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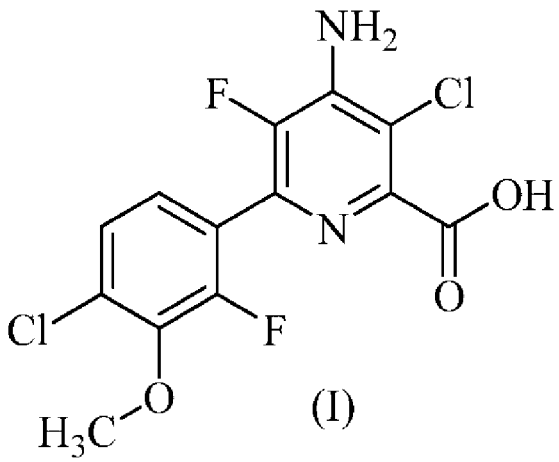

(I)

(57) Abstract: Provided herein are synergistic herbicidal compositions containing and methods of controlling undesirable vegetation utilizing (a) a compound of formula (I); or an agriculturally acceptable salt or ester thereof and (b) halosulfuron-methyl, pyrazosulfuron-ethyl or esprocarb, or an agriculturally acceptable derivative thereof. The compositions and methods provided herein provide control of undesirable vegetation, e.g., in direct-seeded, water-seeded and transplanted rice, cereals, wheat, barley, oats, rye, sorghum, com or maize, sugarcane, sunflower, oilseed rape, canola, sugar beet, soybean, cotton, pineapple, oilseed rape, vegetables, pastures, grasslands, rangelands, fallowland, turf, tree and vine orchards, aquatics, plantation crops, vegetables, industrial vegetation management (IVM) or rights of way (ROW).

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HERBICIDAL COMPOSITIONS COMPRISING 4-AMINO-3-CHLORO-5-FLUORO-6-(4-CHLORO-2-FLUORO-3-METHOXYPHENYL) PYRIDINE-2-CARBOXYLIC ACID OR A DERIVATIVE THEREOF AND HALOSULFURON, PYRAZOSULFURON AND ESPROCARB

Priority Claim

This application claims the benefit of United States provisional patent application number 61/675,110 filed on July 24, 2012 and United States patent application number 13/834,326 filed March 15, 2013, the disclosure of each of which is incorporated herein by reference in its entirety.

Field

Provided herein are herbicidal compositions comprising (a) 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 and (b) halosulfuron-methyl, pyrazosulfuron-ethyl or esprocarb or an agriculturally acceptable salt or ester thereof.

Provided herein are also methods of controlling undesirable vegetation comprising applying (a) 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 and (b) halosulfuron-methyl, pyrazosulfuron-ethyl or esprocarb or an agriculturally acceptable salt or ester thereof.

Background

Reference to any prior art in the specification is not an acknowledgment or suggestion that this prior art forms part of the common general knowledge in any jurisdiction or that this prior art could reasonably be expected to be understood, regarded as relevant, and/or combined with other pieces of prior art by a skilled person in the art.

The protection of crops from weeds and other vegetation which inhibit crop growth is a constantly recurring problem in agriculture. To help combat this problem, researchers in the field of synthetic chemistry have produced an extensive variety of chemicals and chemical formulations effective in the control of such unwanted growth. Chemical herbicides of many types have been disclosed in the literature and a large number are in commercial use. However, there remains a need for compositions and methods that are effective in controlling undesirable vegetation.

Summary

A first embodiment of the invention provided herein includes herbicidal compositions comprising an herbicidally effective amount of (a) a compound of the formula (I)

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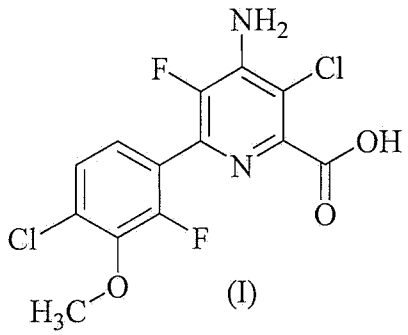

(I)

or an agriculturally acceptable salt or ester thereof, and (b) selected from the group consisting of halosulfuron-methyl, pyrazosulfuron-ethyl or esprocarb or an agriculturally acceptable salt or ester thereof.

