-substituted arylalkyl, formyl, acetyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbonyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-haloalkylcarbonyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxycarbonyl,

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Other preferred compounds of formula (I) according to the invention are those wherein R<sub>1</sub> and R<sub>2</sub> independently represent a hydrogen atom, a halogen atom, a nitro group, a hydroxy group, a cyano group, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-haloalkyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxy, or a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-haloalkoxy; or

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R<sub>1</sub> and R<sub>2</sub> form a saturated or unsaturated, non-aromatic, substituted or non-substituted 4- to 7-membered carbocycle; or

R<sub>1</sub> and R<sub>2</sub> form a saturated or unsaturated, aromatic or non-aromatic, substituted or non-substituted 4- to 7-membered carbocycle fused to another saturated or unsaturated, aromatic or non-aromatic, substituted or non-substituted 4- to 7-membered carbocycle.

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Other more preferred compounds of formula (I) according to the invention are those wherein R<sub>1</sub> and R<sub>2</sub> form a saturated or unsaturated, aromatic or non-aromatic, substituted or non-substituted 4- to 7-membered carbocycle fused to another saturated or unsaturated, aromatic or non-aromatic, substituted or non-substituted 4- to 7-membered carbocycle.

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Other even more preferred compounds of formula (I) according to the invention are those wherein R<sub>1</sub> and R<sub>2</sub> form an unsaturated, non-aromatic, substituted or non-substituted 5-membered carbocycle fused to another unsaturated, aromatic, substituted or non-substituted 6- membered carbocycle.

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Preferred compound of formula (I) according to the invention are those wherein

- X<sub>1</sub>, X<sub>2</sub>, Y<sub>1</sub>, Y<sub>2</sub>, Y<sub>3</sub> and Z independently represent a hydrogen atom, a halogen atom, a nitro group, a hydroxy group, a cyano group, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-haloalkyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxy, or a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-haloalkoxy;

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- X<sub>3</sub> represents hydrogen atom, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkyl, a substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkenyl, a substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkynyl, a substituted or non-substituted arylalkyl, formyl, acetyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbonyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-haloalkylcarbonyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxycarbonyl, and

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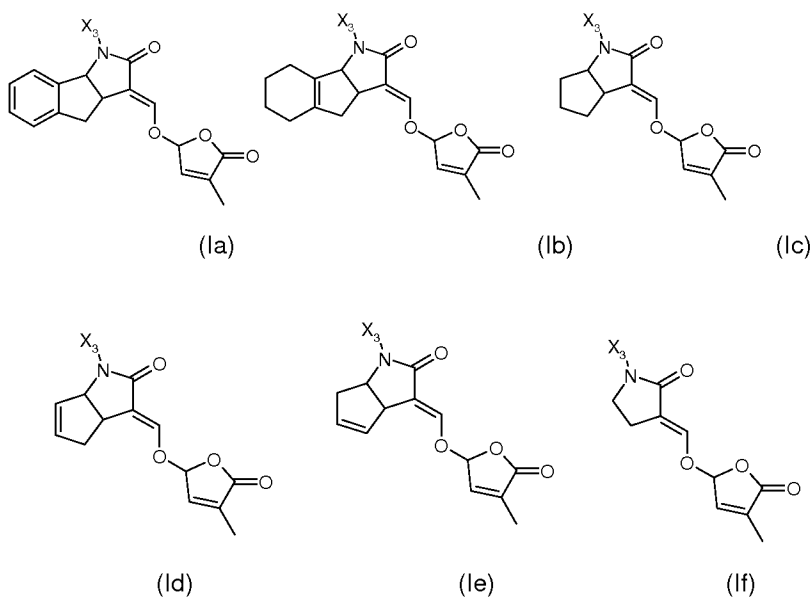
- R<sub>1</sub> and R<sub>2</sub> form an unsaturated, non-aromatic, substituted or non-substituted 5-membered carbocycle fused to another unsaturated, aromatic, substituted or non-substituted 6-membered carbocycle.



More preferred compound of formula (I) according to the invention are those wherein

- $X_1$ ,  $X_2$ ,  $Y_1$ ,  $Y_3$  and  $Z$  independently represent a hydrogen atom;
- $X_3$  represents hydrogen atom, a substituted or non-substituted  $C_1$ - $C_8$ -alkyl, a substituted or non-substituted  $C_2$ - $C_8$ -alkenyl, a substituted or non-substituted  $C_2$ - $C_8$ -alkynyl, a substituted or non-substituted arylalkyl, formyl, acetyl, a substituted or non-substituted  $C_1$ - $C_8$ -alkylcarbonyl, a substituted or non-substituted  $C_1$ - $C_8$ -haloalkylcarbonyl, substituted or non-substituted  $C_1$ - $C_8$ -alkoxycarbonyl,
- $Y_2$  represents a substituted or non-substituted  $C_1$ - $C_8$ -alkyl or a substituted or non-substituted  $C_1$ - $C_8$ -haloalkyl; and
- $R_1$  and  $R_2$  form an unsaturated, non-aromatic substituted or non-substituted 5-membered carbocycle fused to another unsaturated, aromatic, substituted or non-substituted 6-membered carbocycle.

More preferred compound of formula (I) according to the invention are selected in the list consisting of:



- wherein  $X_3$  represents hydrogen atom, a substituted or non-substituted  $C_1$ - $C_8$ -alkyl, a substituted or non-substituted  $C_2$ - $C_8$ -alkenyl, a substituted or non-substituted  $C_2$ - $C_8$ -alkynyl, a substituted or non-substituted arylalkyl, formyl, acetyl, a substituted or non-substituted  $C_1$ - $C_8$ -alkylcarbonyl, a substituted or non-substituted  $C_1$ - $C_8$ -haloalkylcarbonyl, substituted or non-substituted  $C_1$ - $C_8$ -alkoxycarbonyl.

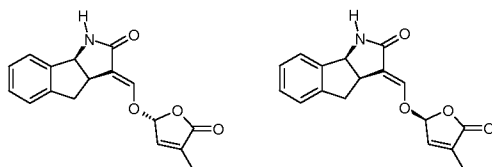
- We proposed here an access to strigolactames, especially nitrogen analogues of GR24 (example 1) and GR5 (example 2).

About the strigolactame analogs of GR24, our synthesis uses a new one-pot four-step route to the known tricyclic compound (A. U. De, B. P. Saha, *J. Pharm. Sci.* 1973, 62, 1363-1364) and a coupling with the described bromo lactone (G. A. Macalpine, R. A. Raphael, A. Shaw, A. W. Taylor, H. J. Wild *J. Chem. Soc., Perkin Trans. 1* 1976, 410-416) affords the new strigolactames.

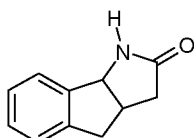
About the strigolactame analogs of GR5, we synthesize the undescribed 3-enoether of N-Bocpyrrolidinone and link it with the same bromolactone as above.

**Example 1:**

**Preparation of (3E,3aR\*,8bS\*)-3-(((2R)-5-hydroxy-4-methyl-2,5-dihydrofuran-2-yl]oxy)methylene)-3,3a,4,8b-tetrahydroindeno[1,2-b]pyrrol-2(1H)-one and (3E,3aR\*,8bS\*)-3-(((2S)-5-hydroxy-4-methyl-2,5-dihydrofuran-2-yl]oxy)methylene)-3,3a,4,8b-tetrahydroindeno[1,2-b]pyrrol-2(1H)-one**



Step 1: (3aR\*,8bS\*)-3,3a,4,8b-Tetrahydroindeno[1,2-b]pyrrol-2(1H)-one



Sodium borohydride (1.39 g, 36.66 mmol, 1 equiv) was added to a mixture of Ethyl (1-oxo-2,3-dihydro-1H-inden-2-yl)acetate (Mangnus, E. M.; Dommerholt, F. J.; Dejong, R. L. P.; Zwanenburg, B. *J. Agric. Food Chem.* **1992**, *40*, 1230 ; Bergmann, E.; Hoffman, E. *J. Org. Chem.* **1961**, *26*, 3555; Ozaki, S.; Adachi, M.; Sekiya, S.; Kamikawa, R. *J. Org. Chem.* **2003**, *68*, 4586) (8.00 g, 36.66 mmol, 1 equiv) in methanol (150 mL) under argon at -10°C. After 3 h, the reaction was quenched with water. The resulting mixture was extracted with CH<sub>2</sub>Cl<sub>2</sub> (3 x), dried (MgSO<sub>4</sub>), filtered and evaporated under reduce pressure.

The concentrated crude intermediate was directly placed in the next step in presence of thionyl chloride (4.80 g, 40.32 mmol, 1.10 equiv) and pyridine (3.19 g, 40.32 mmol, 1.10 equiv) in CH<sub>2</sub>Cl<sub>2</sub> (150 mL) at 0°C. After 4 h at room temperature, the reaction mixture was concentrated to dryness under reduced pressure. The crude oil was solubilized in CH<sub>2</sub>Cl<sub>2</sub> and washed with water and dried over MgSO<sub>4</sub>.

After evaporation under reduced pressure, the crude oil was dissolved in dry DMF (150 mL) in presence of sodium azide (5.24 g, 80.64 mmol, 2.20 equiv). After heating at 90°C during 3 h, the solvent was removed by evaporation under reduced pressure. The crude product was then dissolved with CH<sub>2</sub>Cl<sub>2</sub> and washed with water.

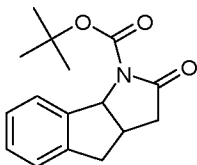
After concentration, it was finally dissolved in methanol (150 mL) in presence of Pd/C 10% (0.92 g, cat) under H<sub>2</sub> atmosphere. After stirring for 6 h at room temperature, the reaction mixture was filtered through a celite pad, and after evaporation of the solvent, the crude product was purified on silica gel (heptane/EtOAc 50:50) to afford the desired product (2.03 g, 11.71 mmol, 23%) as an amorphous

solid (A. W. Johnson, G. Gowda, A. Hassanali, J. Knox, S. Monaco, Z. Razavi, G. Rosebery J. Chem. Soc., Perkin Trans. 1 **1981**, 1734-1743).

<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.34-7.23, 6.95, 5.05, 3.40-3.27, 2.94-2.84, 2.74, 2.24.

5 HRMS (ESI): Calcd for C<sub>11</sub>H<sub>12</sub>NO [M + H]<sup>+</sup>: 174.0919. Found: 174.0911.

Step 2 : *tert*-Butyl (3aR\*,8bS\*)-2-oxo-3,3a,4,8b-tetrahydroindeno[1,2-b]pyrrole-1(2H)-carboxylate



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Boc<sub>2</sub>O (0.26 g, 1.18 mmol, 2.05 equiv) was added to a solution of previous lactam (100.0 mg, 0.58 mmol, 1 equiv) and DMAP (754.0 mg, 0.61 mmol, 1.05 equiv) in a mixture of triethylamine-acetonitrile (3:1) (4 mL) under argon at room temperature. After 3 h, the reaction mixture was diluted with EtOAc. The organic layer was washed successively with HCl (1 M), saturated aqueous sodium hydrogen carbonate and brine. After drying over MgSO<sub>4</sub>, concentration of the solvent gave a residue, which was purified by flash chromatography on silica gel (EtOAc neat) to afford the pure desired product (141.0 mg, 0.52 mmol, 89%) as a hygroscopic white solid.

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<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.51-7.48, 7.25-7.14, 5.54, 3.16-3.04, 2.75, 2.70, 2.20, 1.54.

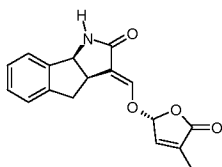
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HRMS (ESI): Calcd for C<sub>16</sub>H<sub>19</sub>NO<sub>3</sub>Na [M + Na]<sup>+</sup>: 296.1263. Found: 296.1261.

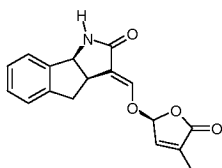
Step 3 :

(3*E*,3a*R*\*,8b*S*\*)-3-(((2*R*\*)-4-methyl-5-oxo-2,5-dihydrofuran-2-yl]oxy)methylene)-3,3a,4,8b-tetrahydroindeno[1,2-b]pyrrol-2(1*H*)-one

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(3*E*,3a*R*\*,8b*S*\*)-3-(((2*S*\*)-4-methyl-5-oxo-2,5-dihydrofuran-2-yl]oxy)methylene)-3,3a,4,8b-tetrahydroindeno[1,2-b]pyrrol-2(1*H*)-one



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Lactam from step 2 (100.0 mg, 0.37 mmol, 1 equiv) was dissolved in *tert*-butoxybis(dimethylamino)methane (Bredereck's reagent) (0.30 mL, 1.46 mmol, 4 equiv) under argon

at room temperature. After heating at 75°C for 3 h, the cooled reaction mixture was diluted with EtOAc, and the resulting mixture was washed with water and brine, and then dried over MgSO<sub>4</sub>. Concentration of the solvent *in vacuo* gave the crude product, which was directly diluted in a mixture of THF (5 mL) and HCl (1 M) (0.44 mL, 0.44 mmol, 1.20 equiv) and stirred for 1 h at room temperature. The mixture was neutralized with saturated aqueous sodium hydrogen carbonate solution and diluted with EtOAc. The organic layer was washed with brine and dried over MgSO<sub>4</sub>. Concentration of the solvent *in vacuo* gave a residue, which was purified by flash chromatography (CH<sub>2</sub>Cl<sub>2</sub>/methanol 95:5) to afford the pure desired product enol (96.0 mg, 0.32 mmol, 80%) as an amorphous solid.

