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(54) **Title:** SELECTIVE WEED CONTROL WITH HALAUXIFEN

(57) **Abstract:** 4-Amino-3-chloro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid (halauxifen) or 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid or agriculturally acceptable esters or salts of either are used for selective pre-emergence and post-emergence control of undesirable vegetation in the presence of vine crops such as grapes and other perennial crops.

SELECTIVE WEED CONTROL WITH HALAUXIFEN

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Cross Reference to Related Applications

This application claims the benefit of U.S. Provisional Patent Application Serial No. 61/915,317 filed December 12, 2013, the disclosure of which is expressly incorporated herein by reference.

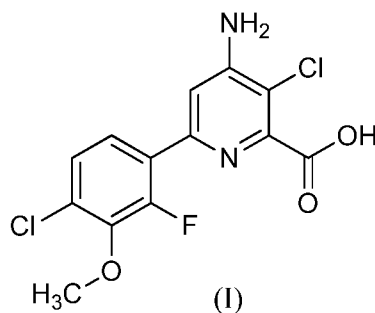
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Background

Pre-emergence and post-emergence weed control options in conventional vine crops are severely limited, and products that are available generally have narrow weed spectra. There is therefore a need for new pre-emergence and post-emergence herbicides to control undesirable vegetation in vineyards.

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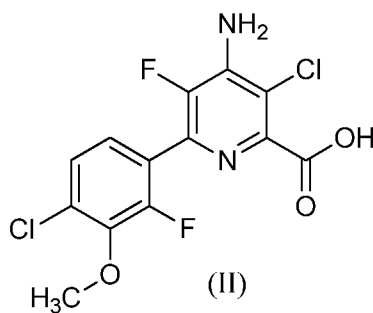
Compounds of formula (I)



and agriculturally acceptable salts and esters thereof are described in U.S. Patent 7,314,849 (B2), which is incorporated herein by reference in its entirety. As used herein, the term Compound I is used to refer to the compound of formula (I), *i.e.* 4-amino-3-chloro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid, known as halauxifen, and to agriculturally acceptable salts and esters thereof.

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Compounds of formula (II)



and agriculturally acceptable salts and esters thereof are described in U.S. Patent 7,314,849 (B2), which is incorporated herein by reference in its entirety. As used herein, the term Compound II is used to refer to the compound of formula (II), *i.e.* 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid and to agriculturally
5 acceptable salts and esters thereof.

Compounds I and II are described in U.S. Patent 7,314,849 (B2) as belonging to a family of compounds with a broad spectrum of weed control activity against woody plants, broadleaf and grass weeds, and sedges in crops such as corn, rice and cereals.

US2009/0062121A1 alleges that Compound I is a preferred compound for the control of
10 weeds in cereal crops including spring, winter and durum wheat, spring and winter barley, oats, and triticale.

U.S. Patent 8,598,084 (B2) states that Compound I is used for the control of weeds in cereal crops, including spring, winter, and durum wheat, and spring and winter barley, and that the methyl ester of the compound of formula (I) controls broadleaf weeds such as
15 *Papaver*, *Galium*, *Lamium*, *Kochia*, *Amaranthus*, *Aeschynomene*, *Sesbania*, and *Monochoria*, and sedge species such as *Cyperus* and *Schoenoplectus*.

Vines are particularly sensitive to growth regulator herbicides, such as auxins, if foliar applied. (<http://viticulture.hort.iastate.edu/info/pdf/herbicideinjury.pdf>;
[http://extension.oregonstate.edu/gilliam/sites/default/files/Prevent_Herbicide_Injury_Grapes_](http://extension.oregonstate.edu/gilliam/sites/default/files/Prevent_Herbicide_Injury_Grapes_EM8860.pdf)
20 [EM8860.pdf](http://extension.oregonstate.edu/gilliam/sites/default/files/Prevent_Herbicide_Injury_Grapes_EM8860.pdf); Wine grape (*Vitis vinifera*) response to repeated exposure of selected sulfonamides and 2,4-D. Bhatti et al, *Weed Technology* **1996**, *10*, 951-956.). In view of the broad spectrum of activity of Compounds I and II against broadleaf weeds, utility of Compounds I and II in vine crops and other perennial crops would not be expected if sprayed directly on the actively growing perennial crops as a foliar application. Compounds I and II
25 applied as directed sprays to the base of the dormant or actively growing vine and other perennial crops with adequate selectivity.

Summary

Provided herein are methods for the selective pre-emergence and post-emergence
30 control of undesirable vegetation in vineyards and other perennial crops which comprises applying a herbicidally effective amount of a compound of formula (I) or formula (II) or an agriculturally acceptable ester or salt of either to the unwanted vegetation or the locus thereof. The compound of formula (I) can be halauxifen (4-amino-3-chloro-6-(4-chloro-2-

fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid) or an agriculturally acceptable ester or salt thereof such as, for example, halauxifen-methyl (methyl 4-amino-3-chloro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylate). The compound of formula (II) can be 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid
5 or agriculturally acceptable ester or salt thereof such as, for example, benzyl 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylate.

Detailed Description

DEFINITIONS

10 The following terms have the indicated meanings when used herein:

As used herein, a herbicidally effective amount is an amount of active ingredient which causes an adversely modifying effect in targeted vegetation. Such effects include deviations from natural development, killing, regulation, desiccation, retardation, and the like.

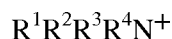
15 As used herein, selective pre- and post-emergence control of undesirable vegetation means preventing, reducing, killing, or otherwise adversely modifying the development of the undesirable vegetation in the presence of crop plants with limited adverse effect on the crop plants. For example, a broadleaf weed control of 80% (rated visually) with crop injury of less than or equal to 20% (rated visually) would constitute selective control. In some
20 embodiments the adverse effect on crop plants is limited to less than 10% visually rated crop injury. Visual crop injury is a composite rating accounting for all phytotoxic effects including chlorosis, necrosis, growth inhibition, epinasty, delays in maturity and seed or fruit deformity. Visual weed control is a composite rating accounting for reductions in pest plant biomass and/or stand reduction.

25 As used herein, a dormant application means applying Compound I or Compound II during the winter when vines and perennial crops are dormant (no active growth with no foliage in temperate climates) but winter annual weeds are actively growing. A spring application means applying Compound I or Compound II when both vines or perennial crops and weeds are actively growing, typically when new growth starts in the spring in temperate
30 climates or year round in tropical climates. Spring or summer applications, when the vine or perennial crops are growing, is selectively accomplished by a directed spray to the base of the perennial crop.

As used herein, applying a herbicide or herbicidal composition means delivering it directly to the targeted vegetation or to the locus thereof or to the area where control of undesired vegetation is desired, but not directly on the vines. Sprays or granules are directed under the vines or perennial crops, with foliar exposure of the vines and perennial crops being avoided.

As used herein, plants and vegetation include, but are not limited to, germinant seeds, emerging seedlings, plants emerging from vegetative propagules, and established vegetation.

As used herein, agriculturally acceptable salts and esters of the compound of formula (I) or the compound of formula (II) refer to salts and esters that (a) do not substantially affect the herbicidal activity and (b) are or can be hydrolyzed, oxidized, metabolized, or otherwise converted in plants or solid to the corresponding carboxylic acid which, depending upon the pH, may be in the dissociated or undissociated form. Exemplary salts include those derived from alkali or alkaline earth metals and those derived from ammonia and amines. Exemplary cations include sodium, potassium, magnesium, and ammonium cations of the formula:



wherein R^1 , R^2 , R^3 and R^4 each, independently represents hydrogen or C_1 - C_{12} alkyl, C_3 - C_{12} alkenyl or C_3 - C_{12} alkynyl, each of which is optionally substituted by one or more hydroxy, C_1 - C_4 alkoxy, C_1 - C_4 alkylthio or phenyl groups, provided that R^1 , R^2 , R^3 and R^4 are sterically compatible. Additionally, any two of R^1 , R^2 , R^3 and R^4 together may represent an aliphatic difunctional moiety containing one to twelve carbon atoms and up to two oxygen or sulfur atoms. Salts can be prepared by treatment with a metal hydroxide, such as sodium hydroxide, with an amine, such as ammonia, trimethylamine, diethanolamine, 2-methylthiopropylamine, bisallylamine, 2-butoxyethylamine, morpholine, cyclododecylamine, or benzylamine or with a tetraalkylammonium hydroxide, such as tetramethylammonium hydroxide or choline hydroxide.

Analog of these compounds in which the acid is derivatized to form a related substituent that can be transformed within plants or the environment to an acid group possess essentially the same herbicidal effect and are within the scope of this disclosure. Therefore, an "agriculturally acceptable derivative", when used to describe the carboxylic acid functionality at the 2-position of the pyridine, is defined as any salt, ester, acylhydrazide, imidate, thioimidate, amidine, amide, orthoester, acylcyanide, acyl halide, thioester, thionoester, dithiolester, nitrile or any other acid derivative well known in the art which (a)

does not substantially affect the herbicidal activity of the active ingredient, and (b) is or can be hydrolyzed, oxidized or metabolized in plants or soil to the picolinic acid of formula (I).