A second embodiment includes the mixture of the first embodiment in which formula (I) is present in at least one of the following forms: a carboxylic acid, a carboxylate salt, an aralkyl, an alkyl ester, an unsubstituted benzyl, a substituted benzyl, a C_{1-4} alkyl, and/or an n-butyl ester.

A third embodiment includes the mixtures according to any of the first, or second, embodiments in which (b) is halosulfuron-methyl wherein the weight ratio of the compound of formula (I) to halosulfuron-methyl given in units of gae/ha to gai/ha or gae/ha to gae/ha is selected from the group of ranges of ratios and ratios consisting of about: 1:70 to 214:1, 1:8 to 19:1, 1:1 to 2.4:1, ½ to 1/3, 1:1, 1:2, 1:4, 1:1.7, 1:0.75, 2:1, 1:5.7, 1:0.8 and 1:0.4, or within any range defined between any pair of the foregoing values.

A fourth embodiment includes the mixtures according to any of the first or second, embodiments in which (b) is pyrazosulfuron-ethyl wherein the weight ratio of the compound of formula (I) to pyrazosulfuron-ethyl given in units of gae/ha to gai/ha or gae/ha to gae/ha is selected from the group of ranges of ratios and ratios consisting of about: 1:60 to 600:1, 1:27 to 4:1, 0.8:1 to 1:6, 1:4 to 4:1, 1:1 to 1:3, 1:5.7, 1:3.4, 1:6.8, 1:14, 1:7, 1:1.7, 1:0.8, 1:2, 1:1, 2:1, and 1:4, or within any range defined between any pair of the foregoing values.

A fifth embodiment includes the mixtures according to any of the first or second, embodiments in which (b) is esprocarb wherein the weight ratio of the compound of formula (I) to esprocarb given in units of gae/ha to gai/ha or gae/ha to gae/ha is selected from the group of ranges of ratios and ratios consisting of about: 1:500 to 6.1, 1:48 to 1:3, 1:12 to 1:24, 1:6 to 1:12, 1:12, 1:6, 1:24, and 1:48, or within any range defined between any pair of the foregoing values.

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A sixth embodiment includes any composition according to any of the first through the fifth embodiments wherein the mixture further comprises at least one an agriculturally acceptable agent selected from the group consisting of an adjuvant, a carrier, or a safener.

A seventh embodiment includes methods of controlling undesirable vegetation comprising the step of applying or otherwise contacting vegetation and/or soil, and/ or water with a herbicidally effective amount of at least one mixture according to any of the first through the sixth embodiments.

An eighth embodiment includes methods according to the seventh embodiment wherein in the method is practiced in at least one member of the group consisting of direct-seeded, water-seeded, and/or transplanted rice, cereals, wheat, barley, oats, rye, sorghum, corn/maize, sugarcane, sunflower, oilseed rape, canola, sugar beet, soybean, cotton, pineapple, pastures, grasslands, rangelands, fallowland, turf, tree and vine orchards, aquatics, plantation crops, vegetables, industrial vegetation management (IVM), or rights-of-way (ROW).

A ninth embodiment includes methods according to either of the seventh and eighth embodiments wherein a herbicidally effective amount of the mixture is applied either pre- or post-emergently to at least one of the following: a crop, a field, a ROW, or a rice paddy.