To a solution of this enol (45.0 mg, 0.15 mmol, 1 equiv) in *N*-methylpyrrolidone (2 mL) was added potassium carbonate (42.0 mg, 0.31 mmol, 2.05 equiv) at room temperature under argon. To this mixture was added a solution of (±)-4-bromo-2-methyl-2-buten-4-olide (G. A. Macalpine, R. A. Raphael, A. Shaw, A. W. Taylor, H. J. Wild J. Chem. Soc., Perkin Trans. 1 1976, 410-416) (28.0 mg, 0.16 mmol, 1.05 equiv) in *N*-methylpyrrolidone (2 mL). After 3 h, the reaction was quenched with a solution of HCl 1N and the product was extracted with EtOAc. The organic layer was washed with water, brine and dried on MgSO<sub>4</sub>. After evaporation, the crude product was purified by preparative TLC (heptane/EtOAc 80:20) to afford the two epimers as two pure fractions (F1, 23.8 mg, 0.06 mmol, 40%; F2, 22.1 mg, 0.06 mmol, 37%) as amorphous white solids.

To a solution of N-Boc F1 (23.8 mg, 0.06 mmol, 1 equiv) in CH<sub>2</sub>Cl<sub>2</sub> (5 mL) was added trifluoroacetic acid (1.83 mL, 24.00 mmol, 400 equiv) at room temperature under argon. After 5 h, the reaction mixture was evaporated to dryness and the crude product was purified on preparative TLC on silica to afford the pure product (2*R*\*) (14.6 mg, 0.05 mmol, 82%) as a white amorphous solid.

Separately, to a solution of N-Boc F2 (22.1 mg, 0.06 mmol, 1 equiv) in CH<sub>2</sub>Cl<sub>2</sub> (5 mL) was added trifluoroacetic acid (1.70 mL, 22.24 mmol, 400 equiv) at room temperature under argon. After 5 h, the reaction mixture was evaporated to dryness and the crude product was purified on preparative TLC on silica to afford the pure product (2*S*\*) (13.2 mg, 0.04 mmol, 80%) as a white amorphous solid.

(3*E*,3*aR*\*,8*bS*\*)-3-(((2*R*\*)-4-methyl-5-oxo-2,5-dihydrofuran-2-yl]oxy)methylene)-3,3*a*,4,8*b*-tetrahydroindeno[1,2-*b*]pyrrol-2(1*H*)-one :

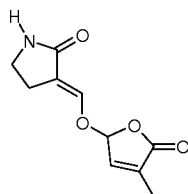
<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): 7.27-7.18, 6.92, 6.68, 6.12, 5.09, 3.92-3.84, 3.41, 3.05, 2.01.

HRMS (ESI): Calcd for C<sub>17</sub>H<sub>15</sub>NO<sub>4</sub>Na [M + Na]<sup>+</sup>: 320.0899. Found: 320.0914.

(3*E*,3*aR*\*,8*bS*\*)-3-(((2*S*\*)-4-methyl-5-oxo-2,5-dihydrofuran-2-yl]oxy)methylene)-3,3*a*,4,8*b*-tetrahydroindeno[1,2-*b*]pyrrol-2(1*H*)-one :

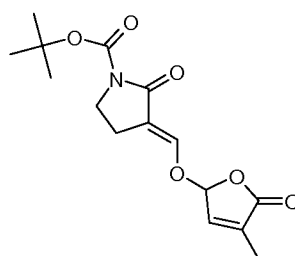
<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): 7.23-7.12, 6.88, 6.67, 6.06, 5.03, 3.88-3.80, 3.38, 3.00, 1.96.

HRMS (ESI): Calcd for C<sub>17</sub>H<sub>15</sub>NO<sub>4</sub>Na [M + Na]<sup>+</sup>: 320.0899. Found: 320.0913.

**Example 2: (3E)-3-[[[4-methyl-5-oxo-2,5-dihydrofuran-2-yl)oxy]methylene]pyrrolidin-2-one**

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Step1 : tert-butyl (3E)-3-[[[4-methyl-5-oxo-2,5-dihydrofuran-2-yl)oxy]methylene]-2-oxopyrrolidine-1-carboxylate



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Boc<sub>2</sub>O (2.63 g, 12.05 mmol, 2.05 equiv) diluted was added to a solution pyrrolidinone (500.0 mg, 6.88 mmol, 1 equiv) and DMAP (754.0 mg, 6.17 mmol, 1.05 equiv) in a mixture of triethylamine-acetonitrile (3:1) (20 mL) under argon at room temperature. After 3 h, the reaction mixture was diluted with EtOAc. The organic layer was washed successively with HCl (1 M), saturated aqueous sodium hydrogen carbonate solution and brine. After drying over MgSO<sub>4</sub>, concentration of the solvent gave a residue, which was purified by flash chromatography (EtOAc neat) to afford the pure desired carbamate (743.0 mg, 4.01 mmol, 68%) as a pale yellow oil (analyses in accordance with the literature data) (Banfi, L.; Basso, A.; Cerulli, V.; Guanti, G.; Riva, R. *J. Org. Chem.* 2008, *73*, 1608-1611).

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The carbamate (250.0 mg, 1.35 mmol, 1 equiv) was dissolved in *tert*-butoxybis(dimethylamino)methane (Bredereck reagent) (1.12 mL, 5.40 mmol, 4 equiv) under argon at room temperature. After heating at 75°C for 3 h, the cooled mixture was diluted with EtOAc, and the organic layer was washed with water and brine, then dried over MgSO<sub>4</sub>. Concentration of the solvent *in vacuo* gave the crude product, which was directly diluted in a mixture of THF (5 mL) and HCl (1 M) (1.62 mL, 1.62 mmol, 1.20 equiv) and stirred for 1 h at room temperature. The reaction mixture was neutralized with saturated aqueous sodium hydrogen carbonate solution and diluted with EtOAc. The organic layer was washed with brine and dried over MgSO<sub>4</sub>. Concentration of the solvent *in vacuo* gave a residue, which was purified by flash chromatography on silica gel (CH<sub>2</sub>Cl<sub>2</sub>/methanol 95:5) to afford the pure desired enol ether (200.0 mg, 0.94 mmol, 69%) as an amorphous solid.

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To a solution of previously obtained enol ether (162.0 mg, 0.76 mmol, 1 equiv) in *N*-methylpyrrolidone (2 mL) was added potassium carbonate (215.3 mg, 1.56 mmol, 2.05 equiv) at room temperature under

argon. To this mixture was added a solution of ( $\pm$ )-4-bromo-2-methyl-2-buten-4-olide<sup>Erreur ! Signet non défini.</sup> (275.7 mg, 1.56 mmol, 2.05 equiv) in *N*-methylpyrrolidone (2 mL). After 3 h, the reaction was quenched with a solution of HCl 1N and the product was extracted with EtOAc. The organic layer was washed with water, brine and dried on MgSO<sub>4</sub>. The crude product was purified on preparative TLC on silica to afford the pure desired product (140.0 mg, 0.42 mmol, 60%) as a white amorphous solid.

<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>):  $\delta$  7.37, 6.89, 6.12, 3.69, 2.60, 1.96, 1.51.

HRMS (ESI): Calcd for C<sub>15</sub>H<sub>18</sub>NO<sub>6</sub> [M - H]<sup>-</sup>: 308.1134. Found: 308.1143.

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Step2 : (3*E*)-3-[[4-methyl-5-oxo-2,5-dihydrofuran-2-yl]oxy]methylene}pyrrolidin-2-one

To a solution of the carbamate (30.0 mg, 0.10 mmol, 1 equiv) in CH<sub>2</sub>Cl<sub>2</sub> (5 mL) was added trifluoroacetic acid (8  $\mu$ L, 0.11 mmol, 1.10 equiv) at room temperature under argon. After 5 h, the reaction mixture was evaporated to dryness and the crude product was purified on preparative TLC on silica to afford the deprotected NH (15.0 mg, 0.07 mmol, 74%) as a white amorphous solid.

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<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>):  $\delta$  7.20, 6.85, 6.47, 6.06, 3.39, 2.72, 1.93.

HRMS (ESI): Calcd for C<sub>10</sub>H<sub>12</sub>NO<sub>4</sub> [M + H]<sup>+</sup>: 210.0766. Found: 210.0759.

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The compound according to the present invention can be prepared according to the processes of preparation described above. It will nevertheless be understood that, on the basis of his general knowledge and of available publications, the skilled worker will be able to adapt the processes of preparation described above according to the specifics of each of the compounds, which it is desired to synthesize.

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In a further aspect, the present invention also relates to a composition comprising an effective and non-phytotoxic amount of an active compound of formula (I).

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The expression "effective and non-phytotoxic amount" means an amount of composition according to the invention that is sufficient for enhancing the plant growth, yield, vigor and/or mycorrhization and that does not entail any appreciable symptom of phytotoxicity for the said plant or crop. Such an amount can vary within a wide range depending on the type of crop, the climatic conditions and the compounds included in the composition according to the invention. This amount can be determined by systematic field trials that are within the capabilities of a person skilled in the art.

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Thus, according to the invention, there is provided a composition comprising, as an active ingredient, an effective amount of a compound of formula (I) as herein defined and an agriculturally acceptable support, carrier or filler.

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In the present specification, the term "support" denotes a natural or synthetic, organic or inorganic material with which the active material is combined to make it easier to apply, notably to the parts of the plant. This support is thus generally inert and should be agriculturally acceptable. The support may

be a solid or a liquid. Examples of suitable supports include clays, natural or synthetic silicates, silica, resins, waxes, solid fertilisers, water, alcohols, in particular butanol, organic solvents, mineral and plant oils and derivatives thereof. Mixtures of such supports may also be used.

5 An "effective amount" of the composition is an amount that increases plant growth, yield, vigor and/or mycchORIZATION when compared with the plant growth, yield, vigor and/or mycchORIZATION of plants or seeds that have not been treated with the composition. For example, strigolactame concentration in the composition may range independently from  $10^{-4}$  M to  $10^{-15}$  M, preferably from  $10^{-6}$  to  $10^{-12}$  M. The agriculturally appropriate solvent is preferably an aqueous solvent, such as water. It may be appropriate to solubilize the compounds in a small volum of organic solvent as acetone, and then to  
10 dilute with water.

Active ingredients concentration in the composition generally corresponds directly or after dilution to the use rate for this particular active ingredient. The use rate for strigolactame compounds is generally from 1  $\mu$ g to 1 g/ha.

15 Other additives that may be applied either simultaneously or sequentially include fertilizers (e.g., calcium, nitrogen, potassium, phosphorous) and micronutrients (e.g., copper, aluminum, magnesium, manganese, and zinc ions).

The composition may be applied to monocot or dicot plants, including legumes and non-legumes. In one embodiment, the composition is applied to field-grown plants. In another embodiment, the  
20 composition is applied to greenhouse-grown plants. For example, the composition may be applied to seeds or foliage of legumes, such as soybeans, peas, chickpeas, dry beans, peanuts, clover, alfalfa, and of non-legumes such as corn, cotton, rice, tomatoes, canola, wheat, barley, sugar beet, and grass. In general, for seed treatment, the composition is applied to seeds in a single application, and the seeds may be planted immediately or stored before planting. The composition may be applied to  
25 foliage. Foliar application generally consists of spraying the composition on the plant foliage one or more times during the growing period.

The term "plant" as used herein includes tubers, roots, stems, leaves, flowers, and fruits. The composition may be applied directly to seeds or plants or may be placed in soil in the vicinity of a seed  
30 or plant prior to or at the time of planting. In a preferred embodiment, the composition is sprayed on seeds, tubers, or foliage.

Seedlings, as well as more mature plants, may be treated. Flowers and fruits may also be treated by spraying. Roots of transplants may be sprayed or dipped in the composition prior to planting.

The composition may also comprise other additional components. In particular, the composition may  
35 further comprise a surfactant. The surfactant can be an emulsifier, a dispersing agent or a wetting agent of ionic or non-ionic type or a mixture of such surfactants. Mention may be made, for example, of polyacrylic acid salts, lignosulphonic acid salts, phenolsulphonic or naphthalenesulphonic acid salts,

polycondensates of ethylene oxide with fatty alcohols or with fatty acids or with fatty amines, substituted phenols (in particular alkylphenols or arylphenols), salts of sulphosuccinic acid esters, taurine derivatives (in particular alkyl taurates), phosphoric esters of polyoxyethylated alcohols or phenols, fatty acid esters of polyols, and derivatives of the above compounds containing sulphate, 5 sulphonate and phosphate functions. The presence of at least one surfactant is generally essential when the active material and/or the inert support are water-insoluble and when the vector agent for the application is water. Preferably, surfactant content may be comprised between 5% and 40% by weight of the composition.