Exemplary esters include those derived from C₁-C₁₂ alkyl, C₃-C₁₂ alkenyl, C₃-C₁₂ alkynyl or C₇-C₁₀ aryl-substituted alkyl alcohols, such as methyl alcohol, isopropyl alcohol, 1-butanol, 2-ethylhexanol, butoxyethanol, methoxypropanol, allyl alcohol, propargyl alcohol, cyclohexanol or unsubstituted or substituted benzyl alcohols. Benzyl alcohols may be substituted with from 1-3 substituents independently selected from halogen, C₁-C₄ alkyl or C₁-C₄ alkoxy. Esters can be prepared by coupling of the acids with the alcohol using any number of suitable activating agents such as those used for peptide couplings such as dicyclohexylcarbodiimide (DCC) or carbonyl diimidazole (CDI); by reacting the acids with alkylating agents such as alkylhalides or alkylsulfonates in the presence of a base such as triethylamine or lithium carbonate; by reacting the corresponding acid chloride of an acid with an appropriate alcohol; by reacting the corresponding acid with an appropriate alcohol in the presence of an acid catalyst or by transesterification.

Specific examples of Compound I that were used in carrying out the examples set forth hereinafter are the methyl ester of the compound of formula (I). Specific examples of Compound II that were used in carrying out the examples set forth hereinafter are the benzyl ester of the compound of formula (II).

Herbicidal activity is exhibited by the compounds when they are applied directly to the plant to be controlled or to the locus of the plant to be controlled at any stage of growth. The effect observed depends upon the plant species to be controlled, the stage of growth of the plant, the application parameters of dilution and spray drop size, the particle size of solid components, the environmental conditions at the time of use, the specific compound employed, the specific adjuvants and carriers employed, the soil type, and the like, as well as the amount of chemical applied. These and other factors can be adjusted to promote non-selective or selective herbicidal action. In the present methods, the compositions described herein are applied as a pre-emergence or post-emergence application to non-germinated undesirable vegetation or to relatively immature and mature undesirable vegetation to achieve the maximum control of weeds.

At an application rate of 2.5 to 40 g ae/ha, Compound I as a pre-emergence and post-emergence application is highly efficacious on several commercially relevant broadleaf and grass weeds, including chickweed (*Stellaria media*), pigweed (*Amaranthus* spp.), common lambsquarters (*Chenopodium album*), hairy fleabane (*Conyza bonariensis*), horseweed

(*Conyza canadensis*), coast fiddleneck (*Amsinckia intermedia*), Shepherd's purse (*Capsella bursa-pastoris*), rockpurslane (*Calandrinia ciliata*), redstem filaree (*Erodium cicutarium*), smallflower malva (*Malva parviflora*), California burclover (*Medicago polymorpha*), annual bluegrass (*Poa annua*), witchgrass (*Panicum capillare*), quackgrass (*Agropyron repens*), and giant foxtail (*Setaria faberi*). The level of crop safety exhibited by grapevines and perennial crops toward Compound I is variable, but generally post-emergence application rates of ≤ 20 g ae/ha cause little to no crop injury when applied as a dormant application or a spring application directed under the crops. Additional examples of application rates for Compound I as a pre-emergence and post-emergence application include 0.25 to 50 g ae/ha, 0.25 to 45 g ae/ha, 0.25 to 40 g ae/ha, 0.25 to 35 g ae/ha, 0.25 to 30 g ae/ha, 0.25 to 25 g ae/ha, 0.25 to 20 g ae/ha, 0.25 to 15 g ae/ha, 0.25 to 10 g ae/ha, 0.25 to 5 g ae/ha, 2.5 to 50 g ae/ha, 5 to 50 g ae/ha, 10 to 50 g ae/ha, 15 to 50 g ae/ha, 20 to 50 g ae/ha, 25 to 50 g ae/ha, 30 to 50 g ae/ha, 35 to 50 g ae/ha, 40 to 50 g ae/ha, 45 to 50 g ae/ha, 5 to 40 g ae/ha, 10 to 40 g ae/ha, 15 to 40 g ae/ha, 20 to 40 g ae/ha, 25 to 40 g ae/ha, 30 to 40 g ae/ha, 35 to 40 g ae/ha, 2.5 to 35 g ae/ha, 2.5 to 30 g ae/ha, 2.5 to 25 g ae/ha, 2.5 to 20 g ae/ha, 2.5 to 15 g ae/ha, 2.5 to 10 g ae/ha, 2.5 to 5 g ae/ha, 5 to 35 g ae/ha, 10 to 30 g ae/ha, 15 to 25 g ae/ha, and 15 to 20 g ae/ha. Further examples of application rates for Compound I as a pre-emergence and post-emergence application include 0.25 g ae/ha, 0.5 g ae/ha, 0.75 g ae/ha, 1 g ae/ha, 1.25 g ae/ha, 1.5 g ae/ha, 1.75 g ae/ha, 2 g ae/ha, 2.25 g ae/ha, 2.5 g ae/ha, 3 g ae/ha, 4 g ae/ha, 5 g ae/ha, 6 g ae/ha, 7 g ae/ha, 8 g ae/ha, 9 g ae/ha, 10 g ae/ha, 12 g ae/ha, 14 g ae/ha, 16 g ae/ha, 18 g ae/ha, 20 g ae/ha, 22 g ae/ha, 24 g ae/ha, 26 g ae/ha, 28 g ae/ha, 30 g ae/ha, 32 g ae/ha, 34 g ae/ha, 36 g ae/ha, 38 g ae/ha, 40 g ae/ha, 42 g ae/ha, 44 g ae/ha, 46 g ae/ha, 48 g ae/ha, and 50 g ae/ha.

At an application rate of 2.5 to 50 g ai/ha, Compound II as a pre-emergence or post-emergence application is highly efficacious on several commercially relevant broadleaf and grass weeds, including chickweed (*Stellaria media*), pigweed (*Amaranthus* spp.), common lambsquarters (*Chenopodium album*), hairy fleabane (*Conyza bonariensis*), horseweed (*Conyza canadensis*), coast fiddleneck (*Amsinckia intermedia*), Shepherd's purse (*Capsella bursa-pastoris*), rock purslane (*Calandrinia ciliata*), redstem filaree (*Erodium cicutarium*), smallflower malva (*Malva parviflora*), morningglory (*Ipomoea* spp.), and California burclover (*Medicago polymorpha*). The level of crop safety exhibited by grapevines and perennial crops toward Compound II is variable, but generally post-emergence application rates of ≤ 20 g ae/ha cause little to no crop injury when applied as a dormant application or as

a spring application directed under the crops. Additional examples of application rates for Compound II as a pre-emergence and post-emergence application include 1 to 100 g ai/ha, 1 to 90 g ai/ha, 1 to 80 g ai/ha, 1 to 70 g ai/ha, 1 to 60 g ai/ha, 1 to 50 g ai/ha, 1 to 45 g ai/ha, 1 to 40 g ai/ha, 1 to 35 g ai/ha, 1 to 30 g ai/ha, 1 to 25 g ai/ha, 1 to 20 g ai/ha, 1 to 15 g ai/ha, 1 to 10 g ai/ha, 1 to 5 g ai/ha, 5 to 100 g ai/ha, 10 to 100 g ai/ha, 15 to 100 g ai/ha, 20 to 100 g ai/ha, 25 to 100 g ai/ha, 30 to 100 g ai/ha, 35 to 100 g ai/ha, 40 to 100 g ai/ha, 45 to 100 g ai/ha, 50 to 100 g ai/ha, 60 to 100 g ai/ha, 70 to 100 g ai/ha, 80 to 100 g ai/ha, 90 to 100 g ai/ha, 5 to 50 g ai/ha, 10 to 50 g ai/ha, 15 to 50 g ai/ha, 20 to 50 g ai/ha, 25 to 50 g ai/ha, 30 to 50 g ai/ha, 35 to 50 g ai/ha, 40 to 50 g ai/ha, 45 to 50 g ai/ha, 2.5 to 45 g ai/ha, 2.5 to 40 g ai/ha, 2.5 to 35 g ai/ha, 2.5 to 30 g ai/ha, 2.5 to 25 g ai/ha, 2.5 to 20 g ai/ha, 2.5 to 15 g ai/ha, 2.5 to 10 g ai/ha, 2.5 to 5 g ai/ha, 5 to 45 g ai/ha, 10 to 40 g ai/ha, 15 to 35 g ai/ha, and 20 to 30 g ai/ha. Further examples of application rates for Compound II as a pre-emergence and post-emergence application include 1 g ai/ha, 1.25 g ai/ha, 1.5 g ai/ha, 1.75 g ai/ha, 2 g ai/ha, 2.25 g ai/ha, 2.5 g ai/ha, 3 g ai/ha, 4 g ai/ha, 5 g ai/ha, 6 g ai/ha, 7 g ai/ha, 8 g ai/ha, 9 g ai/ha, 10 g ai/ha, 12 g ai/ha, 14 g ai/ha, 16 g ai/ha, 18 g ai/ha, 20 g ai/ha, 22 g ai/ha, 24 g ai/ha, 26 g ai/ha, 28 g ai/ha, 30 g ai/ha, 32 g ai/ha, 34 g ai/ha, 36 g ai/ha, 38 g ai/ha, 40 g ai/ha, 42 g ai/ha, 44 g ai/ha, 46 g ai/ha, 48 g ai/ha, 50 g ai/ha, 60 g ai/ha, 70 g ai/ha, 80 g ai/ha, 90 g ai/ha.