A tenth embodiment includes methods according to any of the seventh through the ninth embodiments wherein the undesirable vegetation may be controlled in: glyphosate-, 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase inhibitor-, glufosinate-, glutamine synthetase inhibitor-, dicamba-, phenoxy auxin-, pyridyloxy auxin-, synthetic auxin-, auxin transport inhibitor-, aryloxyphenoxypropionate-, cyclohexanedione-, phenylpyrazoline-, acetyl CoA carboxylase (ACCase) inhibitor-, imidazolinone-, sulfonylurea-, pyrimidinylthiobenzoate-, triazolopyrimidine-sulfonamide, sulfonylaminocarbonyltriazolinone-, acetolactate synthase (ALS) or acetohydroxy acid synthase (AHAS) iinhibitor-, 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitor-, phytoene desaturase inhibitor-, carotenoid biosynthesis inhibitor-, protoporphyrinogen oxidase (PPO) inhibitor-, cellulose biosynthesis inhibitor-, mitosis inhibitor-, microtubule inhibitor-, very long chain fatty acid inhibitor-, fatty acid and lipid biosynthesis inhibitor-, photosystem I inhibitor-, photosystem II inhibitor-, protoporphyrinogen oxidase (PPO) inhibitor-, triazine-, or bromoxynil-tolerant crops.

An eleventh embodiment includes a at least one method according to any of the seventh through the tenth embodiments wherein a plant that is resistant or tolerant to at least one herbicide is treated, and where the resistant or tolerant crop possesses multiple or stacked

traits conferring tolerance to multiple herbicides or inhibitors of multiple modes of action, in some embodiments the treated plant that expresses resistance or tolerance to a herbicide is a itself undesirable vegetation.

A twelfth embodiment includes methods according to the eleventh embodiment, wherein the resistant or tolerant weed is a biotype with resistance or tolerance to multiple herbicides, multiple chemical classes, inhibitors of multiple herbicide modes-of-action, or via multiple resistance mechanisms.

A thirteenth embodiment includes at least one of the methods according to either the eleventh or the twelfth embodiments, wherein the resistant or tolerant undesirable plant is a biotype resistant or tolerant to at least one agent selected from the groups consisting of: acetolactate synthase (ALS) inhibitors or acetohydroxy acid synthase (AHAS), photosystem II inhibitors, acetyl CoA carboxylase (ACCase) inhibitors, synthetic auxins, auxin transport inhibitors, photosystem I inhibitors, 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase inhibitors, microtubule assembly inhibitors, fatty acid and lipid synthesis inhibitors, protoporphyrinogen oxidase (PPO) inhibitors, carotenoid biosynthesis inhibitors, very long chain fatty acid (VLCFA) inhibitors, phytoene desaturase (PDS) inhibitors, glutamine synthetase inhibitors, 4-hydroxyphenyl-pyruvate-dioxygenase (HPPD) inhibitors, mitosis inhibitors, cellulose biosynthesis inhibitors, herbicides with multiple modes-of-action, quinclorac, arylaminopropionic acids, difenzoquat, endothall, or organoarsenicals.

A fourteenth embodiment includes methods of controlling undesirable vegetation comprising the step of applying a herbicidally effective amount of at least one mixture according to the third embodiment wherein the amount of the mixture is applied at a rate, expressed in g ai/ha or g ae/ha of halosulfuron-methyl selected from the group of rates and ranges of rates consisting of about: 1, 2, 4.38, 8.75, 17.5, 35 and 70, or within any range defined between any pair of the foregoing values.

A fifteenth embodiment includes methods according to either of the third and fourteenth embodiments wherein the controlled plant is at least one plant selected from the group consisting of: BRAPP, DIGSA, LEFCH, ECHOR, SCPMA, ECHCG, and CYPRO still other embodiments include controlling plants from the genera consisting of: *Urochloa, Brachiaria, Digitaria , Bolboschoenus , Leptochloa, Echinochloa, Cyperus.*

A sixteenth embodiment includes methods of controlling undesirable vegetation comprising the step of applying a herbicidally effective amount of at least one a mixture according to the fourth embodiment wherein the amount of the mixture is applied at a rate, expressed in g ai/ha or g ae/ha of pyrazosulfuron-ethyl selected from the group of rates and

ranges of rates consisting of about: 5, 7.5, 10, 15, 17.5, 15, 30, 35, 60, 70, and 120, or within any range defined between any pair of the foregoing values.