Additional components may also be included, e.g. protective colloids, adhesives, thickeners, 10 thixotropic agents, penetration agents, stabilisers, sequestering agents. More generally, the active materials can be combined with any solid or liquid additive, which complies with the usual formulation techniques.

In general, the composition according to the invention may contain from 0.00000005 to 99% (by 15 weight) of active material, preferably 0.0000001 to 70% by weight.

Compositions according to the present invention can be used in various forms such as aerosol dispenser, capsule suspension, cold fogging concentrate, dustable powder, emulsifiable concentrate, emulsion oil in water, emulsion water in oil, encapsulated granule, fine granule, flowable concentrate 20 for seed treatment, gas (under pressure), gas generating product, granule, hot fogging concentrate, macrogranule, microgranule, oil dispersible powder, oil miscible flowable concentrate, oil miscible liquid, paste, plant rodlet, powder for dry seed treatment, seed coated with a pesticide, soluble concentrate, soluble powder, solution for seed treatment, suspension concentrate (flowable concentrate), ultra low volume (ulv) liquid, ultra low volume (ulv) suspension, water dispersible 25 granules or tablets, water dispersible powder for slurry treatment, water soluble granules or tablets, water soluble powder for seed treatment and wettable powder.

These compositions include not only compositions which are ready to be applied to the plant or seed to be treated, or in furrow in the soil, by means of a suitable device, such as a spraying or dusting 30 device, but also concentrated commercial compositions which must be diluted before they are applied to the crop.

In another embodiment of the invention, the composition may further comprise a pesticidal active ingredient. Examples of pesticides useful in compositions include fungicides, insecticides, bactericides, nematocides, acaricides, molluscicides, attractants, sterilants, growth regulators, 35 herbicides, safeners, semiochemicals pheromone active substance or other compounds with biological activity.

In an embodiment of the invention, the composition may further comprise another active ingredient which enhances the yield, vigor or growth of the plants, which improves the germination of seeds and vitality of seedlings, which acts as seed safener, which improves nutrient uptake or symbiotic 40 interaction by the plant, or which improves the biotic or abiotic environmental stress tolerance of a



plant. Examples of said compounds include strigolactone compounds, lipochito-oligosaccharide (LCO) compounds, acyl-homoserine lactone (AHL) compounds, flavonoids (such as flavones, flavanols, flavonols, flavanones, isoflavones, hesperetin, formononetin, genistein, daidzein, naringenin, luteolin, apigenin), chitinous compounds (such as chitin or chitosan), plant activators (such as acibenzolar or  
5 probenazole), phytohormones (such as Gibberellic acid), plant growth regulators (such as trinexapac-ethyl, prohexadione-Ca, paclobutrazol, brassinolide, forchlorfenuron, hymexazol, thiametoxam), or other plant regulators (such as benzofluor, buminafos, carvone, ciobutide, clofencet, cloxyfonac, cyanamide, cyclanilide, cycloheximide, cyprosulfamide, epocholeone, ethychlozate, fenridazon, heptopargil, holosulf, inabenfide, karetazan, lead arsenate, methasulfocarb, prohexadione, pydanon,  
10 sintofen, triapenthenol).

Examples of said compounds, the way to prepare them from natural sources or to synthesize them, as well as the conditions to use them, are largely disclosed in WO 2005063784, WO2008085958, WO2008152092, WO2009049747, WO2010125065, WO2011153442, EP11356001.5, EP11356011.4

Examples of plant growth regulators include, but are not limited to antiauxins (clofibric acid, 2,3,5-tri-  
15 iodobenzoic acid), auxins (4-CPA, 2,4-D, 2,4-DB, 2,4-DEP, dichlorprop, fenoprop, IAA, IBA, naphthaleneacetamide, [alpha]-naphthaleneacetic acid, 1-naphthol, naphthoxyacetic acid, potassium naphthenate, sodium naphthenate, 2,4, 5-T), cytokinins (2iP, benzyladenine, kinetin, zeatin), defoliants (calcium cyanamide, dimethipin, endothal, ethephon, merphos, metoxuron, pentachlorophenol, thidiazuron, tribufos), ethylene inhibitors (aviglycine, 1- methylcyclopropene),  
20 ethylene releasers (ACC, etacelasil, ethephon, glyoxime), gibberellins (gibberellic acid, gibberellins, including non-cyclopropene compounds that show gibberellin- like activity, such as, for example, helminthosporic acid, phaseolic acid, kaurenoic acid, and steviol), growth inhibitors (abscisic acid, ancymidol, butralin, carbaryl, chlorphonium, chlorpropham, dikegulac, flumetralin, fluoridamid, fosamine, glyphosine, isopyrimol, jasmonic acid, maleic hydrazide, mepiquat, piproctanyl,  
25 prohydrojasmon, propham, 2,3,5-tri-iodobenzoic acid), morphactins (chlorfluren, chlorflurenol, dichlorflurenol, flurenol), growth retardants/modifiers (chlormequat, daminozide, flurprimidol, mefluidide, paclobutrazol, cyproconazole, tetcyclacis, uniconazole, ancymidol, trinexapac-ethyl, and progexadione-CA), growth stimulators (brassinolide, forchlorfenuron, hymexazol, 2-amino-6-oxypurine derivatives, as described below, indolinone derivatives, as described below, 3,4-disubstituted maleimide  
30 derivatives, as described below, and fused azepinone derivatives, as described below). The term additionally includes other active ingredients such as benzofluor, buminafos, carvone, ciobutide, clofencet, cloxyfonac, cyclanilide, cycloheximide, epocholeone, ethychlozate, ethylene, fenridazon, heptopargil, holosulf, inabenfide, karetazan, lead arsenate, methasulfocarb, prohexadione, pydanon, sintofen, triapenthenol, and trinexapac. Additional plant growth regulators include indolinone derivative  
35 plant stimulators described in WO 2005/107466; 3,4-disubstituted maleimide derivatives described in WO 2005/107465; fused azepinone derivatives described in WO 2005/107471 ; and 2-amino-6-oxypurine derivatives described in WO 2005/107472.

Examples of natural or synthetic strigolactone compounds include, but are not limited to strigol,

sorgolactone, alectrol, orobanchol (Cook et al., 1972, J Am Chem Soc, 94, 6198-6199; Butler, 1995, Allelopathy: organism, processes and application, 158-168; Hauck et al., 1992, J Plant Physiol, 139, 474-478; Muller et al., 1992, J Plant Growth Regul, 11, 77-84, Siame et al., 1993, J Agr Food Chem, 41, 1486- 1491, Yokota et al., 1998, Phytochemistry, 49, 1967-1973), and the synthetic strigolactones compounds of formula (I) specifically disclosed in WO2010125065.

In the meaning of the invention, a lipo-chitooligosaccharide (LCO) compound is a compound having the general LCO structure, i.e. an oligomeric backbone of  $\beta$ -1,4-linked *N*- acetyl-D-glucosamine residues with a N-linked fatty acyl chain at the non-reducing end, as described in US Pat N° 5,549,718; US Pat N° 5,646,018; US Pat N° 5,175,149; and US Pat N° 5,321,011.

This basic structure may contain modifications or substitutions found in naturally occurring LCO's, such as those described in Spaink, Critical Reviews in Plant Sciences 54: 257-288, 2000; D'Haese and Holsters, Glycobiology 12: 79R-105R, 2002. Naturally occurring LCO's are defined as compounds which can be found in nature. This basic structure may also contain modifications or substitutions which have not been found so far in naturally occurring LCO's. Examples of such analogs for which the conjugated amide bond is mimicked by a benzamide bond or which contain a function of benzylamine type are the following compounds of formula (I) which are described in WO2005/063784 and WO2008/071672, the content of which is incorporated herein by reference. The LCO's compounds may be isolated directly from a particular culture of *Rhizobiaceae* bacterial strains, synthesized chemically, or obtained chemo-enzymatically. Via the latter method, the oligosaccharide skeleton may be formed by culturing of recombinant bacterial strains, such as *Escherichia coli*, in a fermenter, and the lipid chain may then be attached chemically.

LCO's used in embodiments of the invention may be recovered from natural *Rhizobiaceae* bacterial strains that produce LCO's, such as strains of *Azorhizobium*, *Bradyrhizobium* (including *B. japonicum*), *Mesorhizobium*, *Rhizobium* (including *R. leguminosarum*), *Sinorhizobium* (including *S. meliloti*), or from bacterial strains genetically engineered to produce LCO's. These methods are known in the art and have been described, for example, in U.S. Pat. Nos. 5,549,718 and 5,646,018, which are incorporated herein by reference. Hungria and Stacey (Soil Biol. Biochem. 29: 819-830, 1997) list specific LCO structures that are produced by different rhizobial species. LCO's may be utilized in various forms of purity and may be used alone or with rhizobia. Methods to provide only LCO's include simply removing the rhizobial cells from a mixture of LCOs and rhizobia, or continuing to isolate and purify the LCO molecules through LCO solvent phase separation followed by HPLC chromatography as described by Lerouge, et.al (US 5,549,718). Purification can be enhanced by repeated HPLC, and the purified LCO molecules can be freeze-dried for long-term storage. This method is acceptable for the production of LCO's from all genera and species of the *Rhizobiaceae*. Commercial products containing LCO's are available, such as OPTIMIZE® (EMD Crop BioScience). LCO compounds, which can be identical or not to naturally occurring LCO's, may also be obtained by chemical synthesis and/or through genetic engineering. Synthesis of precursor oligosaccharide molecules for the construction of LCO by genetically engineered organisms is disclosed in Samain et al., Carbohydrate Research 302: 35-42, 1997.

Preparation of numerous LCOs compounds wherein the oligosaccharide skeleton is obtained by culturing recombinant bacterial strains, such as recombinant *Escherichia coli* cells harboring heterologous gene from rhizobia, and wherein the lipid chain is chemically attached is disclosed in WO2005/063784 and WO2008/07167, the content of which is incorporated herein by reference.

5 Examples of lipochito-oligosaccharide compounds include, but are not limited to LCO compounds specifically disclosed in WO2010125065.

Examples of natural or synthetic acyl-homoserine lactone derivatives (AHLs) include, but are not limited to compounds specifically disclosed in EP11356011.4, the content of which is incorporated  
10 herein by reference.

The composition according to the present invention may further comprise a supplementation with different inoculum sources as for example arbuscular mycorrhizal fungi (AMF), Rhizobia or other plant growth promoting bacteria. Said supplementation may be applied simultaneously or sequentially.

15 AMF could be for example *Glomus* sp., *Gigaspora* sp., or other fungi from the group Glomeromycota, while plant growth promoting bacteria others than Rhizobia could be for example *Azospirillum* sp., *Bacillus* sp.

When the composition according to the invention comprises a strigolactame derivative of formula (I) and a pesticidal active material, the dose of active material usually applied is generally and advantageously between 0.00001 and 1000 g/ha, preferably between 0.0001 and 500 g/ha for applications in foliar treatment. If a drench/drip/in furrow application is possible, the dose can be lower, especially in artificial substrates like rockwool or perlite. The dose of active substance applied is generally and advantageously between 0.000001 and 200 g per 100 kg of seed, preferably between  
20 0.00001 and 150 g per 100 kg of seed in the case of seed treatment. It is clearly understood that the doses indicated above are given as illustrative examples of the invention. A person skilled in the art will know how to adapt the application doses according to the nature of the crop to be treated.  
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The compositions and compounds of the present invention may be used to to increase the yield, growth, vigor and/or mycchorization of the plant and/or for curatively or preventively control pests of crops, as  
30 phytopathogenic fungi, insects, nematodes, acarid, and/or for decreasing the needs of fertilizers.

Thus, according to a further aspect, the present invention provides a method for increasing the yield, growth, vigor or mycchorization of a plant or crop characterised in that a composition according to the  
35 invention is applied via seed treatment, foliar application, stem application, drench/drip application (chemigation) to the seed, the plant or to the fruit of the plant, or to soil, particularly in furrow, and/or to inert substrate (e.g. inorganic substrates (e.g. sand, rockwool, glasswool, expanded minerals (e.g. perlite, vermiculite, zeolite, expanded clay)), Pumice, Pyroclastic materials/tuff, synthetic organic substrates (e.g. Polyurethane), organic substrates (e.g. peat, composts, tree waste products (e.g. coir, wood fibre/chips,

tree bark) and/or to a liquid substrate (e.g. floating hydroponic systems, Nutrient Film Technique, Aeroponics) wherein the plant is growing or wherein it is desired to grow.

The composition as used comprises an effective and non-phytotoxic amount of active compound.

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The method of treatment according to the present invention is useful to treat propagation material such as tubers or rhizomes, but also seeds, seedlings or seedlings pricking out and plants or plants pricking out. This method of treatment can also be useful to treat roots. The method of treatment according to the present invention can also be useful to treat the overground parts of the plant such as

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trunks, stems or stalks, leaves, flowers and fruit of the concerned plant.