The mixtures described herein can be applied in conjunction with one or more other herbicides to control a wider variety of undesirable vegetation. When used in conjunction with other herbicides, the composition can be formulated with the other herbicide or herbicides, tank mixed with the other herbicide or herbicides, or applied sequentially with the other herbicide or herbicides. Some of the herbicides that can be employed in conjunction with the compositions and methods described herein include, but are not limited to: 4-CPA, 4-CPB, 4-CPP, 2,4-D, 2,4-D choline salt, 2,4-D esters and amines, 2,4-DB, 3,4-DA, 3,4-DB, 2,4-DEB, 2,4-DEP, 3,4-DP, 2,3,6-TBA, 2,4,5-T, 2,4,5-TB, acetochlor, acifluorfen, aclonifen, acrolein, alachlor, allidochlor, alloxymid, allyl alcohol, alorac, ametrifone, ametryn, amibuzin, amicarbazone, amidosulfuron, aminocyclopyrachlor, aminopyralid, amiprofos-methyl, amitrole, ammonium sulfamate, anilofos, anisuron, asulam, atraton, atrazine, azafenidin, azimsulfuron, aziprotryne, barban, BCPC, beflubutamid, benazolin, bencarbazon, benfluralin, benfuresate, bensulfuron-methyl, bensulide, benthio carb, bentazon-sodium, benzadox, benzfendizone, benzipram, benzobicyclon, benzofenap, benzofluor, benzoylprop, benzthiazuron, bialaphos, bicyclopyrone, bifenox, bilanafos,

bispyribac-sodium, borax, bromacil, bromobonil, bromobutide, bromofenoxim, bromoxynil, brompyrazon, butachlor, butafenacil, butamifos, butenachlor, buthidazole, buthiuron, butralin, butroxydim, buturon, butylate, cacodylic acid, cafenstrole, calcium chlorate, calcium cyanamide, cambendichlor, carbasulam, carbetamide, carboxazole, carfentrazone-ethyl, 5 CDEA, CEPC, chlomethoxyfen, chloramben, chloranocryl, chlorazifop, chlorazine, chlorbromuron, chlorbufam, chloreturon, chlorfenac, chlorfenprop, chlorflurazole, chlorflurenol, chloridazon, chlorimuron, chlornitrofen, chloropon, chlorotoluron, chloroxuron, chloroxynil, chlorprocarb, chlorpropham, chlorsulfuron, chlorthal, chlorthiamid, cinidon-ethyl, cinmethylin, cinosulfuron, cisanilide, clethodim, cliodinate, clodinafop- 10 propargyl, clofop, clomazone, clomeprop, cloprop, cloproxydim, clopyralid, cloransulam-methyl, CMA, copper sulfate, CPMF, CPPC, credazine, cresol, cumyluron, cyanatryn, cyanazine, cycloate, cyclopyrimorate, cyclosulfamuron, cycloxydim, cycluron, cyhalofop-butyl, cyperquat, cyprazine, cyprazole, cypromid, daimuron, dalapon, dazomet, delachlor, desmedipham, desmetryn, di-allate, dicamba, dichlobenil, dichloralurea, dichlormate, 15 dichlorprop, dichlorprop-P, diclofop-methyl, diclosulam, diethamquat, diethatyl, difenopenten, difenoxuron, difenzoquat, diflufenican, diflufenzopyr, dimefuron, dimepiperate, dimethachlor, dimethametryn, dimethenamid, dimethenamid-P, dimexano, dimidazon, dinitramine, dinofenate, dinoprop, dinosam, dinoseb, dinoterb, diphenamid, dipropetryn, diquat, disul, dithiopyr, diuron, DMPA, DNOC, DSMA, EBEP, eglinazine, 20 endothal, epronaz, EPTC, erbon, esprocarb, ethalfluralin, ethbenzamide, ethametsulfuron, ethidimuron, ethiolate, ethobenzamid, etobenzamid, ethofumesate, ethoxyfen, ethoxysulfuron, etinofen, etnipromid, etobenzanid, EXD, fenasulam, fenoprop, fenoxaprop, fenoxaprop-P-ethyl, fenoxaprop-P-ethyl + isoxadifen-ethyl, fenoxasulfone, fenquinotrione, fenteracol, fenthiaprop, fentrazamide, fenuron, ferrous sulfate, flamprop, flamprop-M, 25 flazasulfuron, florasulam, fluazifop, fluazifop-P-butyl, fluazolate, flucarbazone, flucetosulfuron, fluchloralin, flufenacet, flufenican, flufenpyr-ethyl, flumetsulam, flumezin, flumiclorac-pentyl, flumioxazin, flumipropyn, fluometuron, fluorodifen, fluoroglycofen, fluoromidine, fluoronitrofen, fluothiuron, flupoxam, flupropacil, flupropanate, flupyrsulfuron, fluridone, flurochloridone, fluroxy pyr, fluroxy pyr-meptyl, flurtamone, 30 fluthiacet, fomesafen, foramsulfuron, fosamine, fumiclorac, furyloxyfen, glufosinate, glufosinate-ammonium, glufosinate-P-ammonium, glyphosate, halosafen, halosulfuron-methyl, haloxydine, haloxyfop-methyl, haloxyfop-P-methyl, hexachloroacetone, hexaflurate, hexazinone, imazamethabenz, imazamox, imazapic, imazapyr, imazaquin, imazosulfuron,

imazethapyr, indanofan, indaziflam, iodobonil, iodomethane, iodosulfuron, iodosulfuron-ethyl-sodium, iofensulfuron, ioxynil, ipazine, ipfencarbazone, iprymidam, isocarbamid, isocil, isomethiozin, isonoruron, isopolinate, isopropalin, isoproturon, isouron, isoxaben, isoxachlortole, isoxaflutole, isoxapyrifop, karbutilate, ketospiradox, lactofen, lenacil, linuron, 5 MAA, MAMA, MCPA esters and amines, MCPA-thioethyl, MCPB, mecoprop, mecoprop-P, medinoterb, mefenacet, mefluidide, mesoprazine, mesosulfuron, mesotrione, metam, metamifop, metamitron, metazachlor, metazosulfuron, metflurazon, methabenzthiazuron, methalpropalin, methazole, methiobencarb, methiozolin, methiuron, methometon, methoprotryne, methyl bromide, methyl isothiocyanate, methyldymron, metobenzuron, 10 metobromuron, metolachlor, metosulam, metoxuron, metribuzin, metsulfuron, metsulfuron-methyl, molinate, monalide, monisouron, monochloroacetic acid, monolinuron, monuron, morfamquat, MSMA, naproanilide, napropamide, napropamide-M, naptalam, neburon, nicosulfuron, nipyraclufen, nitralin, nitrofen, nitrofluorfen, norflurazon, noruron, OCH, orbencarb, *ortho*-dichlorobenzene, orthosulfamuron, oryzalin, oxadiargyl, oxadiazon, 15 oxapyrazon, oxasulfuron, oxaziclomefone, oxyfluorfen, paraflufen-ethyl, parafluron, paraquat, pebulate, pelargonic acid, pendimethalin, penoxsulam, pentachlorophenol, pentanochlor, pentoxazone, perfluidone, pethoxamid, phenisopham, phenmedipham, phenmedipham-ethyl, phenobenzuron, phenylmercury acetate, picloram, picolinafen, pinoxaden, piperophos, potassium arsenite, potassium azide, potassium cyanate, pretilachlor, 20 primisulfuron-methyl, procyazine, prodiamine, profluazol, profluralin, profoxydim, proglinazine, prohexadione-calcium, prometon, prometryn, pronamide, propachlor, propanil, propaquizafop, propazine, propham, propisochlor, propoxycarbazone, propyrisulfuron, propyzamide, prosulfalin, prosulfocarb, prosulfuron, proxan, prynachlor, pydanon, pyraclonil, pyraflufen-ethyl, pyrasulfotole, pyrazogyl, pyrazolynate, pyrazosulfuron-ethyl, 25 pyrazoxyfen, pyribenzoxim, pyributicarb, pyriclor, pyridafof, pyridate, pyriftalid, pyriminobac, pyrimisulfan, pyriothiobac-sodium, pyroxasulfone, pyroxulam, quinclorac, quinmerac, quinclamine, quinonamid, quizalofop, quizalofop-P-ethyl, rhodethanil, rimsulfuron, saflufenacil, S-metolachlor, sebuthylazine, secbumeton, sethoxydim, siduron, simazine, simeton, simetryn, SMA, sodium arsenite, sodium azide, sodium chlorate, 30 sulcotrione, sulfallate, sulfentrazone, sulfometuron, sulfosate, sulfosulfuron, sulfuric acid, sulglycapin, swep, TCA, tebutam, tebuthiuron, tefuryltrione, tembotrione, tepraloxymid, terbacil, terbucarb, terbuchlor, terbumeton, terbuthylazine, terbutryn, tetrafluron, thenylchlor, thiazafluron, thiazopyr, thidiazimin, thidiazuron, thiencarbazone-methyl, thifensulfuron,

thifensulfuron-methyl, thiobencarb, tiocarbazil, tioclorim, topramezone, tralkoxydim, triafamone, tri-allate, triasulfuron, triaziflam, tribenuron, tribenuron-methyl, tricamba, triclopyr choline salt, triclopyr esters and salts, tridiphane, trietazine, trifloxysulfuron, trifluralin, triflusulfuron, trifop, trifopsime, trihydroxytriazine, trimeturon, tripropindan, tritac, tritosulfuron, vernolate, xylachlor and salts, esters, optically active isomers and mixtures thereof. Particularly preferred mixing partners include glyphosate salts and esters, glufosinate-ammonium, paraquat, oxyfluorfen, penoxsulam, flumioxazin, fluroxypyr, clopyralid, flazasulfuron, pendimethalin, isoxaben, indaziflam and saflufenacil.