A seventeenth embodiment includes methods according to either of the fourth and sixteenth embodiments wherein the controlled plant is at least one plant selected from the group consisting of: CYPDI, ECHCG, ECHOR, SCPMA, DIGSA, BRAPP and LEFCH, still other embodiments include controlling plants from the genera consisting of: *Cyperus, Brachiaria, Digitaria, Echinochloa, Bolboschoenus,* and *Leptochloa.*

A eighteenth embodiment includes methods of controlling undesirable vegetation comprising the step of applying a herbicidally effective amount of at least one a mixture according to the fifth embodiment wherein the amount of the mixture is applied at a rate, expressed in g ai/ha or g ae/ha of esprocarb selected from the group of rates and ranges of rates consisting of about: 52.5, 105, and 210, or within any range defined between any pair of the foregoing values.

A nineteenth embodiment includes methods according to either of the fifth and eighteenth embodiments wherein the controlled plant is at least one plant selected from the group consisting of: BRAPP, ECHCO, CYPIR, SCPJU, FIMMI, and CYPRO, still other embodiments include controlling plants from the genera consisting of: *Urochloa, Brachiaria, Echinochloa, Cyperus, Schoenoplectus,* and *Fimbristylis.*

A twentieth embodiment includes compositions according to the first or second embodiments, wherein (a) is the compound of formula (I) or an agriculturally acceptable benzyl ester and (b) is halosulfuron-methyl.

A twenty-first embodiment includes compositions according to the first or second embodiments, wherein (a) is the compound of formula (I) or an agriculturally acceptable benzyl ester and (b) is pyrazosulfuron-ethyl.

A twenty-second embodiment includes compositions according to the first or second embodiments, wherein (a) is the compound of formula (I) or an agriculturally acceptable benzyl ester and (b) is esprocarb.

A twenty-third embodiment includes compositions according to any of the first through the sixth or twentieth through twenty-second embodiments, wherein the composition is synergistic according to the Colby equation.

A twenty-fourth embodiment includes methods according to any of the seventh through nineteenth embodiments, wherein the undesirable vegetation is immature.

A twenty-fifth embodiment includes methods according to any of the seventh through nineteenth embodiments,, wherein the (a) and (b) are applied to water.

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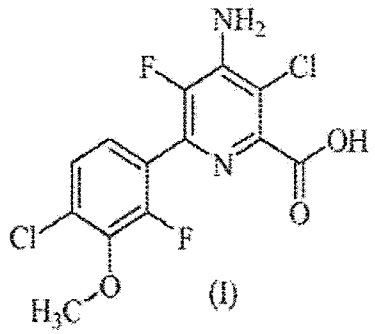
Provided herein are herbicidal compositions comprising a herbicidally effective amount of (a) a compound of the formula (I)



(I)

or an agriculturally acceptable salt or ester thereof, and (b) halosulfuron-methyl, pyrazosulfuron-ethyl or esprocarb. The compositions may also contain an agriculturally acceptable adjuvant or carrier.

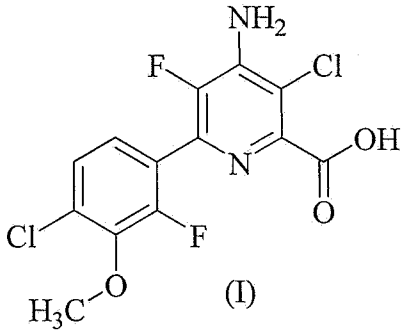
Provided herein are also methods of controlling undesirable vegetation comprising applying (a) to a compound of formula (I) or an agriculturally acceptable ester or salt thereof and (b) halosulfuron-methyl, pyrazosulfuron-ethyl or esprocarb or an agriculturally acceptable salt or ester thereof.