Among the plants that can be treated by the method according to the present invention, mention may be made of cotton; flax; vine; fruit or vegetable crops such as *Rosaceae sp.* (for instance pip fruit such as apples and pears, but also stone fruit such as apricots, almonds and peaches), *Ribesioideae sp.*,

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*Juglandaceae sp.*, *Betulaceae sp.*, *Anacardiaceae sp.*, *Fagaceae sp.*, *Moraceae sp.*, *Oleaceae sp.*, *Actinidaceae sp.*, *Lauraceae sp.*, *Musaceae sp.* (for instance banana trees and plantains), *Rubiaceae sp.*, *Theaceae sp.*, *Sterculiaceae sp.*, *Rutaceae sp.* (for instance lemons, oranges and grapefruit);

*Solanaceae sp.* (for instance tomatoes), *Liliaceae sp.*, *Asteraceae sp.* (for instance lettuces),

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*Umbelliferae sp.*, *Cruciferae sp.*, *Chenopodiaceae sp.*, *Cucurbitaceae sp.*, *Papilionaceae sp.* (for instance peas), *Rosaceae sp.* (for instance strawberries); major crops such as *Graminae sp.* (for instance maize, lawn or cereals such as wheat, rice, barley and triticale), *Asteraceae sp.* (for instance sunflower), *Cruciferae sp.* (for instance oil seed rape), *Fabaceae sp.* (for instance peanuts),

*Papilionaceae sp.* (for instance soybean), *Solanaceae sp.* (for instance potatoes), *Chenopodiaceae sp.* (for instance beetroots); horticultural and forest crops; as well as genetically modified homologues

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of these crops.

Strigolactame compounds of the invention, and compositions comprising said strigolactame compounds, eventually in combination with fungicides, insecticides, or other additives, can be used in the treatment of genetically modified organisms (GMOs), e.g. plants or seeds.

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Genetically modified plants (or transgenic plants) are plants of which a heterologous gene has been stably integrated into genome. The expression "heterologous gene" essentially means a gene which is provided or assembled outside the plant and when introduced in the nuclear, chloroplastic or mitochondrial genome gives the transformed plant new or improved agronomic or other properties by expressing a protein or polypeptide of interest or by downregulating or silencing other gene(s) which are present in the plant (using

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for example, antisense technology, cosuppression technology or RNA interference – RNAi - technology). A heterologous gene that is located in the genome is also called a transgene. A transgene that is defined by its particular location in the plant genome is called a transformation or transgenic event.

Depending on the plant species or plant cultivars, their location and growth conditions (soils, climate, vegetation period, diet), the treatment according to the invention may also result in superadditive

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("synergistic") effects. Thus, for example, reduced application rates and/or a widening of the activity

spectrum and/or an increase in the activity of the active compounds and compositions which can be used according to the invention, better plant growth, increased tolerance to high or low temperatures, increased tolerance to drought or to water or soil salt content, increased flowering performance, easier harvesting, accelerated maturation, higher harvest yields, bigger fruits, larger plant height, greener leaf color, earlier flowering, higher quality and/or a higher nutritional value of the harvested products, higher sugar concentration within the fruits, better storage stability and/or processability of the harvested products are possible, which exceed the effects which were actually to be expected.

At certain application rates, the active compound combinations according to the invention may also have a strengthening effect in plants. Accordingly, they are also suitable for mobilizing the defense system of the plant against attack by unwanted microorganisms. This may, if appropriate, be one of the reasons of the enhanced activity of the combinations according to the invention, for example against fungi. Plant-strengthening (resistance-inducing) substances are to be understood as meaning, in the present context, those substances or combinations of substances which are capable of stimulating the defense system of plants in such a way that, when subsequently inoculated with unwanted microorganisms, the treated plants display a substantial degree of resistance to these microorganisms. In the present case, unwanted microorganisms are to be understood as meaning phytopathogenic fungi, bacteria and viruses. Thus, the substances according to the invention can be employed for protecting plants against attack by the abovementioned pathogens within a certain period of time after the treatment. The period of time within which protection is effected generally extends from 1 to 21 days, preferably 1 to 14 days, after the treatment of the plants with the active compounds.

As already mentioned above, it is possible to treat all plants and their parts in accordance with the invention. In a preferred embodiment, wild plant species and plant cultivars, or those obtained by conventional biological breeding methods, such as crossing or protoplast fusion, and also parts thereof, are treated. In a further preferred embodiment, transgenic plants and plant cultivars obtained by genetic engineering methods, if appropriate in combination with conventional methods (Genetically Modified Organisms), and parts thereof are treated. The terms "parts" or "parts of plants" or "plant parts" have been explained above. More preferably, plants of the plant cultivars which are commercially available or are in use are treated in accordance with the invention. Plant cultivars are understood to mean plants which have new properties ("traits") and have been obtained by conventional breeding, by mutagenesis or by recombinant DNA techniques. They can be cultivars, varieties, bio- or genotypes.

The method of treatment according to the invention can be used in the treatment of genetically modified organisms (GMOs), e.g. plants or seeds. Genetically modified plants (or transgenic plants) are plants of which a heterologous gene has been stably integrated into genome. The expression "heterologous gene" essentially means a gene which is provided or assembled outside the plant and when introduced in the nuclear, chloroplastic or mitochondrial genome gives the transformed plant new or improved agronomic or other properties by expressing a protein or polypeptide of interest or by downregulating or silencing other gene(s) which are present in the plant (using for example, antisense technology, cosuppression technology, RNA interference – RNAi – technology or microRNA – miRNA - technology). A heterologous

gene that is located in the genome is also called a transgene. A transgene that is defined by its particular location in the plant genome is called a transformation or transgenic event.

Depending on the plant species or plant cultivars, their location and growth conditions (soils, climate, vegetation period, diet), the treatment according to the invention may also result in superadditive

5 ("synergistic") effects. Thus, for example, reduced application rates and/or a widening of the activity spectrum and/or an increase in the activity of the active compounds and compositions which can be used according to the invention, better plant growth, increased tolerance to high or low temperatures, increased tolerance to drought or to water or soil salt content, increased flowering performance, easier harvesting, accelerated maturation, higher harvest yields, bigger fruits, larger plant height, greener leaf color, earlier  
10 flowering, higher quality and/or a higher nutritional value of the harvested products, higher sugar concentration within the fruits, better storage stability and/or processability of the harvested products are possible, which exceed the effects which were actually to be expected.

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20 unwanted microorganisms, the treated plants display a substantial degree of resistance to these microorganisms. In the present case, unwanted microorganisms are to be understood as meaning phytopathogenic fungi, bacteria and viruses. Thus, the substances according to the invention can be employed for protecting plants against attack by the abovementioned pathogens within a certain period of time after the treatment. The period of time within which protection is effected generally  
25 extends from 1 to 10 days, preferably 1 to 7 days, after the treatment of the plants with the active compounds.

Plants and plant cultivars which are preferably to be treated according to the invention include all plants which have genetic material which impart particularly advantageous, useful traits to these plants (whether obtained by breeding and/or biotechnological means).

30 Plants and plant cultivars which are also preferably to be treated according to the invention are resistant against one or more biotic stresses, i.e. said plants show a better defense against animal and microbial pests, such as against nematodes, insects, mites, phytopathogenic fungi, bacteria, viruses and/or viroids.

Examples of nematode or insect resistant plants are described in e.g. U.S. Patent Applications 11/765,491,  
35 11/765,494, 10/926,819, 10/782,020, 12/032,479, 10/783,417, 10/782,096, 11/657,964, 12/192,904, 11/396,808, 12/166,253, 12/166,239, 12/166,124, 12/166,209, 11/762,886, 12/364,335, 11/763,947, 12/252,453, 12/209,354, 12/491,396, 12/497,221, 12/644,632, 12/646,004, 12/701,058, 12/718,059, 12/721,595, 12/638,591.

Plants and plant cultivars which may also be treated according to the invention are those plants which are  
40 resistant to one or more abiotic stresses. Abiotic stress conditions may include, for example, drought, cold

temperature exposure, heat exposure, osmotic stress, flooding, increased soil salinity, increased mineral exposure, ozone exposure, high light exposure, limited availability of nitrogen nutrients, limited availability of phosphorus nutrients, shade avoidance.

Plants and plant cultivars which may also be treated according to the invention, are those plants  
5 characterized by enhanced yield characteristics. Increased yield in said plants can be the result of, for example, improved plant physiology, growth and development, such as water use efficiency, water retention efficiency, improved nitrogen use, enhanced carbon assimilation, improved photosynthesis, increased germination efficiency and accelerated maturation. Yield can furthermore be affected by  
10 improved plant architecture (under stress and non-stress conditions), including but not limited to, early flowering, flowering control for hybrid seed production, seedling vigor, plant size, internode number and distance, root growth, seed size, fruit size, pod size, pod or ear number, seed number per pod or ear, seed mass, enhanced seed filling, reduced seed dispersal, reduced pod dehiscence and lodging resistance. Further yield traits include seed composition, such as carbohydrate content, protein content, oil content and composition, nutritional value, reduction in anti-nutritional compounds, improved processability and better  
15 storage stability.

Plants that may be treated according to the invention are hybrid plants that already express the characteristic of heterosis or hybrid vigor which results in generally higher yield, vigor, health and resistance towards biotic and abiotic stresses). Such plants are typically made by crossing an inbred male-sterile parent line (the female parent) with another inbred male-fertile parent line (the male  
20 parent). Hybrid seed is typically harvested from the male sterile plants and sold to growers. Male sterile plants can sometimes (e.g. in corn) be produced by detasseling, i.e. the mechanical removal of the male reproductive organs (or males flowers) but, more typically, male sterility is the result of genetic determinants in the plant genome. In that case, and especially when seed is the desired product to be harvested from the hybrid plants it is typically useful to ensure that male fertility in the  
25 hybrid plants is fully restored. This can be accomplished by ensuring that the male parents have appropriate fertility restorer genes which are capable of restoring the male fertility in hybrid plants that contain the genetic determinants responsible for male-sterility. Genetic determinants for male sterility may be located in the cytoplasm. Examples of cytoplasmic male sterility (CMS) were for instance described in *Brassica* species (WO 92/05251, WO 95/09910, WO 98/27806, WO 05/002324, WO  
30 06/021972 and US 6,229,072). However, genetic determinants for male sterility can also be located in the nuclear genome. Male sterile plants can also be obtained by plant biotechnology methods such as genetic engineering. A particularly useful means of obtaining male-sterile plants is described in WO 89/10396 in which, for example, a ribonuclease such as barnase is selectively expressed in the tapetum cells in the stamens. Fertility can then be restored by expression in the tapetum cells of a  
35 ribonuclease inhibitor such as barstar (e.g. WO 91/02069).

Plants or plant cultivars (obtained by plant biotechnology methods such as genetic engineering) which may be treated according to the invention are herbicide-tolerant plants, i.e. plants made tolerant to one or more given herbicides. Such plants can be obtained either by genetic transformation, or by selection of plants containing a mutation imparting such herbicide tolerance.

Herbicide-resistant plants are for example glyphosate-tolerant plants, i.e. plants made tolerant to the herbicide glyphosate or salts thereof. Plants can be made tolerant to glyphosate through different means. For example, glyphosate-tolerant plants can be obtained by transforming the plant with a gene encoding the enzyme 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS). Examples of such EPSPS genes are

5 the AroA gene (mutant CT7) of the bacterium *Salmonella typhimurium* (*Science* 1983, 221, 370-371), the CP4 gene of the bacterium *Agrobacterium sp.* (*Curr. Topics Plant Physiol.* 1992, 7, 139-145), the genes encoding a Petunia EPSPS (*Science* 1986, 233, 478-481), a Tomato EPSPS (*J. Biol. Chem.* 1988, 263, 4280-4289), or an Eleusine EPSPS (WO 01/66704). It can also be a mutated EPSPS as described in for example EP 0837944, WO 00/66746, WO 00/66747 or WO 02/26995. Glyphosate-tolerant plants can also

10 be obtained by expressing a gene that encodes a glyphosate oxido-reductase enzyme as described in US 5,776,760 and US 5,463,175. Glyphosate-tolerant plants can also be obtained by expressing a gene that encodes a glyphosate acetyl transferase enzyme as described in for example WO 02/036782, WO 03/092360, WO 2005/012515 and WO 2007/024782. Glyphosate-tolerant plants can also be obtained by selecting plants containing naturally-occurring mutations of the above-mentioned genes, as described in for

15 example WO 01/024615 or WO 03/013226. Plants expressing EPSPS genes that confer glyphosate tolerance are described in e.g. U.S. Patent Applications 11/517,991, 10/739,610, 12/139,408, 12/352,532, 11/312,866, 11/315,678, 12/421,292, 11/400,598, 11/651,752, 11/681,285, 11/605,824, 12/468,205, 11/760,570, 11/762,526, 11/769,327, 11/769,255, 11/943801 or 12/362,774. Plants comprising other genes that confer glyphosate tolerance, such as decarboxylase genes, are described in e.g. U.S. Patent

20 Applications 11/588,811, 11/185,342, 12/364,724, 11/185,560 or 12/423,926.

Other herbicide resistant plants are for example plants that are made tolerant to herbicides inhibiting the enzyme glutamine synthase, such as bialaphos, phosphinothricin or glufosinate. Such plants can be obtained by expressing an enzyme detoxifying the herbicide or a mutant glutamine synthase enzyme that is resistant to inhibition, e.g. described in U.S. Patent Application 11/760,602. One such

25 efficient detoxifying enzyme is an enzyme encoding a phosphinothricin acetyltransferase (such as the bar or pat protein from *Streptomyces* species). Plants expressing an exogenous phosphinothricin acetyltransferase are for example described in U.S. Patents 5,561,236; 5,648,477; 5,646,024; 5,273,894; 5,637,489; 5,276,268; 5,739,082; 5,908,810 and 7,112,665.