The compositions and methods described herein can further be used in conjunction with glyphosate, glufosinate, dicamba, phenoxy auxins, pyridyloxy auxins, aryloxyphenoxypropionates, acetyl CoA carboxylase (ACCase) inhibitors, imidazolinones, acetolactate synthase (ALS) inhibitors, 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitors, protoporphyrinogen oxidase (PPO) inhibitors, triazines, and bromoxynil on glyphosate-tolerant, glufosinate-tolerant, dicamba-tolerant, phenoxy auxin-tolerant, pyridyloxy auxin-tolerant, aryloxyphenoxypropionate-tolerant, ACCase-tolerant, imidazolinone-tolerant, ALS-tolerant, HPPD-tolerant, PPO-tolerant, triazine-tolerant, bromoxynil-tolerant, and crops possessing multiple or stacked traits conferring tolerance to multiple chemistries and/or multiple modes-of-action. In some embodiments, the compound of formula (I) or formula (II) or salts or esters thereof and a complementary herbicide or salt or ester thereof are used in combination with herbicides that are selective for the crop being treated and which complement the spectrum of weeds controlled by these compounds at the application rate employed. In some embodiments, the compositions described herein and other complementary herbicides are applied at the same time, either as a combination formulation or as a tank mix.

The compounds of formula I or formula II or agriculturally acceptable salts or esters thereof may be used to control herbicide resistant or tolerant weeds. The methods employing the combination of a compound of formula I or formula II or agriculturally acceptable salt or ester thereof and the compositions described herein may also be employed to control herbicide resistant or tolerant weeds. Exemplary resistant or tolerant weeds include, but are not limited to, biotypes resistant or tolerant to acetolactate synthase (ALS) or acetohydroxy acid synthase (AHAS) inhibitors (*e.g.*, imidazolinones, sulfonyleureas, pyrimidinylthiobenzoates, triazolopyrimidines, sulfonylaminocarbonyltriazolinones); photosystem II inhibitors (*e.g.*, phenylcarbamates, pyridazinones, triazines, triazinones,

uracils, amides, ureas, benzothiadiazinones, nitriles, phenylpyridazines); acetyl CoA carboxylase (ACCase) inhibitors (*e.g.*, aryloxyphenoxypropionates, cyclohexanediones, phenylpyrazolines); synthetic auxins (*e.g.*, benzoic acids, phenoxy-carboxylic acids, pyridine carboxylic acids, quinoline carboxylic acids); auxin transport inhibitors (*e.g.*, phthalamates, 5 semicarbazones); photosystem I inhibitors (*e.g.*, bipyridyliums); 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase inhibitors (*e.g.*, glyphosate); glutamine synthetase inhibitors (*e.g.*, glufosinate, bialafos); microtubule assembly inhibitors (*e.g.*, benzamides, benzoic acids, dinitroanilines, phosphoramidates, pyridines); mitosis inhibitors (*e.g.*, carbamates); very long chain fatty acid (VLCFA) inhibitors (*e.g.*, acetamides, chloroacetamides, oxyacetamides, 10 tetrazolinones); fatty acid and lipid synthesis inhibitors (*e.g.*, phosphorodithioates, thiocarbamates, benzofuranes, chlorocarbonic acids); protoporphyrinogen oxidase (PPO) inhibitors (*e.g.*, diphenylethers, *N*-phenylphthalimides, oxadiazoles, oxazolidinediones, phenylpyrazoles, pyrimidindiones, thiadiazoles, triazolinones); carotenoid biosynthesis inhibitors (*e.g.*, clomazone, amitrole, aclonifen); phytoene desaturase (PDS) inhibitors (*e.g.*, 15 amides, anilidex, furanones, phenoxybutan-amides, pyridiazinones, pyridines); 4-hydroxyphenyl-pyruvate-dioxygenase (HPPD) inhibitors (*e.g.*, callistemones, isoxazoles, pyrazoles, triketones); cellulose biosynthesis inhibitors (*e.g.*, nitriles, benzamides, quinclorac, triazolocarboxamides); herbicides with multiple modes-of-action such as quinclorac; and unclassified herbicides such as arylaminopropionic acids, difenzoquat, endothall, and 20 organoarsenicals. Exemplary resistant or tolerant weeds include, but are not limited to, biotypes with resistance or tolerance to single or multiple herbicides, biotypes with resistance or tolerance to single or multiple chemical classes, biotypes with resistance or tolerance to single or multiple herbicide modes-of-action, and biotypes with multiple resistance or tolerance mechanisms (*e.g.*, target site resistance or metabolic resistance).

25 In some embodiments, the methods provided herein are utilized to control undesirable vegetation found in vine crops and other perennial crops, including, but not limited to, grapevines and tree and fruit orchards, including, but not limited to, almond, apple, apricot, avocado, beechnut, Brazil nut, butternut, cashew, cherry, chestnut, chinquapin, citrus, crab apple, date, feijoa, fig, grapefruit, filbert, hickory nut, kiwi, lemon, lime, loquat, macadamia 30 nut, mandarin, mayhaws, nectarine, olives, oranges (sweet and sour), peach, pear, pecan, persimmon, pistachio, plum, pome fruit, pomegranates, prune, quince, stone fruit, tangerine, tangelo, tree nuts and walnut, and perennial plantation crops including, but not limited to, rubber, oil palm, coffee and cacao. In certain embodiments, the undesirable vegetation is

Agropyren repens L. (quackgrass, AGRRE), *Alopecurus myosuroides* Huds. (blackgrass, ALOMY), *Avena fatua* L. (wild oat, AVEFA), *Brachiaria decumbens* Stapf. or *Urochloa decumbens* (Stapf) R.D. Webster (Surinam grass, BRADC), *Brachiaria brizantha* (Hochst. ex A. Rich.) Stapf. or *Urochloa brizantha* (Hochst. ex A. Rich.) R.D. (beard grass, BRABR),
5 *Brachiaria platyphylla* (Groseb.) Nash or *Urochloa platyphylla* (Nash) R.D. Webster (broadleaf signalgrass, BRAPP), *Brachiaria plantaginea* (Link) Hitchc. or *Urochloa plantaginea* (Link) R.D. Webster (alexandergrass, BRAPL), *Cenchrus echinatus* L. (southern sandbur, CENEC), *Digitaria horizontalis* Willd. (Jamaican crabgrass, DIGHO), *Digitaria insularis* (L.) Mez ex Ekman (sourgrass, TRCIN), *Digitaria sanguinalis* (L.) Scop. (large
10 crabgrass, DIGSA), *Echinochloa crus-galli* (L.) P. Beauv. (barnyardgrass, ECHCG), *Echinochloa colonum* (L.) Link (junglerice, ECHCO), *Eleusine indica* (L.) Gaertn. (goosegrass, ELEIN), *Lolium multiflorum* Lam. (Italian ryegrass, LOLMU), *Panicum capillare* (witchgrass, PANCA), *Panicum dichotomiflorum* Michx. (fall panicum, PANDI), *Panicum miliaceum* L. (wild-proso millet, PANMI), *Poa annua* L. (annual bluegrass,
15 POAAN), *Setaria faberi* Herrm. (giant foxtail, SETFA), *Setaria viridis* (L.) Beauv. (green foxtail, SETVI), *Sorghum halepense* (L.) Pers. (Johnsongrass, SORHA), *Sorghum bicolor* (L.) Moench ssp. *Arundinaceum* (shattercane, SORVU), *Cyperus esculentus* L. (yellow nutsedge, CYPES), *Cyperus rotundus* L. (purple nutsedge, CYPRO), *Abutilon theophrasti* Medik. (velvetleaf, ABUTH), *Amaranthus* species (pigweeds and amaranths, AMASS),
20 *Ambrosia artemisiifolia* L. (common ragweed, AMBEL), *Ambrosia psilostachya* DC. (western ragweed, AMBPS), *Ambrosia trifida* L. (giant ragweed, AMBTR), *Amsinckia intermedia* L. (coast fiddleneck, AMSIN), *Anoda cristata* (L.) Schlecht. (spurred anoda, ANVCR), *Asclepias syriaca* L. (common milkweed, ASCSY), *Bidens pilosa* L. (hairy beggarticks, BIDPI), *Borreria* species (BOISS), *Borreria alata* (Aubl.) DC. or *Spermacoce*
25 *alata* Aubl. or *Spermacoce latifolia* (broadleaf buttonweed, BOILF), *Capsella bursa-pastoris* L. (Shepherd's purse, CAPBP), *Chenopodium album* L. (common lambsquarters, CHEAL), *Cirsium arvense* (L.) Scop. (Canada thistle, CIRAR), *Calandrinia ciliata* L. (rock purslane, CLNCM), *Commelina benghalensis* L. (tropical spiderwort, COMBE), *Datura stramonium* L. (jimsonweed, DATST), *Daucus carota* L. (wild carrot, DAUCA), *Euphorbia heterophylla*
30 L. (wild poinsettia, EPHHL), *Euphorbia hirta* L. or *Chamaesyce hirta* (L.) Millsp. (garden spurge, EPHHI), *Euphorbia dentata* Michx. (toothed spurge, EPHDE), *Erigeron bonariensis* L. or *Conyza bonariensis* (L.) Cronq. (hairy fleabane, ERIBO), *Erigeron canadensis* L. or *Conyza canadensis* (L.) Cronq. (horseweed, ERICA), *Conyza sumatrensis* (Retz.) E. H.