Detailed Description

DEFINITIONS

As used herein, except where the context requires otherwise, the term "comprise" and variations of the term, such as "comprising", "comprises" and "comprised", are not intended to exclude other additives, components, integers or steps.

As used herein, the compound of formula (I) has the following structure:



(I)

The compound of formula (I) can be identified by the name 4-amino-3-chloro-6-(4-chloro-2-fluoro-3-methoxyphenyl)-5-fluoropyridine-2-carboxylic acid and has been described in U.S. Patent 7,314,849 (B2), which is incorporated herein by reference in its entirety. Exemplary uses of the compound of the formula (I) include controlling undesirable vegetation, including grass, broadleaf and sedge weeds, in multiple non-crop and cropping situations.

As used herein, sulfonylureas are used for control of nuisance broadleaf, sedge and grass weeds.

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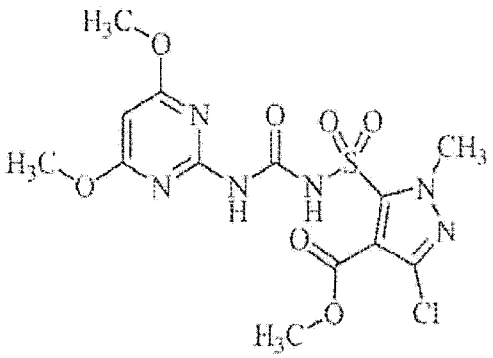
Halosulfuron-methyl and pyrazosulfuron-ethyl belong to a class of compounds referred to as sulfonylureas. Without being bound by any theory, sulfonylureas are believed to inhibit acetolactate synthase (ALS), an enzyme common to plants and microorganisms but not found in animals.

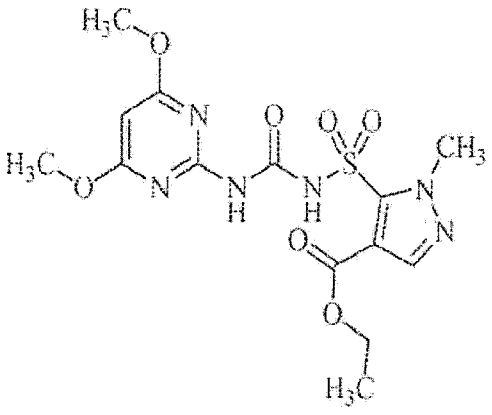
Esprocarb belongs to a class of compounds referred to as VLCFA (very-long-chain fatty acid) and lipid synthesis inhibiting herbicides. Without being limited to any theory, this class of compounds are believed to inhibit very-long-chain fatty acid (VLCFA, fatty acids, *e.g.*, >C18) synthesis and lipid synthesis.

As used herein, halosulfuron-methyl is methyl 3-chloro-5-[[[[(4,6-dimethoxy-2-pyrimidinyl)amino]carbonyl]amino]sulfonyl]-1-methyl-1*H*-pyrazole-4-carboxylate and possesses the following structure:



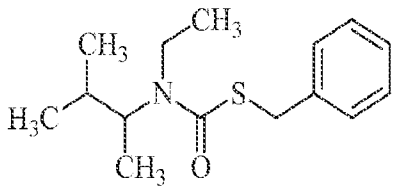
The compound is described in Tomlin, C., ed. A World Compendium The Pesticide Manual. 15th ed. Alton: BCPC Publications, 2009 (hereafter *"The Pesiticde Manual*, Fifteenth Edition, 2009."). Exemplary uses of halosulfuron-methyl include its use for control of annual broadleaf weeds and annual/perennial sedges, *e.g.*, in maize, sugar cane, rice, sorghum, tree nuts and turf.