Further herbicide-tolerant plants are also plants that are made tolerant to the herbicides inhibiting the enzyme hydroxyphenylpyruvatedioxygenase (HPPD). HPPD is an enzyme that catalyze the reaction

30 in which para-hydroxyphenylpyruvate (HPP) is transformed into homogentisate. Plants tolerant to HPPD-inhibitors can be transformed with a gene encoding a naturally-occurring resistant HPPD enzyme, or a gene encoding a mutated or chimeric HPPD enzyme as described in WO 96/38567, WO 99/24585, WO 99/24586, WO 09/144079, WO 02/046387, or US 6,768,044. Tolerance to HPPD-

35 inhibitors can also be obtained by transforming plants with genes encoding certain enzymes enabling the formation of homogentisate despite the inhibition of the native HPPD enzyme by the HPPD-inhibitor. Such plants and genes are described in WO 99/34008 and WO 02/36787. Tolerance of plants to HPPD inhibitors can also be improved by transforming plants with a gene encoding an enzyme having prephenate deshydrogenase (PDH) activity in addition to a gene encoding an HPPD-

40 tolerant enzyme, as described in WO 04/024928. Further, plants can be made more tolerant to HPPD-



inhibitor herbicides by adding into their genome a gene encoding an enzyme capable of metabolizing or degrading HPPD inhibitors, such as the CYP450 enzymes shown in WO 2007/103567 and WO 2008/150473.

Still further herbicide resistant plants are plants that are made tolerant to acetolactate synthase (ALS)

5 inhibitors. Known ALS-inhibitors include, for example, sulfonylurea, imidazolinone, triazolopyrimidines, pyrimidinyoxy(thio)benzoates, and/or sulfonylaminocarbonyltriazolinone herbicides. Different mutations in the ALS enzyme (also known as acetohydroxyacid synthase, AHAS) are known to confer tolerance to different herbicides and groups of herbicides, as described for example in Tranel and Wright (*Weed Science* 2002, 50, 700-712), but also, in U.S. Patents 5,605,011, 5,378,824, 5,141,870, and 5,013,659.

10 The production of sulfonylurea-tolerant plants and imidazolinone-tolerant plants is described in U.S. Patents 5,605,011; 5,013,659; 5,141,870; 5,767,361; 5,731,180; 5,304,732; 4,761,373; 5,331,107; 5,928,937; and 5,378,824; and WO 96/33270. Other imidazolinone-tolerant plants are also described in for example WO 2004/040012, WO 2004/106529, WO 2005/020673, WO 2005/093093, WO 2006/007373, WO 2006/015376, WO 2006/024351, and WO 2006/060634. Further sulfonylurea- and imidazolinone-  
15 tolerant plants are also described in for example WO 2007/024782 and U.S. Patent Application 61/288958. Other plants tolerant to imidazolinone and/or sulfonylurea can be obtained by induced mutagenesis, selection in cell cultures in the presence of the herbicide or mutation breeding as described for example for soybeans in US 5,084,082, for rice in WO 97/41218, for sugar beet in US 5,773,702 and WO 99/057965, for lettuce in US 5,198,599, or for sunflower in WO 01/065922.

20 Plants or plant cultivars (obtained by plant biotechnology methods such as genetic engineering) which may also be treated according to the invention are insect-resistant transgenic plants, i.e. plants made resistant to attack by certain target insects. Such plants can be obtained by genetic transformation, or by selection of plants containing a mutation imparting such insect resistance.

An "insect-resistant transgenic plant", as used herein, includes any plant containing at least one  
25 transgene comprising a coding sequence encoding:

1) an insecticidal crystal protein from *Bacillus thuringiensis* or an insecticidal portion thereof, such as the insecticidal crystal proteins listed by Crickmore et al. (1998, *Microbiology and Molecular Biology Reviews*, 62: 807-813), updated by Crickmore et al. (2005) at the *Bacillus thuringiensis* toxin nomenclature, online at: [http://www.lifesci.sussex.ac.uk/Home/Neil\\_Crickmore/Bt/](http://www.lifesci.sussex.ac.uk/Home/Neil_Crickmore/Bt/)), or insecticidal  
30 portions thereof, e.g., proteins of the Cry protein classes Cry1Ab, Cry1Ac, Cry1B, Cry1C, Cry1D, Cry1F, Cry2Ab, Cry3Aa, or Cry3Bb or insecticidal portions thereof (e.g. EP-A 1 999 141 and WO 2007/107302), or such proteins encoded by synthetic genes as e.g. described in and U.S. Patent Application 12/249,016 ; or

2) a crystal protein from *Bacillus thuringiensis* or a portion thereof which is insecticidal in the  
35 presence of a second other crystal protein from *Bacillus thuringiensis* or a portion thereof, such as the binary toxin made up of the Cry34 and Cry35 crystal proteins (*Nat. Biotechnol.* 2001, 19, 668-72; *Applied Environm. Microbiol.* 2006, 71, 1765-1774) or the binary toxin made up of the Cry1A or Cry1F proteins and the Cry2Aa or Cry2Ab or Cry2Ae proteins (U.S. Patent Application 12/214,022 and EP-A 2 300 618); or

- 3) a hybrid insecticidal protein comprising parts of different insecticidal crystal proteins from *Bacillus thuringiensis*, such as a hybrid of the proteins of 1) above or a hybrid of the proteins of 2) above, e.g., the Cry1A.105 protein produced by corn event MON89034 (WO 2007/027777); or
- 4) a protein of any one of 1) to 3) above wherein some, particularly 1 to 10, amino acids have been replaced by another amino acid to obtain a higher insecticidal activity to a target insect species, and/or to expand the range of target insect species affected, and/or because of changes introduced into the encoding DNA during cloning or transformation, such as the Cry3Bb1 protein in corn events MON863 or MON88017, or the Cry3A protein in corn event MIR604; or
- 5) an insecticidal secreted protein from *Bacillus thuringiensis* or *Bacillus cereus*, or an insecticidal portion thereof, such as the vegetative insecticidal (VIP) proteins listed at: [http://www.lifesci.sussex.ac.uk/home/Neil\\_Crickmore/Bt/vip.html](http://www.lifesci.sussex.ac.uk/home/Neil_Crickmore/Bt/vip.html), e.g., proteins from the VIP3Aa protein class; or
- 6) a secreted protein from *Bacillus thuringiensis* or *Bacillus cereus* which is insecticidal in the presence of a second secreted protein from *Bacillus thuringiensis* or *B. cereus*, such as the binary toxin made up of the VIP1A and VIP2A proteins (WO 94/21795); or
- 7) a hybrid insecticidal protein comprising parts from different secreted proteins from *Bacillus thuringiensis* or *Bacillus cereus*, such as a hybrid of the proteins in 1) above or a hybrid of the proteins in 2) above; or
- 8) a protein of any one of 5) to 7) above wherein some, particularly 1 to 10, amino acids have been replaced by another amino acid to obtain a higher insecticidal activity to a target insect species, and/or to expand the range of target insect species affected, and/or because of changes introduced into the encoding DNA during cloning or transformation (while still encoding an insecticidal protein), such as the VIP3Aa protein in cotton event COT102; or
- 9) a secreted protein from *Bacillus thuringiensis* or *Bacillus cereus* which is insecticidal in the presence of a crystal protein from *Bacillus thuringiensis*, such as the binary toxin made up of VIP3 and Cry1A or Cry1F (U.S. Patent Applications 61/126083 and 61/195019), or the binary toxin made up of the VIP3 protein and the Cry2Aa or Cry2Ab or Cry2Ae proteins (U.S. Patent Application 12/214,022 and EP-A 2 300 618).
- 10) a protein of 9) above wherein some, particularly 1 to 10, amino acids have been replaced by another amino acid to obtain a higher insecticidal activity to a target insect species, and/or to expand the range of target insect species affected, and/or because of changes introduced into the encoding DNA during cloning or transformation (while still encoding an insecticidal protein)

Of course, an insect-resistant transgenic plant, as used herein, also includes any plant comprising a combination of genes encoding the proteins of any one of the above classes 1 to 10. In one embodiment, an insect-resistant plant contains more than one transgene encoding a protein of any one of the above

classes 1 to 10, to expand the range of target insect species affected when using different proteins directed at different target insect species, or to delay insect resistance development to the plants by using different proteins insecticidal to the same target insect species but having a different mode of action, such as binding to different receptor binding sites in the insect.

5 An "insect-resistant transgenic plant", as used herein, further includes any plant containing at least one transgene comprising a sequence producing upon expression a double-stranded RNA which upon ingestion by a plant insect pest inhibits the growth of this insect pest, as described e.g. in WO 2007/080126, WO 2006/129204, WO 2007/074405, WO 2007/080127 and WO 2007/035650.

10 Plants or plant cultivars (obtained by plant biotechnology methods such as genetic engineering) which may also be treated according to the invention are tolerant to abiotic stresses. Such plants can be obtained by genetic transformation, or by selection of plants containing a mutation imparting such stress resistance. Particularly useful stress tolerance plants include:

1) plants which contain a transgene capable of reducing the expression and/or the activity of poly(ADP-ribose) polymerase (PARP) gene in the plant cells or plants as described in  
15 WO 00/04173, WO 2006/045633, EP-A 1 807 519, or EP-A 2 018 431.

2) plants which contain a stress tolerance enhancing transgene capable of reducing the expression and/or the activity of the PARG encoding genes of the plants or plants cells, as described e.g. in WO 2004/090140.

3) plants which contain a stress tolerance enhancing transgene coding for a plant-functional enzyme  
20 of the nicotineamide adenine dinucleotide salvage synthesis pathway including nicotinamidase, nicotinate phosphoribosyltransferase, nicotinic acid mononucleotide adenylyl transferase, nicotinamide adenine dinucleotide synthetase or nicotine amide phosphoribosyltransferase as described e.g. in EP-A 1 794 306, WO 2006/133827, WO 2007/107326, EP-A 1 999 263, or WO 2007/107326.

25 Plants or plant cultivars (obtained by plant biotechnology methods such as genetic engineering) which may also be treated according to the invention show altered quantity, quality and/or storage-stability of the harvested product and/or altered properties of specific ingredients of the harvested product such as:

1) transgenic plants which synthesize a modified starch, which in its physical-chemical  
30 characteristics, in particular the amylose content or the amylose/amylopectin ratio, the degree of branching, the average chain length, the side chain distribution, the viscosity behaviour, the gelling strength, the starch grain size and/or the starch grain morphology, is changed in comparison with the synthesised starch in wild type plant cells or plants, so that this is better suited for special applications. Said transgenic plants synthesizing a modified starch are disclosed, for example, in  
35 EP-A 0 571 427, WO 95/04826, EP-A 0 719 338, WO 96/15248, WO 96/19581, WO 96/27674, WO 97/11188, WO 97/26362, WO 97/32985, WO 97/42328, WO 97/44472, WO 97/45545, WO 98/27212, WO 98/40503, WO 99/58688, WO 99/58690, WO 99/58654, WO 00/08184, WO 00/08185, WO 00/08175, WO 00/28052, WO 00/77229, WO 01/12782, WO 01/12826,

5 WO 02/101059, WO 03/071860, WO 04/056999, WO 05/030942, WO 2005/030941, WO 2005/095632, WO 2005/095617, WO 2005/095619, WO 2005/095618, WO 2005/123927, WO 2006/018319, WO 2006/103107, WO 2006/108702, WO 2007/009823, WO 00/22140, WO 2006/063862, WO 2006/072603, WO 02/034923, WO 2008/017518, WO 2008/080630, WO 2008/080631, EP 07090007.1, WO 2008/090008, WO 01/14569, WO 02/79410, WO 03/33540, WO 2004/078983, WO 01/19975, WO 95/26407, WO 96/34968, WO 98/20145, WO 99/12950, WO 99/66050, WO 99/53072, US 6,734,341, WO 00/11192, WO 98/22604, WO 98/32326, WO 01/98509, WO 01/98509, WO 2005/002359, US 5,824,790, US 6,013,861, WO 94/04693, WO 94/09144, WO 94/11520, WO 95/35026, WO 97/20936, WO 2010/012796, 10 WO 2010/003701,

2) transgenic plants which synthesize non starch carbohydrate polymers or which synthesize non starch carbohydrate polymers with altered properties in comparison to wild type plants without genetic modification. Examples are plants producing polyfructose, especially of the inulin and levan-type, as disclosed in EP-A 0 663 956, WO 96/01904, WO 96/21023, WO 98/39460, and 15 WO 99/24593, plants producing alpha-1,4-glucans as disclosed in WO 95/31553, US 2002031826, US 6,284,479, US 5,712,107, WO 97/47806, WO 97/47807, WO 97/47808 and WO 00/14249, plants producing alpha-1,6 branched alpha-1,4-glucans, as disclosed in WO 00/73422, plants producing alternan, as disclosed in e.g. WO 00/47727, WO 00/73422, EP 06077301.7, US 5,908,975 and EP-A 0 728 213,

20 3) transgenic plants which produce hyaluronan, as for example disclosed in WO 2006/032538, WO 2007/039314, WO 2007/039315, WO 2007/039316, JP-A 2006-304779, and WO 2005/012529.