Walker (tall fleabane, ERIFL), *Erodium cicutarium* L. (redstem filaree, EROCI), *Helianthus annuus* L. (common sunflower, HELAN), *Jacquemontia tammifolia* (L.) Griseb. (smallflower morningglory, IAQTA), *Ipomoea hederacea* (L.) Jacq. (ivy leaf morningglory, IPOHE),
 5 *Ipomoea lacunosa* L. (white morningglory, IPOLA), *Ipomoea* species (morningglory, IPOSS), *Lactuca serriola* L./Torn. (prickly lettuce, LACSE), *Malva parviflora* L. (smallflower malva, MALPA), *Medicago polymorpha* L. (California burclover, MEDPO),
Portulaca oleracea L. (common purslane, POROL), *Richardia* species (pusley, RCHSS),
Sida species (sida, SIDSS), *Sida spinosa* L. (prickly sida, SIDSP), *Sinapis arvensis* L. (wild mustard, SINAR), *Sonchus arvensis* L. (perennial sowthistle, SONAR), *Solanum*
 10 *ptychanthum* Dunal (eastern black nightshade, SOLPT), *Stellaria media* L. (common chickweed, STEME), *Taraxacum officinale* G.H. Weber ex Wiggers (dandelion, TAROF),
Tridax procumbens L. (coat buttons, TRQPR), and *Xanthium strumarium* L. (common cocklebur, XANST).

In some embodiments, the compositions described herein are employed in
 15 combination with one or more herbicide safeners, such as AD-67 (MON 4660), benoxacor, benthocarb, brassinolide, cloquintocet (mexyl), cyometrinil, daimuron, dichlormid, dicyclonon, dimepiperate, disulfoton, fenchlorazole-ethyl, fenclorim, flurazole, fluxofenim, furilazole, harpin proteins, isoxadifen-ethyl, jiecaowan, jiecaoxi, mefenpyr-diethyl, mephenate, naphthalic anhydride (NA), oxabetrinil, R29148 and *N*-phenyl-sulfonylbenzoic acid amides, 1-[4-(*N*-(2-methoxybenzoyl)sulfamoyl)phenyl]-3-methylurea, *N*-(2-
 20 methoxybenzoyl)-4-[(methylaminocarbonyl)amino]benzenesulfonamide, to enhance their selectivity. In some embodiments, the safener is cloquintocet or an ester or salt thereof. In certain embodiments, cloquintocet is utilized to antagonize harmful effects of the compositions, particularly in rice and cereals. In some embodiments, the safener is
 25 cloquintocet (mexyl).

In some embodiments, compositions provided herein further comprise at least one agriculturally acceptable adjuvant or carrier. Suitable adjuvants or carriers should not be phytotoxic to valuable crops, particularly at the concentrations employed in applying the compositions for selective weed control in the presence of crops, and should not react
 30 chemically with herbicidal components or other composition ingredients. Such mixtures can be designed for application directly to weeds or their locus or can be concentrates or formulations that are normally diluted with additional carriers and adjuvants before application. They can be solids, such as, for example, dusts, granules, water-dispersible

granules, or wettable powders, or liquids, such as, for example, emulsifiable concentrates, solutions, emulsions or suspensions. They can also be provided as a pre-mix or tank mixed.

Suitable agricultural adjuvants and carriers include, but are not limited to, crop oil concentrate; nonylphenol ethoxylate; benzylcocoalkyldimethyl quaternary ammonium salt; 5 blend of petroleum hydrocarbon, alkyl esters, organic acid, and anionic surfactant; C₉-C₁₁ alkylpolyglycoside; phosphated alcohol ethoxylate; natural primary alcohol (C₁₂-C₁₆) ethoxylate; di-*sec*-butylphenol EO-PO block copolymer; polysiloxane-methyl cap; nonylphenol ethoxylate + urea ammonium nitrate; emulsified methylated seed oil; tridecyl alcohol (synthetic) ethoxylate (8EO); tallow amine ethoxylate (15 EO); PEG(400) dioleate- 10 99; paraffinic oil, alkoxyated alcohol non-ionic surfactant; mineral oil, surfactant blend.

Liquid carriers that can be employed include water and organic solvents. The organic solvents include, but are not limited to, petroleum fractions or hydrocarbons such as mineral oil, aromatic solvents, paraffinic oils, and the like; vegetable oils such as soybean oil, rapeseed oil, olive oil, castor oil, sunflower seed oil, coconut oil, corn oil, cottonseed oil, 15 linseed oil, palm oil, peanut oil, safflower oil, sesame oil, tung oil and the like; esters of the above vegetable oils; esters of monoalcohols or dihydric, trihydric, or other lower polyalcohols (4-6 hydroxy containing), such as 2-ethyl hexyl stearate, *n*-butyl oleate, isopropyl myristate, propylene glycol dioleate, di-octyl succinate, di-butyl adipate, di-octyl phthalate and the like; esters of mono, di and polycarboxylic acids and the like. Specific 20 organic solvents include, but are not limited to toluene, xylene, petroleum naphtha, crop oil, acetone, methyl ethyl ketone, cyclohexanone, trichloroethylene, perchloroethylene, ethyl acetate, amyl acetate, butyl acetate, propylene glycol monomethyl ether and diethylene glycol monomethyl ether, methyl alcohol, ethyl alcohol, isopropyl alcohol, amyl alcohol, ethylene glycol, propylene glycol, glycerine, *N*-methyl-2-pyrrolidinone, *N,N*-dimethyl alkylamides, 25 dimethyl sulfoxide, liquid fertilizers and the like. In certain embodiments, water is the carrier for the dilution of concentrates.

Suitable solid carriers include but are not limited to talc, pyro-phyllite clay, silica, attapulugus clay, kaolin clay, kieselguhr, chalk, diatomaceous earth, lime, calcium carbonate, bentonite clay, Fuller's earth, cottonseed hulls, wheat flour, soybean flour, pumice, wood 30 flour, walnut shell flour, lignin, cellulose, and the like.

In some embodiments, the compositions described herein further comprise one or more surface-active agents. In some embodiments, such surface-active agents are employed in both solid and liquid compositions, and in certain embodiments those designed to be

diluted with carrier before application. The surface-active agents can be anionic, cationic or nonionic in character and can be employed as emulsifying agents, wetting agents, suspending agents, or for other purposes. Surfactants which may also be used in the present formulations are described, *inter alia*, in *McCutcheon's Detergents and Emulsifiers Annual*, MC

5 Publishing Corporation: Ridgewood, NJ, 1998 and in *Encyclopedia of Surfactants, Vol. I-III*, Chemical Publishing Company: New York, 1980-81. Surface-active agents include, but are not limited to salts of alkyl sulfates, such as diethanolammonium lauryl sulfate; alkylarylsulfonate salts, such as calcium dodecylbenzenesulfonate; alkylphenol-alkylene oxide addition products, such as nonylphenol-C₁₈ ethoxylate; alcohol-alkylene oxide addition
10 products, such as tridecyl alcohol-C₁₆ ethoxylate; soaps, such as sodium stearate; alkyl-naphthalene-sulfonate salts, such as sodium dibutyl-naphthalenesulfonate; dialkyl esters of sulfosuccinate salts, such as sodium di(2-ethylhexyl) sulfosuccinate; sorbitol esters, such as sorbitol oleate; quaternary amines, such as lauryl trimethylammonium chloride; polyethylene glycol esters of fatty acids, such as polyethylene glycol stearate; block copolymers of
15 ethylene oxide and propylene oxide; salts of mono and dialkyl phosphate esters; vegetable or seed oils such as soybean oil, rapeseed/canola oil, olive oil, castor oil, sunflower seed oil, coconut oil, corn oil, cottonseed oil, linseed oil, palm oil, peanut oil, safflower oil, sesame oil, tung oil and the like; and esters of the above vegetable oils, and in certain embodiments, methyl esters.