As used herein, pyrazosulfuron-ethyl is ethyl 5-[[[[(4,6-dimethoxy-2-pyrimidinyl)amino]carbonyl]amino]sulfonyl]-1-methyl-*1*H-pyrazol-4carboxylate and possesses the following structure:



The compound is described in *The Pesticide Manual*, Fifteenth Edition, 2009. Exemplary uses of pyrazosulfuron-ethyl include its use for control of annual and perennial broadleaf weeds and sedges, *e.g.*, in wet-sown and transplanted rice crops.

As used herein, esprocarb is *S*-(phenylmethyl) *N*-(1,2-dimethylpropyl)-*N*-ethylcarbamothioate and possesses the following structure:



The compound is described in *The Pesticide Manual*, Fifteenth Edition, 2009. Exemplary uses of esprocarb include its use for pre- and post-emergence control of annual weeds and *Echinochloa* spp. *e.g.*, in paddy rice.

As used herein, herbicide means a compound, *e.g.*, active ingredient that kills, controls or otherwise adversely modifies the growth of plants.

As used herein, a herbicidally effective or vegetation controlling amount is an amount of active ingredient which causes an adversely modifying effect to the vegetation *e.g.*, causing deviations from natural development, killing, effecting regulation, causing desiccation, causing retardation, and the like.

As used herein, controlling undesirable vegetation means preventing, reducing, killing, or otherwise adversely modifying the development of plants and vegetation. Described herein are methods of controlling undesirable vegetation through the application of certain herbicide combinations or compositions. Methods of application include, but are not limited to applications to the vegetation or locus thereof, *e.g.*, application to the area adjacent to the vegetation, as well as preemergence, postemergence, foliar (broadcast, directed, banded, spot, mechanical, over-the-top, or rescue),, and in-water applications (emerged and submerged vegetation, broadcast, spot, mechanical, water-injected, granular broadcast, granular spot, shaker bottle, or stream spray) via hand, backpack, machine, tractor, or aerial (airplane and helicopter) application methods.

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

As used herein, agriculturally acceptable salts and esters refer to salts and esters that exhibit herbicidal activity, or that are or can be converted in plants, water, or soil to the referenced herbicide. Exemplary agriculturally acceptable esters are those that are or can be

hydrolyzed, oxidized, metabolized, or otherwise converted, *e.g.*, in plants, water, or soil, to the corresponding carboxylic acid which, depending on 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 aminium cations of the formula:

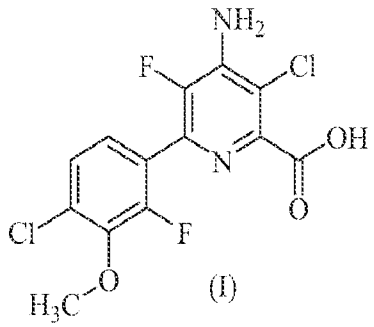
$$R^1R^2R^3R^4N^+$$

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.

Exemplary esters include those derived from C_1-C_{12} alkyl, C_3-C_{12} alkenyl, C_3-C_{12} alkynyl or C_7-C_{10} 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, C_1-C_4 alkyl or C_1-C_4 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.

Compositions and Methods

Provided herein are herbicidal compositions comprising a herbicidally effective amount of (a) a compound of the formula (I)



(I)

or an agriculturally acceptable salt or ester of thereof, and (b) halosulfuron-methyl, pyrazosulfuron-ethyl or esprocarb, or an agriculturally acceptable salt, ester, carboxylic acid, or carboxylate salt thereof.

Provided herein are also methods of controlling undesirable vegetation comprising contacting the vegetation or the locus thereof, *i.e.*, area adjacent to the plant, with or applying to the soil or water to prevent the emergence or growth of vegetation a herbicidally effective amount of the compound of formula (I) or salt or ester thereof and (b) halosulfuron-methyl, pyrazosulfuron-ethyl or esprocarb, or an agriculturally acceptable salt, ester, carboxylic acid, or carboxylate salt thereof. In certain embodiments, the methods employ the compositions described herein.