4) transgenic plants or hybrid plants, such as onions with characteristics such as 'high soluble solids content', 'low pungency' (LP) and/or 'long storage' (LS), as described in U.S. Patent Applications 12/020,360 and 61/054,026.

25 Plants or plant cultivars (that can be obtained by plant biotechnology methods such as genetic engineering) which may also be treated according to the invention are plants, such as cotton plants, with altered fiber characteristics. Such plants can be obtained by genetic transformation, or by selection of plants contain a mutation imparting such altered fiber characteristics and include:

30 a) Plants, such as cotton plants, containing an altered form of cellulose synthase genes as described in WO 98/00549.

b) Plants, such as cotton plants, containing an altered form of rsw2 or rsw3 homologous nucleic acids as described in WO 2004/053219.

c) Plants, such as cotton plants, with increased expression of sucrose phosphate synthase as described in WO 01/17333.

35 d) Plants, such as cotton plants, with increased expression of sucrose synthase as described in WO 02/45485.

e) Plants, such as cotton plants, wherein the timing of the plasmodesmatal gating at the basis of the fiber cell is altered, e.g. through downregulation of fiber-selective  $\beta$ -1,3-glucanase as described in WO 2005/017157, or as described in WO 2009/143995.

5 f) Plants, such as cotton plants, having fibers with altered reactivity, e.g. through the expression of N-acetylglucosaminetransferase gene including nodC and chitin synthase genes as described in WO 2006/136351.

10 Plants or plant cultivars (that can be obtained by plant biotechnology methods such as genetic engineering) which may also be treated according to the invention are plants, such as oilseed rape or related Brassica plants, with altered oil profile characteristics. Such plants can be obtained by genetic transformation, or by selection of plants contain a mutation imparting such altered oil profile characteristics and include:

a) Plants, such as oilseed rape plants, producing oil having a high oleic acid content as described e.g. in US 5,969,169, US 5,840,946 or US 6,323,392 or US 6,063,947

15 b) Plants such as oilseed rape plants, producing oil having a low linolenic acid content as described in US 6,270,828, US 6,169,190, or US 5,965,755

c) Plant such as oilseed rape plants, producing oil having a low level of saturated fatty acids as described e.g. in US 5,434,283 or U.S. Patent Application 12/668303

20 Plants or plant cultivars (that can be obtained by plant biotechnology methods such as genetic engineering) which may also be treated according to the invention are plants, such as oilseed rape or related Brassica plants, with altered seed shattering characteristics. Such plants can be obtained by genetic transformation, or by selection of plants contain a mutation imparting such altered seed shattering characteristics and include plants such as oilseed rape plants with delayed or reduced seed shattering as described in U.S. Patent Application 61/135,230, WO 2009/068313 and WO 2010/006732.

25 Plants or plant cultivars (that can be obtained by plant biotechnology methods such as genetic engineering) which may also be treated according to the invention are plants, such as Tobacco plants, with altered post-translational protein modification patterns, for example as described in WO 2010/121818 and WO 2010/145846.

30 Particularly useful transgenic plants which may be treated according to the invention are plants containing transformation events, or combination of transformation events, that are the subject of petitions for non-regulated status, in the United States of America, to the Animal and Plant Health Inspection Service (APHIS) of the United States Department of Agriculture (USDA) whether such petitions are granted or are still pending. At any time this information is readily available from APHIS (4700 River Road, Riverdale, MD 20737, USA), for instance on its internet site (URL  
35 [http://www.aphis.usda.gov/brs/not\\_reg.html](http://www.aphis.usda.gov/brs/not_reg.html)). On the filing date of this application the petitions for nonregulated status that were pending with APHIS or granted by APHIS were those which contains the following information:

- Petition: the identification number of the petition. Technical descriptions of the transformation events can be found in the individual petition documents which are obtainable from APHIS, for example on the APHIS website, by reference to this petition number. These descriptions are herein incorporated by reference.
- 5 – Extension of Petition: reference to a previous petition for which an extension is requested.
- Institution: the name of the entity submitting the petition.
- Regulated article: the plant species concerned.
- Transgenic phenotype: the trait conferred to the plants by the transformation event.
- Transformation event or line: the name of the event or events (sometimes also designated as lines
- 10 – (or lines) for which nonregulated status is requested.
- APHIS documents: various documents published by APHIS in relation to the Petition and which can be requested with APHIS.

Additional particularly useful plants containing single transformation events or combinations of transformation events are listed for example in the databases from various national or regional regulatory agencies (see for example [http://gmoinfo.jrc.it/gmp\\_browse.aspx](http://gmoinfo.jrc.it/gmp_browse.aspx) and <http://www.agbios.com/dbase.php>).

Particularly useful transgenic plants which may be treated according to the invention are plants containing transformation events, or a combination of transformation events, and that are listed for example in the databases for various national or regional regulatory agencies including Event 1143-14A (cotton, insect control, not deposited, described in WO 2006/128569); Event 1143-51B (cotton, insect control, not deposited, described in WO 2006/128570); Event 1445 (cotton, herbicide tolerance, not deposited, described in US-A 2002-120964 or WO 02/034946); Event 17053 (rice, herbicide tolerance, deposited as PTA-9843, described in WO 2010/117737); Event 17314 (rice, herbicide tolerance, deposited as PTA-9844, described in WO 2010/117735); Event 281-24-236 (cotton, insect control - herbicide tolerance, deposited as PTA-6233, described in WO 2005/103266 or US-A 2005-216969); Event 3006-210-23 (cotton, insect control - herbicide tolerance, deposited as PTA-6233, described in US-A 2007-143876 or WO 2005/103266); Event 3272 (corn, quality trait, deposited as PTA-9972, described in WO 2006/098952 or US-A 2006-230473); Event 40416 (corn, insect control - herbicide tolerance, deposited as ATCC PTA-11508, described in WO 2011/075593); Event 43A47 (corn, insect control - herbicide tolerance, deposited as ATCC PTA-11509, described in WO 2011/075595); Event 5307 (corn, insect control, deposited as ATCC PTA-9561, described in WO 2010/077816); Event ASR-368 (bent grass, herbicide tolerance, deposited as ATCC PTA-4816, described in US-A 2006-162007 or WO 2004/053062); Event B16 (corn, herbicide tolerance, not deposited, described in US-A 2003-126634); Event BPS-CV127-9 (soybean, herbicide tolerance, deposited as NCIMB No. 41603, described in WO 2010/080829); Event CE43-67B (cotton, insect

control, deposited as DSM ACC2724, described in US-A 2009-217423 or WO2006/128573); Event CE44-69D (cotton, insect control, not deposited, described in US-A 2010-0024077); Event CE44-69D (cotton, insect control, not deposited, described in WO 2006/128571); Event CE46-02A (cotton, insect control, not deposited, described in WO 2006/128572); Event COT102 (cotton, insect control, not deposited, described in US-A 2006-130175 or WO 2004/039986); Event COT202 (cotton, insect control, not deposited, described in US-A 2007-067868 or WO 2005/054479); Event COT203 (cotton, insect control, not deposited, described in WO 2005/054480); Event DAS40278 (corn, herbicide tolerance, deposited as ATCC PTA-10244, described in WO 2011/022469); Event DAS-59122-7 (corn, insect control - herbicide tolerance, deposited as ATCC PTA 11384 , described in US-A 2006-070139); Event DAS-59132 (corn, insect control - herbicide tolerance, not deposited, described in WO 2009/100188); Event DAS68416 (soybean, herbicide tolerance, deposited as ATCC PTA-10442, described in WO 2011/066384 or WO 2011/066360); Event DP-098140-6 (corn, herbicide tolerance, deposited as ATCC PTA-8296, described in US-A 2009-137395 or WO 2008/112019); Event DP-305423-1 (soybean, quality trait, not deposited, described in US-A 2008-312082 or WO 2008/054747); Event DP-32138-1 (corn, hybridization system, deposited as ATCC PTA-9158, described in US-A 2009-0210970 or WO 2009/103049); Event DP-356043-5 (soybean, herbicide tolerance, deposited as ATCC PTA-8287, described in US-A 2010-0184079 or WO 2008/002872); Event EE-1 (brinjal, insect control, not deposited, described in WO 2007/091277); Event FI117 (corn, herbicide tolerance, deposited as ATCC 209031, described in US-A 2006-059581 or WO 98/044140); Event GA21 (corn, herbicide tolerance, deposited as ATCC 209033, described in US-A 2005-086719 or WO 98/044140); Event GG25 (corn, herbicide tolerance, deposited as ATCC 209032, described in US-A 2005-188434 or WO 98/044140); Event GHB119 (cotton, insect control - herbicide tolerance, deposited as ATCC PTA-8398, described in WO 2008/151780); Event GHB614 (cotton, herbicide tolerance, deposited as ATCC PTA-6878, described in US-A 2010-050282 or WO 2007/017186); Event GJ11 (corn, herbicide tolerance, deposited as ATCC 209030, described in US-A 2005-188434 or WO 98/044140); Event GM RZ13 (sugar beet, virus resistance , deposited as NCIMB-41601, described in WO 2010/076212); Event H7-1 (sugar beet, herbicide tolerance, deposited as NCIMB 41158 or NCIMB 41159, described in US-A 2004-172669 or WO 2004/074492); Event JOPLIN1 (wheat, disease tolerance, not deposited, described in US-A 2008-064032); Event LL27 (soybean, herbicide tolerance, deposited as NCIMB41658, described in WO 2006/108674 or US-A 2008-320616); Event LL55 (soybean, herbicide tolerance, deposited as NCIMB 41660, described in WO 2006/108675 or US-A 2008-196127); Event LLcotton25 (cotton, herbicide tolerance, deposited as ATCC PTA-3343, described in WO 03/013224 or US-A 2003-097687); Event LLRICE06 (rice, herbicide tolerance, deposited as ATCC-23352, described in US 6,468,747 or WO 00/026345); Event LLRICE601 (rice, herbicide tolerance, deposited as ATCC PTA-2600, described in US-A 2008-2289060 or WO 00/026356); Event LY038 (corn, quality trait, deposited as ATCC PTA-5623, described in US-A 2007-028322 or WO 2005/061720); Event MIR162 (corn, insect control, deposited as PTA-8166, described in US-A 2009-300784 or WO 2007/142840); Event MIR604 (corn, insect control, not deposited, described in US-A 2008-167456 or WO 2005/103301); Event MON15985 (cotton, insect control, deposited as ATCC PTA-2516, described in US-A 2004-250317 or WO 02/100163); Event MON810 (corn, insect control, not