20 In some embodiments, these materials, such as vegetable or seed oils and their esters, can be used interchangeably as an agricultural adjuvant, as a liquid carrier or as a surface active agent.

Other exemplary additives for use in the compositions provided herein include but are not limited to compatibilizing agents, antifoam agents, sequestering agents, neutralizing
25 agents and buffers, corrosion inhibitors, dyes, odorants, spreading agents, penetration aids, sticking agents, dispersing agents, thickening agents, freezing point depressants, antimicrobial agents, and the like. The compositions may also contain other compatible components, for example, other herbicides, plant growth regulants, fungicides, insecticides, and the like and can be formulated with liquid fertilizers or solid, particulate fertilizer carriers
30 such as ammonium nitrate, urea and the like.

In some embodiments, the concentration of the active ingredients in the compositions described herein is from 0.0005 to 98 percent by weight. In some embodiments, the concentration is from 0.0006 to 90 percent by weight. In compositions designed to be

employed as concentrates, the active ingredients, in certain embodiments, are present in a concentration from 0.1 to 98 weight percent, and in certain embodiments 0.5 to 90 weight percent. Such compositions are, in certain embodiments, diluted with an inert carrier, such as water, before application. The diluted compositions usually applied to weeds or the locus of
5 weeds contain, in certain embodiments, 0.0006 to 15.0 weight percent active ingredient and in certain embodiments contain 0.01 to 7.0 weight percent.

The present compositions can be applied to weeds or their locus by the use of conventional ground or aerial dusters, sprayers, and granule applicators, by addition to irrigation water, and by other conventional means known to those skilled in the art. Vines are
10 particularly sensitive to growth regulator herbicides, such as the auxins, if foliar applied. (<http://viticulture.hort.iastate.edu/info/pdf/herbicideinjury.pdf>;
http://extension.oregonstate.edu/gilliam/sites/default/files/Prevent_Herbicide_Injury_Grapes_EM8860.pdf; Wine grape (*Vitis vinifera*) response to repeated exposure of selected sulfonamides and 2,4-D. Bhatti et al., *Weed Technology* **1996**, *10*, 951-956.

15 The described embodiments and following examples are for illustrative purposes and are not intended to limit the scope of the claims. Other modifications, uses, or combinations with respect to the compositions described herein will be apparent to a person of ordinary skill in the art without departing from the spirit and scope of the claimed subject matter.

20 Examples

Field Trials:

Small plot research experiments were conducted in Fresno, California, USA to evaluate the pre-emergence and post-emergence herbicidal weed control activity and the vines crop tolerance to pre-emergence and post-emergence application of Compound I and
25 Compound II to the weeds. Application water volume of 100 to 187 liters per hectare (L/ha) was used for all experiments. All treatments were applied with a standard small plot carbon dioxide (CO₂) backpack sprayer. All treatments were tank-mixed with Crop Oil Concentrate (COC), a well known adjuvant, at 2.34 L/ha. Experimental emulsifiable concentrate (EC) formulations were used for Compounds I and II. The dimethylammonium (DMA) salt of
30 glyphosate was used in all trials. Pindar[®] GT is a commercial formulation containing a pre-mix of penoxsulam + oxyfluorfen (10 + 476 grams of active ingredient per liter (g ai/L), respectively). Vine crop stage was dormant (no leaves on the vines during the winter) or early spring growth at the time of Compound I or Compound II application. Generally,

weeds were not emerged for the pre-emergence treatments or were at the two to six-leaf stage at the time of the post-emergence herbicide application.

Tables 1, 2 and 6 provide weed control results from pre-emergence applications of Compounds I and/or II prior to weed emergence; Tables 4, 7 and 8 provide weed control results from post-emergence applications of Compounds I and/or II applied to actively growing weeds; Tables 3 and 5 provide vine response data from pre-emergence and post-emergence applications of Compound I respectively.

Table 1. Percent visual weed control at 90 Days After Application (DAA) of Halauxifen-methyl ester (I-Me) when applied prior to Weed Emergence as a Dormant Application (December) in California vineyards.

Compound	Rate	Unit	% Visual Control 90 DAA											
			HORMU		CAPBP		ERICA		MALPA		EROCI		POAAN	
I-Me	10	g ae/ha	100	a	62	b	75	a	85	a	58	d	58	b
I-Me	20	g ae/ha	100	a	58	b	100	a	88	a	72	c	65	b
I-Me	40	g ae/ha	100	a	82	ab	100	a	89	a	82	b	63	b
PINDAR® GT	1,698	g ai/ha	100	a	100	a	100	a	100	a	100	a	100	a
Untreated			0	b	0	c	0	b	0	b	0	e	0	c
LSD (P=0.05)			0		23.12		26.29		17.57		8.99		21.88	

Means followed by same letter do not significantly differ (P=0.05, Student-Newman-Keuls)

15

Table 2. Percent visual weed control at 184 Days After Application (DAA) of Halauxifen-methyl ester (I-Me) when applied prior to weed emergence as a Dormant Application (December) in California vineyards.

Compound	Rate	Unit	% Visual Control 184 DAA											
			HORMU		ERICA		MALPA		EROCI		POAAN		PANCA	
I-Me	10	g ae/ha	90	a	92	a	45	b	47	a	48	ab	60	ab
I-Me	20	g	88	a	97	a	60	b	52	a	28	b	33.3	ab

			% Visual Control 184 DAA											
Compound	Rate	Unit	HORMU		ERICA		MALPA		EROCI		POAAN		PANCA	
		ae/ha												
I-Me	40	g ae/ha	92	a	100	a	47	b	55	a	47	ab	63.3	ab
PINDAR® GT	1,698	g ai/ha	98	a	100	a	96	a	73	a	100	a	97	a
Untreated			0	b	0	b	0	c	0	b	0	b	0	b
LSD (P=0.05)			16.19		11.91		21.02		19.93		49.1		56.57	

Means followed by same letter do not significantly differ (P=0.05, Student-Newman-Keuls)

5 Table 3. Percent visual vine injury and growth response at 124, 184 and 236 Days After Application (DAA) from Halauxifen-methyl ester (I-Me) applied to the soil as a Dormant Application (December) in California vineyards.

			VITSS									
Compound	Rate	Unit	% Visual Injury 124 DAA		% Visual Injury 184 DAA		Branch Length (cm) 184 DAA		Internode Length (cm) 184 DAA		Yield (Lbs) 236 DAA	
I-Me	10	g ae/ha	0	a	15	a	187	a	7	a	71	a
I-Me	20	g ae/ha	0	a	18	a	172	ab	7	a	63	a
I-Me	40	g ae/ha	0	a	37	a	125	ab	6	b	31	a
PINDAR® GT	1,698	g ai/ha	0	a	18	a	126	ab	5	b	69	a
Untreated			0	a	0	a	112	b	5	b	34	a
LSD (P=0.05)			0		22.6		45.4		1.2		75.2	

Means followed by same letter do not significantly differ (P=0.05, Student-Newman-Keuls)

10

15 Table 4. Percent visual weed control at 60 Days After Application (DAA) of Halauxifen-methyl ester (I-Me) when applied as a Post-Emergence Directed Spring Application (April) in California vineyards.

			% Visual Control 60 DAA											
Compound	Rate	Unit	ERIBO		MALPA		EROCI		PANCA		AGRRE		SETFA	
Untreated			0	b	0	c	0	c	0	b	0	b	4	b
I-Me	5	g ae/ha	97	a	75	a	62	ab	82	a	87	a	98	a
I-Me	10	g ae/ha	95	a	72	a	70	ab	88	a	80	a	80	a

I-Me	20	g ae/ha	93	a	73	a	86	a	86	a	83	a	97	a
Penoxsulam	35	g ai/ha	85	a	85	a	87	a	85	a	87	a	97	a
LSD (P=0.05)			20.4		13.4		19.0		19.4		18.6		22.2	

Means comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL.

5 Table 5. Vine response when rated at 60 Days After Application (DAA) of Halauxifen-methyl ester (I-Me) applied as a Post-Emergence Directed Spring Application (April) in California vineyards.

			VITSS 60 DAA			
Compound	Rate	Unit	Vine Length (cm)		Node Count	
Untreated			122	a	22	a
I-Me	5	g ae/ha	114	a	23	a
I-Me	10	g ae/ha	88	a	19	a
I-Me	20	g ae/ha	91	a	20	a
Penoxsulam	35	g ai/ha	89	a	20	a
LSD (P=0.05)			26.3		3.7	

Means followed by same letter do not significantly differ (P=0.05, Student-Newman-Keuls)

Table 6. Percent visual weed control at 48 Days After Application (DAA) following Halauxifen-methyl ester (I-Me) and Compound II benzyl ester (II-Bn) applied as a Pre-Emergence Application (February) in California vineyards.