Furthermore, in some embodiments, the combination of compound (I) or agriculturally acceptable salt or ester thereof and halosulfuron-methyl, pyrazosulfuron-ethyl or esprocarb, or a salt, ester, carboxylic acid, or carboxylate salt thereof, exhibits synergism, *e.g.*, the herbicidal active ingredients are more effective in combination than when applied individually. The *Herbicide Handbook* of the Weed Science Society of America, Ninth Edition, 2007, p. 429 notes that "'synergism' [is] an interaction of two or more factors such that the effect when combined is greater than the predicted effect based on the response of each factor applied separately." In certain embodiments, the compositions exhibit synergy as determined by the Colby's equation. Colby, S.R. 1967. Calculation of the synergistic and antagonistic response of herbicide combinations. Weeds 15:20-22.

In certain embodiments of the compositions and methods described herein, the compound of formula (I), *i.e.*, the carboxylic acid, is employed. In certain embodiments, a carboxylate salt of the compound of formula (I) is employed. In certain embodiments, an aralkyl or alkyl ester is employed. In certain embodiments, a benzyl, substituted benzyl, or

C_{1-4} alkyl, *e.g.*, n-butyl ester is employed. In certain embodiments, the benzyl ester is employed

In some embodiments, the compound of formula (I) or salt or ester thereof and halosulfuron-methyl, pyrazosulfuron-ethyl or esprocarb, or an agriculturally acceptable derivative thereof are formulated in one composition, tank mixed, applied simultaneously, or applied sequentially.

Herbicidal activity is exhibited by the compounds when they are applied directly to the plant or to the locus of the plant 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 some embodiments, the compositions described herein are applied as a post-emergence application, pre-emergence application, or in-water application to flooded paddy rice or water bodies (*e.g.*, ponds, lakes and streams), to relatively immature undesirable vegetation to achieve the maximum control of weeds.

In some embodiments, the compositions and methods provided herein are utilized to control weeds in crops, including but not limited to direct-seeded, water-seeded and transplanted rice, cereals, wheat, barley, oats, rye, sorghum, corn/maize, sugarcane, sunflower, oilseed rape, canola, sugar beet, soybean, cotton, pineapple, pastures, grasslands, rangelands, fallowland, turf, tree and vine orchards, aquatics, plantation crops, vegetables, industrial vegetation management (IVM) and rights of way (ROW).

In certain embodiments, the compositions and methods provided herein are utilized to control weeds in rice. In certain embodiments, the rice is direct-seeded, water-seeded, or transplanted rice.

The compositions and methods described herein may be used to control undesirable vegetation in glyphosate-tolerant-, 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase inhibitor-tolerant-, glufosinate-tolerant-, glutamine synthetase inhibitor-tolerant-, dicamba-tolerant-, phenoxy auxin-tolerant-, pyridyloxy auxin-tolerant-, auxin-tolerant-, auxin transport inhibitor-tolerant-, aryloxyphenoxypropionate-tolerant-, cyclohexanedione-tolerant-, phenylpyrazoline-tolerant-, acetyl CoA carboxylase (ACCase) inhibitor-tolerant-, imidazolinone-tolerant-, sulfonylurea-tolerant-, pyrimidinylthiobenzoate-tolerant-, triazolopyrimidine-sulfonamide tolerant-, sulfonylaminocarbonyltriazolinone-tolerant-,