deposited, described in US-A 2002-102582); Event MON863 (corn, insect control, deposited as ATCC PTA-2605, described in WO 2004/011601 or US-A 2006-095986); Event MON87427 (corn, pollination control, deposited as ATCC PTA-7899, described in WO 2011/062904); Event MON87460 (corn, stress tolerance, deposited as ATCC PTA-8910, described in WO 2009/111263 or US-A 2011-0138504); Event MON87701 (soybean, insect control, deposited as ATCC PTA-8194, described in US-A 2009-130071 or WO 2009/064652); Event MON87705 (soybean, quality trait - herbicide tolerance, deposited as ATCC PTA-9241, described in US-A 2010-0080887 or WO 2010/037016); Event MON87708 (soybean, herbicide tolerance, deposited as ATCC PTA9670, described in WO 2011/034704); Event MON87754 (soybean, quality trait, deposited as ATCC PTA-9385, described in WO 2010/024976); Event MON87769 (soybean, quality trait, deposited as ATCC PTA-8911, described in US-A 2011-0067141 or WO 2009/102873); Event MON88017 (corn, insect control - herbicide tolerance, deposited as ATCC PTA-5582, described in US-A 2008-028482 or WO 2005/059103); Event MON88913 (cotton, herbicide tolerance, deposited as ATCC PTA-4854, described in WO 2004/072235 or US-A 2006-059590); Event MON89034 (corn, insect control, deposited as ATCC PTA-7455, described in WO 2007/140256 or US-A 2008-260932); Event MON89788 (soybean, herbicide tolerance, deposited as ATCC PTA-6708, described in US-A 2006-282915 or WO 2006/130436); Event MS11 (oilseed rape, pollination control - herbicide tolerance, deposited as ATCC PTA-850 or PTA-2485, described in WO 01/031042); Event MS8 (oilseed rape, pollination control - herbicide tolerance, deposited as ATCC PTA-730, described in WO 01/041558 or US-A 2003-188347); Event NK603 (corn, herbicide tolerance, deposited as ATCC PTA-2478, described in US-A 2007-292854); Event PE-7 (rice, insect control, not deposited, described in WO 2008/114282); Event RF3 (oilseed rape, pollination control - herbicide tolerance, deposited as ATCC PTA-730, described in WO 01/041558 or US-A 2003-188347); Event RT73 (oilseed rape, herbicide tolerance, not deposited, described in WO 02/036831 or US-A 2008-070260); Event T227-1 (sugar beet, herbicide tolerance, not deposited, described in WO 02/44407 or US-A 2009-265817); Event T25 (corn, herbicide tolerance, not deposited, described in US-A 2001-029014 or WO 01/051654); Event T304-40 (cotton, insect control - herbicide tolerance, deposited as ATCC PTA-8171, described in US-A 2010-077501 or WO 2008/122406); Event T342-142 (cotton, insect control, not deposited, described in WO 2006/128568); Event TC1507 (corn, insect control - herbicide tolerance, not deposited, described in US-A 2005-039226 or WO 2004/099447); Event VIP1034 (corn, insect control - herbicide tolerance, deposited as ATCC PTA-3925., described in WO 03/052073), Event 32316 (corn,insect control-herbicide tolerance,deposited as PTA-11507, described in WO 2011/084632), Event 4114 (corn,insect control-herbicide tolerance,deposited as PTA-11506, described in WO 2011/084621).

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## EXAMPLES

### 1. Seed germination of parasitic weed species

Purpose of the test is to determine the  $EC_{50}$  of for strigolactame derivatives, i.e. the concentration of compound which is able to germinate 50% of seeds of the weeds *Phelipanche ramosa* (= *Orobanch*

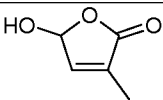
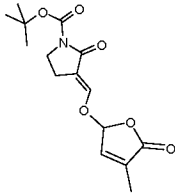
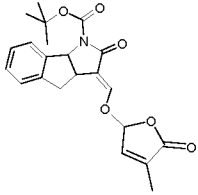


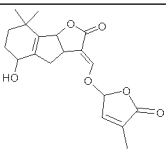
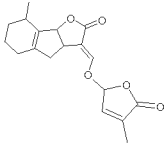
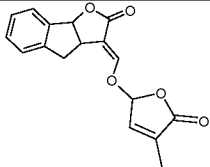
*ramosa*) pathovar C.

Strigolactame derivatives are tested in comparison to strigolactone derivatives, such as GR24, strigol or sorgolactone.

**Germination stimulation activity assay:** GR24 and SL analogues were resuspended in acetone at 10 mmol L<sup>-1</sup>, then diluted with water at 1 mmol L<sup>-1</sup> (water/acetone; v/v; 99/1). Dilutions of 1×10<sup>-3</sup> mol L<sup>-1</sup> to 1×10<sup>-15</sup> mol L<sup>-1</sup> are then performed in water/acetone (v/v; 99/1). Phelipanche *ramosa*'s seeds (St Martin de Fraigneau, France, 2005) were surface-sterilized according to Vieira Dos Santos et al. (C. V. Dos Santos, P. Letousey, P. Delavault, P. Thalouarn, *Phytopathology* 2003, 93, 451-457), then resuspended in sterile water (10 g L<sup>-1</sup>) and distributed in 96-wells plate (50 μL ≈ 100 seeds per well). After preconditioning (7 days, 21 °C, in dark, sealed plate), GR24 (10×) or other molecules were added and volumes were adjusted to 100 μL with water (water/acetone; v/v; 999/1). Controls were made with water/acetone (v/v; 999/1) and without seeds. Plates were incubated for germination as previously described. The methylthiazolyldiphenyl-tetrazolium bromide assays were carried out according to Mossman (T. Mosmann, *J. Immunol. Methods* 1983, 65, 55-63) with minor modification of the solubilization buffer (Triton X-100 10%, HCl 0.04 mol L<sup>-1</sup> in isopropanol). For each compound tested, dose-reponse curves (A=f(c), A :Absorbance 570 nm ; c : concentration (mol. L<sup>-1</sup>)) and EC 50 are modeled with a four parameter logistic curve computed with SigmaPlot® 10.0.

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		EC 50 (M)
Control		3.7 10 <sup>-6</sup>
Compound A		3.5 10 <sup>-9</sup>
Compound B		1.2 10 <sup>-9</sup>

Strigol		$6.7 \cdot 10^{-11}$
Sorgolactone		$6 \cdot 10^{-11}$
GR24		$2.1 \cdot 10^{-12}$

As known, strigolactone derivatives are able to stimulate germination of the weed *Phelipanche ramosa* seeds with a great efficiency: GR24 is able to germinate 50% of seeds of the weeds *Phelipanche ramosa* at a concentration of  $2.1 \cdot 10^{-12}$  M. Other strigolactones, such as strigol and sorgolactone, are less efficient than GR24, and need a concentration around 10 times higher to get the same results than GR24.

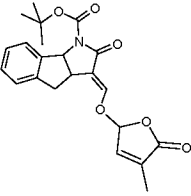
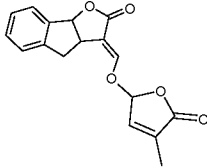
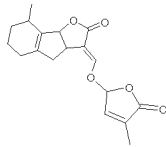
Comparatively, Strigolactame derivatives are very significantly less efficient for the germination of parasitic weed species than GR24, but also less efficient than other strigolactones: Strigolactame compound needs a concentration from 500 to 1600 times higher than GR24 and other tested strigolactones to get the same result.

Used as same concentration, strigolactame derivatives will dramatically be less active than strigolactone compounds to stimulate the seed germination of weeds, which is a great advantage for agricultural practices.

## 2. *Glomus intraradices* spore germination

Test is performed in climate chamber, at 27°C. Compounds are dissolved in acetone in a concentration of  $10^{-6}$ M. Three replicates are done by compounds. The percentage of *Glomus intraradices* germinated spores is measured after 3 days of incubation. Untreated control and control with the solvent (acetone) only are done in same conditions.

		% germination
Untreated control		54%
Acetone		56%

Compound B		82%
GR24		82%
(+)-Sorgolactone		76%

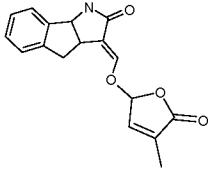
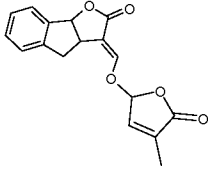
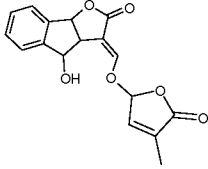
Strigolactone derivatives, and particularly GR24, are known to stimulate arbuscular mycorrhizae (AM) fungi spore germination and branching of germinating hyphae (Besserer et al., Plant Physiol. 2008, 148(1):402-13). Several tests, including the test of *Glomus intraradices* spore germination used here or the measure of branching of germinating *Gigaspora margarita* hyphae are considered as equivalent for determinate the activity of compounds on AMF fungi and therefore the capability to stimulate mycchorization (Akiyama K. et al., Nature, 2005, 435, 824).

Results of the *Glomus intraradices* spore germination show that strigolactone derivatives are efficient, and in particular as efficient as strigolactone derivatives, to stimulate arbuscular mycorrhizae (AM) fungi spore germination and mycchorization.

### 3. Test on the inhibition of the axillary bud

*P.sativum ccd8* shoot branching mutants of pea are strigolactone deficient plants which show a hyper-branched phenotype. Application of strigolactone directly to the axillary buds is able to restore the wild-type branching phenotype to *ccd8* mutants (Gomez-Roldan et al, 2008, Nature, 455, 189-194).

Compounds to be tested have been diluted in acetone in desired concentration and applied directly to the axillary N4 buds of *P.sativum ccd8* mutant. Length of axillary N3 or N4 bud is measured 10 days after treatment and compared to the length observed with a blank (untreated) control.

		Growth inhibition
Compound C (1 $\mu$ M)		++
GR24 (1 $\mu$ M)		+++
GR24-4OH (1 $\mu$ M)		++

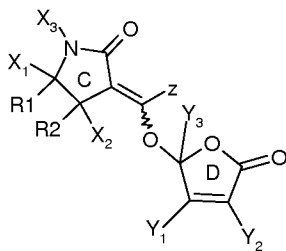
++ : 20% < length of axillary treated bud / length of untreated bud < 50%

+++ : length of axillary treated bud / length of untreated bud  $\leq$  20%

- As expected, application of the strigolactone compound GR24 directly to the axillary N4 buds of
- 5 *P. sativum ccd8* mutant restores in a significant amount (more than 80%) the wild-type branching phenotype.
- Restoration is also observed with a GR24-derived compound, although with a less efficiency (between 50 and 80 % of restoration).
- Strigolactame derivative compound C restores the wild-type branching phenotype, with an efficiency
- 10 comparable to the GR24-derived compound.

## Claims

1. A compound of formula (I)



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(I)

wherein :

- 10 - X<sub>1</sub>, X<sub>2</sub>, X<sub>3</sub>, Y<sub>1</sub>, Y<sub>2</sub>, Y<sub>3</sub> and Z independently represent a hydrogen atom, a halogen atom, a nitro group, a hydroxy group, a cyano group, an amino group, a sulphenyl group, a sulphinyl group, a sulphonyl group, a formyl group, a acetyl group, a formyloxy group, a formylamino group, a carbamoyl group, a N-hydroxycarbamoyl group, a carbamate group, substituted or non-substituted (hydroxyimino)-C<sub>1</sub>-C<sub>6</sub>-alkyl group, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkyl, substituted or non-substituted tri(C<sub>1</sub>-C<sub>8</sub>-alkyl)silyl-C<sub>1</sub>-C<sub>8</sub>-alkyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-cycloalkyl, substituted or non-substituted tri(C<sub>1</sub>-C<sub>8</sub>-alkyl)silyl-C<sub>1</sub>-C<sub>8</sub>-cycloalkyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenocycloalkyl having 1 to 5 halogen atoms, a substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkenyl, substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkynyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylamino, substituted or non-substituted di-C<sub>1</sub>-C<sub>8</sub>-alkylamino, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxy, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkoxy having 1 to 5 halogen atoms, substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkynyloxy, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylsulphenyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylsulphenyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkenyloxy, substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-halogenoalkenyloxy having 1 to 5 halogen atoms, substituted or non-substituted C<sub>3</sub>-C<sub>8</sub>-halogenoalkynyloxy having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbonyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylcarbonyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbamoyl, substituted or non-substituted di-C<sub>1</sub>-C<sub>8</sub>-alkylcarbamoyl, substituted or non-substituted N-C<sub>1</sub>-C<sub>8</sub>-alkyloxycarbamoyl, substituted or non-substituted di-C<sub>1</sub>-C<sub>8</sub>-alkoxy carbamoyl, substituted or non-substituted N-C<sub>1</sub>-C<sub>8</sub>-alkyl-C<sub>1</sub>-C<sub>8</sub>-alkoxy carbamoyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxy carbonyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkoxy carbonyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbonyloxy, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylcarbonyloxy having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbonylamino, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylcarbonylamino having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-
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5 C<sub>8</sub>-alkylaminocarbonyloxy, substituted or non-substituted di-C<sub>1</sub>-C<sub>8</sub>-alkylaminocarbonyloxy, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkyloxy carbonyloxy, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylsulphenyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylsulphenyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylsulphinyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylsulphinyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylsulphonyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylsulphonyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylaminosulfamoyl, substituted or non-substituted di-C<sub>1</sub>-C<sub>8</sub>-alkylaminosulfamoyl, substituted or non-substituted (C<sub>1</sub>-C<sub>6</sub>-alkoxyimino)-C<sub>1</sub>-C<sub>6</sub>-alkyl, substituted or non-substituted (C<sub>1</sub>-C<sub>6</sub>-alkenyloxyimino)-C<sub>1</sub>-C<sub>6</sub>-alkyl, substituted or non-substituted (C<sub>1</sub>-C<sub>6</sub>-alkynyloxyimino)-C<sub>1</sub>-C<sub>6</sub>-alkyl, substituted or non-substituted (benzyloxyimino)-C<sub>1</sub>-C<sub>6</sub>-alkyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxyalkyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkoxyalkyl having 1 to 5 halogen atoms, a substituted or non-substituted arylalkyl substituted or non-substituted benzyloxy, substituted or non-substituted benzylsulphenyl, substituted or non-substituted benzylamino, substituted or non-substituted phenoxy, substituted or non-substituted phenylsulphenyl, substituted or non-substituted phenylamino, a substituted or non-substituted or a 4-, 5-, 6- or 7-membered heterocycle comprising up to 4 heteroatoms selected in the list consisting of N, O, S]