Compound	Rate	Unit	% Visual Control 48 DAA					
			AMSIN		CAPBP		CLNCM	
Untreated			0	d	0	e	0	d
Glyphosate	1680	g ae/ha	0	d	0	e	0	d
I-Me	2.5	g ae/ha	25	c	50	d	27.6	c
I-Me	5	g ae/ha	43.3	b	76.7	b	43.3	bc
I-Me	10	g ae/ha	36.7	bc	90	e	86.7	a
II-Bn	5	g ai/ha	0	d	0	e	0	d
II-Bn	10	g ai/ha	33.3	bc	60	c	40	bc
II-Bn	20	g ai/ha	40	b	76.7	b	56.7	bc
II-Bn	40	g ai/ha	87.3	a	100	a	90	a
II-Bn	50	g ai/ha	84.3	a	96.7	a	96.7	a
PINDAR [®] GT	1700	g ai/ha	100	a	100	a	100	a
LSD (P=.05)			10.93		9.38		17.49	

Means followed by same letter do not significantly differ (P=0.05, Student-Newman-Keuls)

5

Table 7. Percent visual weed control at 59 Days After Application (DAA) of Halauxifen-methyl ester (I-Me) and Compound II benzyl ester (II-Bn) applied as a Post-Emergence Directed Spring Application (March) in California vineyards.

Compound	Rate	Unit	% Visual Control 59 DAA							
			MEDPO		MALPA		EROCI		STEME	
Untreated			0	b	0	c	0	c	0	c
Glyphosate	1680	g ae/ha	100	a	86.7	ab	91	a	93.3	a
I-Me	2.5	g ae/ha	100	a	80	ab	43.3	b	46.7	b
I-Me	5	g ae/ha	100	a	90	ab	89.7	a	94	a
I-Me	10	g ae/ha	100	a	96.7	ab	94	a	95.7	a
II-Bn	5	g ai/ha	100	a	61.9	b	81.7	a	70	a
II-Bn	10	g ai/ha	100	a	83.4	ab	85	a	75	a
II-Bn	20	g ai/ha	100	a	90	ab	85	a	84.3	a
II-Bn	40	g ai/ha	100	a	95	ab	94.3	a	94.3	a
II-Bn	50	g ai/ha	100	a	96.7	ab	96	a	97.3	a
PINDAR [®] GT	1700	g ai/ha	100	a	95	ab	92.7	a	96.7	a
LSD (P=.05)			8.49		20.45		19.24		20.97	

Means followed by same letter do not significantly differ (P=0.05, Student-Newman-Keuls)

Table 8. Percent visual weed control at 57 Days After Application (DAA) of Halauxifen-methyl ester (I-Me) and Compound II benzyl ester (II-Bn) applied as a Post-Emergence Directed Dormant Application (December) in California vineyards.

Compound	Rate	Unit	% Visual Control 57 DAA									
			AMSIN		CAPBP		CHEAL		AMARE		IPOSS	
Untreated			0	c	0	c	0	b	0	b	0	b
Glyphosate	1680	g ae/ha	100	a	99.3	a	95	a	0	b	51.7	ab
I-Me	2.5	g ae/ha	38.3	b	91.7	a	100	a	95	a	57.8	ab
I-Me	5	g ae/ha	76.7	a	99.3	a	96.7	a	96.7	a	65	ab
I-Me	10	g ae/ha	97.3	a	100	a	100	a	100	a	66.7	ab
II-Bn	5	g ai/ha	56.7	ab	100	a	96.7	a	100	a	55	ab
II-Bn	10	g ai/ha	96.7	a	100	a	100	a	95	a	46.7	ab
II-Bn	20	g ai/ha	86.7	a	100	a	100	a	100	a	66.7	ab
II-Bn	40	g ai/ha	100	a	100	a	100	a	100	a	66.7	ab
II-Bn	50	g ai/ha	100	a	100	a	100	a	100	a	97.3	a
PINDAR [®] GT	1700	g ai/ha	100	a	100	a	93.3	a	100	a	100	a
LSD (P=0.05)			26.37		16.86		33.95		5.34		52.7	

Means followed by same letter do not significantly differ (P=0.05, Student-Newman-Keuls)

- 5 AGRRE = *Agropyron repens* (quackgrass)
- AMARE = *Amaranthus retroflexus* (redroot pigweed)
- AMSIN = *Amsinckia intermedia* (coast fiddleneck)
- CAPBP = *Capsella bursa-pastoris* (Shepherd’s purse)
- CHEAL = *Chenopodium album* (common lambsquarters)
- 10 CLNCM = *Calandrinia ciliata* (rock purslane)
- ERIBO = *Conyza bonariensis* (hairy fleabane)
- ERICA = *Conyza canadensis* (horseweed)
- EROCI = *Erodium cicutarium* (redstem filaree)
- HORMU = *Hordeum murinam* (wall barley)
- 15 IPOSS = *Ipomoea* spp (morningglory)
- MALPA = *Malva parviflora* (smallflower malva)
- MEDPO = *Medicago polymorpha* (California burclover)
- PANCA = *Panicum capillare* (witchgrass)
- POAAN = *Poa annua* (annual bluegrass)
- 20 SETFA = *Setaria faberi* (giant foxtail)
- STEME = *Stellaria media* (common chickweed)
- VITSS = *Vitis* spp (grape)

- g ae/ha = grams of acid equivalent/hectare
- 25 g ai/ha = grams of active ingredient/hectare
- DAA = Days After Application
- cm = centimeters
- lbs = pounds

30 The compositions and methods of the appended claims are not limited in scope by the specific compositions and methods described herein, which are intended as illustrations of a

few aspects of the claims and any compositions and methods that are functionally equivalent are intended to fall within the scope of the claims. Various modifications of the compositions and methods in addition to those shown and described herein are intended to fall within the scope of the appended claims. Further, while only certain representative composition

5 materials and method steps disclosed herein are specifically described, other combinations of the composition materials and method steps also are intended to fall within the scope of the appended claims, even if not specifically recited. Thus, a combination of steps, elements, components, or constituents may be explicitly mentioned herein; however, other combinations of steps, elements, components, and constituents are included, even though not

10 explicitly stated. The term “comprising” and variations thereof as used herein is used synonymously with the term “including” and variations thereof and are open, non-limiting terms. Although the terms “comprising” and “including” have been used herein to describe various embodiments, the terms “consisting essentially of” and “consisting of” can be used in place of “comprising” and “including” to provide for more specific embodiments of the

15 invention and are also disclosed.

WHAT IS CLAIMED IS:

1. A method for the selective pre-emergence and post-emergence control of undesirable vegetation in vineyards which comprises applying a herbicidally effective amount of halauxifen (4-amino-3-chloro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid) or 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid or an agriculturally acceptable ester or salt of either to the unwanted vegetation or the locus thereof.
2. The method of claim 1 wherein the herbicide is halauxifen (4-amino-3-chloro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid) or an agriculturally acceptable ester or salt thereof.
3. The method of claim 2 wherein the halauxifen herbicide is halauxifen-methyl (methyl 4-amino-3-chloro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylate).
4. The method of claim 2 wherein the halauxifen herbicide is applied at a rate of 0.25 to 50 g ae/ha.
5. The method of claim 3 wherein the halauxifen-methyl is applied at a rate of 2.5 to 40 g ae/ha.
6. The method of claim 1 wherein the herbicide is 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid or an agriculturally acceptable ester or salt thereof.
7. The method of claim 6 wherein the herbicide is benzyl 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylate.
8. The method of claim 6 wherein the 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid or agriculturally acceptable ester or salt thereof is applied at a rate of 1 to 100 g ai/ha.

9. The method of claim 7 wherein the benzyl 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylate is applied at a rate of 5 to 50 g ai/ha.

5 10. The method of any of claims 1-9 wherein halauxifen or 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid or an agriculturally acceptable ester or salt of either is applied pre-emergence to the undesirable vegetation.

10 11. The method of any of claims 1-9 wherein halauxifen or 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid or an agriculturally acceptable ester or salt of either is applied post-emergence to the undesirable vegetation.

12. The method of any of claims 1-11 wherein the vineyard is a grape vineyard.

15 13. A method for the selective pre-emergence and post-emergence control of undesirable vegetation in perennial crops which comprises applying a herbicidally effective amount of halauxifen (4-amino-3-chloro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid) or 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid or an agriculturally acceptable ester or salt of either to the
20 unwanted vegetation or the locus thereof.

14. The method of claim 13 wherein the herbicide is halauxifen (4-amino-3-chloro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid) or agriculturally acceptable ester or salt thereof.

25

15. The method of claim 14 wherein the halauxifen herbicide is halauxifen-methyl (methyl 4-amino-3-chloro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylate).