20 - R<sub>1</sub> and R<sub>2</sub> independently represent a hydrogen atom, a halogen atom, a nitro group, a hydroxy group, a cyano group, an amino group, a sulphenyl group, a sulphinyl group, a sulphonyl group, a formyl group, a formyloxy group, a formylamino group, a carbamoyl group, a N-hydroxycarbamoyl group, a carbamate group, substituted or non-substituted (hydroxyimino)-C<sub>1</sub>-C<sub>6</sub>-alkyl group, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkyl, substituted or non-substituted tri(C<sub>1</sub>-C<sub>8</sub>-alkyl)silyl-C<sub>1</sub>-C<sub>8</sub>-alkyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-cycloalkyl, substituted or non-substituted tri(C<sub>1</sub>-C<sub>8</sub>-alkyl)silyl-C<sub>1</sub>-C<sub>8</sub>-cycloalkyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenocycloalkyl having 1 to 5 halogen atoms, a substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkenyl, substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkynyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylamino, substituted or non-substituted di-C<sub>1</sub>-C<sub>8</sub>-alkylamino, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxy, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkoxy having 1 to 5 halogen atoms, substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkynyloxy, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylsulphenyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylsulphenyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkenyloxy, substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-halogenoalkenyloxy having 1 to 5 halogen atoms, substituted or non-substituted C<sub>3</sub>-C<sub>8</sub>-halogenoalkynyloxy having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbonyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylcarbonyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbamoyl, substituted or non-substituted di-C<sub>1</sub>-C<sub>8</sub>-alkylcarbamoyl, substituted or non-substituted N-C<sub>1</sub>-C<sub>8</sub>-alkyloxycarbamoyl, substituted or non-substituted di-C<sub>1</sub>-C<sub>8</sub>-alkoxycarbamoyl, substituted or non-substituted N-C<sub>1</sub>-C<sub>8</sub>-alkyl-C<sub>1</sub>-C<sub>8</sub>-alkoxycarbamoyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxycarbonyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkoxycarbonyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbonyloxy, substituted or

- non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylcarbonyloxy having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbonylamino, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylcarbonylamino having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylaminocarbonyloxy, substituted or non-substituted di-C<sub>1</sub>-C<sub>8</sub>-alkylaminocarbonyloxy, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkyloxycarbonyloxy, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylsulphenyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylsulphenyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylsulphinyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylsulphinyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylsulphonyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylsulphonyl having 1 to 5 halogen atoms, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylaminosulfamoyl, substituted or non-substituted di-C<sub>1</sub>-C<sub>8</sub>-alkylaminosulfamoyl, substituted or non-substituted (C<sub>1</sub>-C<sub>6</sub>-alkoxyimino)-C<sub>1</sub>-C<sub>6</sub>-alkyl, substituted or non-substituted (C<sub>1</sub>-C<sub>6</sub>-alkenyloxyimino)-C<sub>1</sub>-C<sub>6</sub>-alkyl, substituted or non-substituted (C<sub>1</sub>-C<sub>6</sub>-alkynyloxyimino)-C<sub>1</sub>-C<sub>6</sub>-alkyl, substituted or non-substituted (benzyloxyimino)-C<sub>1</sub>-C<sub>6</sub>-alkyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxyalkyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkoxyalkyl having 1 to 5 halogen atoms, substituted or non-substituted benzyloxy, substituted or non-substituted benzylsulphenyl, substituted or non-substituted benzylamino, substituted or non-substituted phenoxy, substituted or non-substituted phenylsulphenyl, substituted or non-substituted phenylamino, a substituted or non-substituted or a 4-, 5-, 6- or 7-membered heterocycle comprising up to 4 heteroatoms selected in the list consisting of N, O, S]; or
- R<sub>1</sub> and R<sub>2</sub> form a saturated or unsaturated, non-aromatic, substituted or non-substituted 4- to 7-membered carbocycle; or
- R<sub>1</sub> and R<sub>2</sub> form a saturated or unsaturated, aromatic or non-aromatic, substituted or non-substituted 4- to 7-membered carbocycle fused to an other saturated or unsaturated, aromatic or non-aromatic, substituted or non-substituted 4- to 7- membered carbocycle.
- as well as salts, N-oxides, metallic complexes, metalloidic complexes and optically active or geometric isomers thereof.
2. A compound according to claim 1 wherein X<sub>1</sub>, X<sub>2</sub>, Y<sub>1</sub>, Y<sub>2</sub>, Y<sub>3</sub> and Z independently represent a hydrogen atom, a halogen atom, a nitro group, a hydroxy group, a cyano group, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-haloalkyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxy, or a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-haloalkoxy.
3. A compound according to claim 2 wherein X<sub>1</sub>, X<sub>2</sub>, Y<sub>1</sub>, Y<sub>3</sub> and Z represent a hydrogen atom.
4. A compound according to any one of claims 1 to 3 wherein Y<sub>2</sub> represents a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkyl, or a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-haloalkyl.
5. A compound according to to any one of claims 1 to 4 wherein X<sub>3</sub> represents hydrogen atom, a formyl group, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-

halogenoalkyl having 1 to 5 halogen atoms, a substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkenyl, a substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkynyl, a substituted or non-substituted arylalkyl, acetyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbonyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-halogenoalkylcarbonyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxycarbonyl.

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6. A compound according to claim 5 wherein X<sub>3</sub> represents hydrogen atom, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkyl, a substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkenyl, a substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkynyl, a substituted or non-substituted arylalkyl, formyl, acetyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbonyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-haloalkylcarbonyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxycarbonyl.

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7. A compound according to anyone of claims 1 to 6 wherein R<sub>1</sub> and R<sub>2</sub> independently represent a hydrogen atom, a halogen atom, a nitro group, a hydroxy group, a cyano group, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-haloalkyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxy, or a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-haloalkoxy; or

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R<sub>1</sub> and R<sub>2</sub> form a saturated or unsaturated, non-aromatic, substituted or non-substituted 4- to 7-membered carbocycle; or

R<sub>1</sub> and R<sub>2</sub> form a saturated or unsaturated, aromatic or non-aromatic, substituted or non-substituted 4- to 7-membered carbocycle fused to another saturated or unsaturated, aromatic or non-aromatic, substituted or non-substituted 4- to 7-membered carbocycle.

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8. A compound according to claim 7 wherein R<sub>1</sub> and R<sub>2</sub> form a saturated or unsaturated, aromatic or non-aromatic, substituted or non-substituted 4- to 7-membered carbocycle fused to another saturated or unsaturated, aromatic or non-aromatic, substituted or non-substituted 4- to 7-membered carbocycle.

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9. A compound according to claim 8 wherein R<sub>1</sub> and R<sub>2</sub> form an unsaturated, non-aromatic, substituted or non-substituted 5-membered carbocycle fused to another unsaturated, aromatic, substituted or non-substituted 6- membered carbocycle.

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10. A compound according to any one of claims 1 to 9 wherein

- X<sub>1</sub>, X<sub>2</sub>, Y<sub>1</sub>, Y<sub>2</sub>, Y<sub>3</sub> and Z independently represent a hydrogen atom, a halogen atom, a nitro group, a hydroxy group, a cyano group, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-haloalkyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxy, or a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-haloalkoxy;

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- X<sub>3</sub> represents hydrogen atom, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkyl, a substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkenyl, a substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkynyl, a substituted or non-substituted arylalkyl, formyl, acetyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbonyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-haloalkylcarbonyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxycarbonyl, and

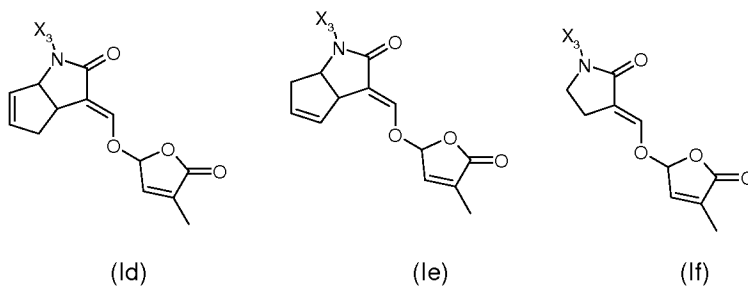
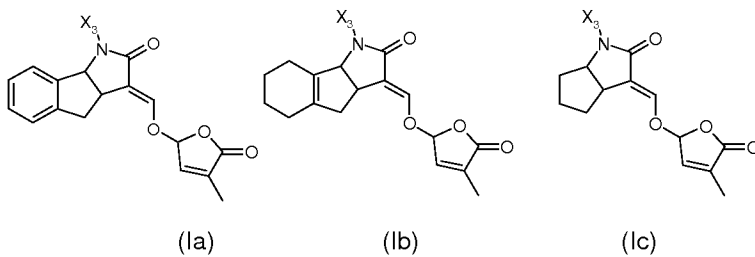


- R<sub>1</sub> and R<sub>2</sub> form an unsaturated, non-aromatic, substituted or non-substituted 5-membered carbocycle fused to another unsaturated, aromatic, substituted or non-substituted 6-membered carbocycle.

11. A compound according to claim 10 wherein

- 5 - X<sub>1</sub>, X<sub>2</sub>, Y<sub>1</sub>, Y<sub>3</sub> and Z independently represent a hydrogen atom;  
 - X<sub>3</sub> represents hydrogen atom, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkyl, a substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkenyl, a substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkynyl, a substituted or non-substituted arylalkyl, formyl, acetyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbonyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-haloalkylcarbonyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxycarbonyl,  
 10 - Y<sub>2</sub> represents a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkyl or a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-haloalkyl; and  
 - R<sub>1</sub> and R<sub>2</sub> form an unsaturated, non-aromatic substituted or non-substituted 5-membered carbocycle fused to another unsaturated, aromatic, substituted or non-substituted 6-membered carbocycle.

- 15 12. A compound according to any one of claims 1 to 10 selected in the list consisting of



wherein X<sub>3</sub> represents hydrogen atom, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkyl, a substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkenyl, a substituted or non-substituted C<sub>2</sub>-C<sub>8</sub>-alkynyl, a substituted or non-substituted arylalkyl, formyl, acetyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkylcarbonyl, a substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-haloalkylcarbonyl, substituted or non-substituted C<sub>1</sub>-C<sub>8</sub>-alkoxycarbonyl.

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13. Composition characterized by a content of at least one compound of the formula (I) according to Claim 1 or 2, in addition to at least one further active ingredient selected from the group of the insecticides, attractants, sterilants, bactericides, acaricides, nematocides, fungicides, growth regulators, herbicides, fertilizers, safeners and semiochemicals.

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14. A method for enhancing the growth, yield, vigor and/or mycchorization of a plant, characterized in that an agronomically effective quantity of a compound according to claims 1 to 12 is applied to the soil where plants grow or are capable of growing, to the leaves and/or the fruit of plants or to the seeds of plants.

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15. The use of a compound as claimed in any one of claims 1 to 12 for improving the plant growth and/or for enhancing the yield and/or decreasing the needs for fertilizers.

## INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2013/056009

A. CLASSIFICATION OF SUBJECT MATTER  
 INV. C07D405/12 A01N43/36  
 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)  
 C07D A01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

EPO-Internal, WPI Data, CHEM ABS Data

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JOHANSSON A W ET AL: "THE PREPARATION OF SYNTHETIC ANALOGUES OF STRIGOL", JOURNAL OF THE CHEMICAL SOCIETY, PERKIN TRANSACTIONS 1, CHEMICAL SOCIETY, LETCHWORTH; GB, no. 6, 1 January 1981 (1981-01-01), pages 1734-1743, XP002024940, ISSN: 0300-922X, DOI: 10.1039/P19810001734 cited in the application see derivatives of compounds 20, page 1737, left column, second paragraph and page 1742, right column, second full paragraph	1-15
A	----- EP 2 380 876 A1 (NIPPON SODA CO [JP]) 26 October 2011 (2011-10-26) claim 1 ----- -/--	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

\* Special categories of cited documents :

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

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

15 April 2013

Date of mailing of the international search report

23/04/2013

Name and mailing address of the ISA/

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Bérillon, Laurent

## INTERNATIONAL SEARCH REPORT

International application No  
PCT/EP2013/056009

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	WO 2005/077177 A2 (UNIV TOULOUSE [FR]; CENTRE NAT RECH SCIENT [FR]; BECARD GUILLAUME [FR]) 25 August 2005 (2005-08-25) cited in the application claim 1 -----	1-15
A	WO 2010/125065 A2 (BAYER CROPSCIENCE AG [DE]; DAHMEN PETER [DE]; PORTZ DANIELA [DE]; SPIC) 4 November 2010 (2010-11-04) claim 1 -----	1-15

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Information on patent family members

International application No PCT/EP2013/056009
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