16. The method of claim 14 wherein the halauxifen herbicide is applied at a rate of
30 0.25 to 50 g ae/ha.

17. The method of claim 15 wherein the halauxifen-methyl is applied at a rate of 2.5 to 40 g ae/ha.

18. The method of claim 13 wherein the herbicide is 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid or agriculturally acceptable ester or salt thereof.

5

19. The method of claim 18 wherein the herbicide is benzyl 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylate.

20. The method of claim 18 wherein the 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid or agriculturally acceptable ester or salt thereof is applied at a rate of 1 to 100 g ai/ha.

10

21. The method of claim 19 wherein the benzyl 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylate is applied at a rate of 5 to 50 g ai/ha.

15

22. The method of any of claims 13-21 wherein halauxifen or 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid or an agriculturally acceptable ester or salt of either is applied pre-emergence to the undesirable vegetation.

20

23. The method of any or claims 13-21 wherein halauxifen or 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid or an agriculturally acceptable ester or salt of either is applied post-emergence to the undesirable vegetation.

25

24. The method of any of claims 13-23 wherein the perennial crop is tree and fruit orchards, including almond, apple, apricot, avocado, beechnut, Brazil nut, butternut, cashew, cherry, chestnut, chinquapin, citrus, crab apple, date, feijoa, fig, filbert, hickory nut, grapefruit, kiwi, lemon, lime, loquat, macadamia nut, mandarin, mayhaws, nectarine, olives, oranges (sweet and sour), peach, pear, pecan, persimmon, pistachio, plum, pome fruit, pomegranates, prune, quince, stone fruit, tangerine, tangelo, tree nuts, and walnut; and perennial plantation crops including rubber, oil palm, coffee and cacao.

30

25. The method of any of claims 1-24 wherein the undesirable vegetation includes chickweed (*Stellaria media*), pigweed (*Amaranthus* spp.), common lambsquarters (*Chenopodium album*), hairy fleabane (*Conyza bonariensis*), horseweed (*Conyza canadensis*), coast fiddleneck (*Amsinckia intermedia*), Shepherd's purse (*Capsella bursa-pastoris*), rock purslane (*Calandrinia ciliata*), redstem filaree (*Erodium cicutarium*), wall
5 barley (*Hordeum murinam*), morningglory (*Ipomoea* spp), smallflower malva (*Malva parviflora*), California burclover (*Medicago polymorpha*), annual bluegrass (*Poa annua*), witchgrass (*Panicum capillare*), quackgrass (*Agropyron repens*) or giant foxtail (*Setaria faberi*)

10

26. The method of any of claims 1-25 wherein the herbicidally effective amount of halauxifen or 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid or an agriculturally acceptable ester or salt of either, is applied in a dormant application when vines and perennial crops are dormant but winter annual weeds are actively
15 growing (post-emergence to the weeds).

27. The method of any of claims 1-25 wherein the herbicidally effective amount of halauxifen or 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid or an agriculturally acceptable ester or salt of either is applied in a spring or
20 summer application when both vines or perennial crops and weeds are actively growing (post-emergence to the weeds).

20

28. The method of any of claims 1-25 wherein the herbicidally effective amount of halauxifen or 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid or an agriculturally acceptable ester or salt of either is applied in a dormant
25 application when vines and perennial crops are dormant but winter annual weeds have not germinated (pre-emergence to the weeds).

25

29. The method of any of claims 1-28 wherein the herbicidally effective amount of halauxifen or 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid or an agriculturally acceptable ester or salt of either is applied under the
30 vines or perennial crops, with foliar exposure of the vines or perennial crops being avoided.

30

30. The method of any of claims 1-29 wherein the herbicidally effective amount of halauxifen or 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid or an agriculturally acceptable ester or salt of either is applied with glyphosate salts and esters, glufosinate-ammonium, paraquat, oxyfluorfen, penoxsulam,
5 flumioxazin, fluroxypyr, clopyralid, flazasulfuron, pendimethalin, isoxaben, indaziflam or saflufenacil.

31. The method of any of claims 1-30, wherein the undesirable vegetation comprises a herbicide resistant or tolerant weed, wherein the resistant or tolerant weed is a
10 biotype with resistance or tolerance to single or multiple herbicides, single or multiple chemical classes, and single or multiple herbicide modes-of-action or via single or multiple resistance mechanisms.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US14/69656

<p>A. CLASSIFICATION OF SUBJECT MATTER IPC(8) - A01N 43/54, 43/40 (2015.01) CPC - A01N 43/54, 43/40 According to International Patent Classification (IPC) or to both national classification and IPC</p>																				
<p>B. FIELDS SEARCHED</p> <p>Minimum documentation searched (classification system followed by classification symbols) IPC(8): A01N 43/54, 43/40 (2015.01) CPC: A01N 43/54, 43/40</p> <p>Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched</p> <p>Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, INPADOC Data); ProQuest; Scifinder; Google/Google Scholar; KEYWORDS: herbicide, halauxifen, auxinic, vineyard, perennial, emergence, undesirable, unwanted, harmful, vegetation, weeds, grapes</p>																				
<p>C. DOCUMENTS CONSIDERED TO BE RELEVANT</p> <table border="1" style="width:100%; border-collapse: collapse;"> <thead> <tr> <th style="width:10%;">Category*</th> <th style="width:60%;">Citation of document, with indication, where appropriate, of the relevant passages</th> <th style="width:30%;">Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>X -- Y</td> <td>US 2010/0137137 A1 (ROSINGER, CH et al.) 03 June 2010; paragraphs [0005]-[0011], [0015], [0022], [0028], [0039], [0460]-[0461], [0557], [0565], [0568]</td> <td>1-2, 6-9, 10/1-2, 10/6-9, 11/1-2, 11/6-9, 13-14, 18-21, 22/13-14, 22/18-21, 23/13-14, 23/18-21 3-5, 10/3-5, 11/3-5, 15-17, 22/15-17, 23/15-17</td> </tr> <tr> <td>Y</td> <td>US 2008/0051596 A1 (BALKO, TW et al.) 28 February 2008; paragraphs [0024]-[0027], [0032]-[0035], [0043]</td> <td>3, 5, 10/3, 10/5, 11/3, 11/5, 15, 17, 22/15, 22/17, 23/15, 23/17</td> </tr> <tr> <td>Y</td> <td>US 2012/0178627 A1 (RICHBURG, JS et al.) 12 July 2012; paragraph [0034]</td> <td>4-5, 10/4-5, 11/4-5, 16-17, 22/16-17, 23/16-17</td> </tr> <tr> <td>A</td> <td>US 2012/0115727 A1 (SATCHIVI, NM et al.) 10 May 2012; entire document</td> <td>1-9, 10/1-9, 11/1-9, 13-21, 22/13-21, 23/13-21</td> </tr> <tr> <td>A</td> <td>US 2009/0062121 A1 (SATCHIVI, NM et al.) 05 March 2009; entire document</td> <td>1-9, 10/1-9, 11/1-9, 13-21, 22/13-21, 23/13-21</td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	X -- Y	US 2010/0137137 A1 (ROSINGER, CH et al.) 03 June 2010; paragraphs [0005]-[0011], [0015], [0022], [0028], [0039], [0460]-[0461], [0557], [0565], [0568]	1-2, 6-9, 10/1-2, 10/6-9, 11/1-2, 11/6-9, 13-14, 18-21, 22/13-14, 22/18-21, 23/13-14, 23/18-21 3-5, 10/3-5, 11/3-5, 15-17, 22/15-17, 23/15-17	Y	US 2008/0051596 A1 (BALKO, TW et al.) 28 February 2008; paragraphs [0024]-[0027], [0032]-[0035], [0043]	3, 5, 10/3, 10/5, 11/3, 11/5, 15, 17, 22/15, 22/17, 23/15, 23/17	Y	US 2012/0178627 A1 (RICHBURG, JS et al.) 12 July 2012; paragraph [0034]	4-5, 10/4-5, 11/4-5, 16-17, 22/16-17, 23/16-17	A	US 2012/0115727 A1 (SATCHIVI, NM et al.) 10 May 2012; entire document	1-9, 10/1-9, 11/1-9, 13-21, 22/13-21, 23/13-21	A	US 2009/0062121 A1 (SATCHIVI, NM et al.) 05 March 2009; entire document	1-9, 10/1-9, 11/1-9, 13-21, 22/13-21, 23/13-21
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<p><input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/></p>																				
<p>* Special categories of cited documents:</p> <table style="width:100%;"> <tr> <td style="width:50%;"> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"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)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </td> <td style="width:50%;"> <p>"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</p> <p>"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</p> <p>"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</p> <p>"&" document member of the same patent family</p> </td> </tr> </table>			<p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"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)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"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</p> <p>"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</p> <p>"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</p> <p>"&" document member of the same patent family</p>																
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<p>Date of the actual completion of the international search 01 February 2015 (01.02.2015)</p>		<p>Date of mailing of the international search report 16 MAR 2015</p>																		
<p>Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201</p>		<p>Authorized officer: Shane Thomas</p> <p>PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774</p>																		

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US14/69656

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. Claims Nos.: 12, 24-31
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.