acetolactate synthase (ALS) or acetohydroxy acid synthase (AHAS) inhibitor-tolerant-, 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitor -tolerant-, phytoene desaturase inhibitor-tolerant-, carotenoid biosynthesis inhibitor-tolerant-, protoporphyrinogen oxidase (PPO) inhibitor -tolerant-, cellulose biosynthesis inhibitor-tolerant-, mitosis inhibitor-tolerant-, microtubule inhibitor-tolerant-, very long chain fatty acid inhibitor-tolerant-, fatty acid and lipid biosynthesis inhibitor-tolerant-, photosystem I inhibitor-tolerant-, photosystem II inhibitor-tolerant-, triazine-tolerant- and bromoxynil-tolerant-crops (such as, but not limited to, soybean, cotton, canola/oilseed rape, rice, cereals, corn, sorghum, sunflower, sugar beet, sugarcane, turf, etc.), for example, in conjunction with glyphosate, EPSP synthase inhibitors, glufosinate, glutamine synthase inhibitors, dicamba, phenoxy auxins, pyridyloxy auxins, synthetic auxins, auxin transport inhibitors, aryloxyphenoxypropionates, cyclohexanediones, phenylpyrazolines, ACCase inhibitors, imidazolinones, sulfonylureas, pyrimidinylthiobenzoates, triazolopyrimidine sulfonamides, sulfonylaminocarbonyltriazolinones, ALS or AHAS inhibitors, HPPD inhibitors, phytoene desaturase inhibitors, carotenoid biosynthesis inhibitors, PPO inhibitors, cellulose biosynthesis inhibitors, mitosis inhibitors, microtubule inhibitors, very long chain fatty acid inhibitors, fatty acid and lipid biosynthesis inhibitors, photosystem I inhibitors, photosystem II inhibitors, triazines and bromoxynil. The compositions and methods may be used in controlling undesirable vegetation in crops possessing multiple or stacked traits conferring tolerance to multiple chemistries and/or inhibitors of multiple modes of action. In some embodiments, the compound of formula (I) or salt or ester thereof and 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, tank mix or sequentially.

The compositions and methods may be used in controlling undesirable vegetation in crops possessing agronomic stress tolerance (including but not limited to drought, cold, heat, salt, water, nutrient, fertility, pH), pest tolerance (including but not limited to insects, fungi and pathogens) and crop improvement traits (including but not limited to yield; protein, carbohydrate, or oil content; protein, carbohydrate, or oil composition; plant stature and plant architecture).

The compositions and methods provided herein are utilized to control undesirable vegetation. Undesirable vegetation includes, but is not limited to, undesirable vegetation that

occurs in rice, cereals, wheat, barley, oats, rye, sorghum, corn/maize, sugarcane, sunflower, oilseed rape, canola, sugar beet, soybean, cotton, pineapple, range and pasture, rangelands, fallowland, row crops (*e.g.*, corn, soybean, cotton, canola), turf, tree and vine orchards, ornamental species, aquatic, plantation crops, vegetables or non-crop settings, (*e.g.*, rights-of-way, industrial vegetation management).

In some embodiments, the methods provided herein are utilized to control undesirable vegetation in rice. In certain embodiments, the undesirable vegetation is *Brachiaria platyphylla* (Groseb.) Nash or *Urochloa platyphylla* (Nash) R.D. Webster (broadleaf signalgrass, BRAPP), *Digitaria sanguinalis* (L.) Scop. (large crabgrass, DIGSA), *Echinochloa* species (ECHSS), *Echinochloa crus-galli* (L.) P. Beauv. (barnyardgrass, ECHCG), *Echinochloa crus-pavonis* (Kunth) Schult. (gulf cockspur, ECHCV), *Echinochloa colonum* (L.) LINK (junglerice, ECHCO), *Echinochloa oryzoides* (Ard.) Fritsch (early watergrass, ECHOR), *Echinochloa oryzicola* (Vasinger) Vasinger (late watergrass, ECHPH), *Echinochloa phyllopogon* (Stapf) Koso-Pol. (rice barnyardgrass, ECHPH), *Echinochloa polystachya* (Kunth) Hitchc. (creeping river grass, ECHPO), *Ischaemum rugosum* Salisb. (saramollagrass, ISCRU), *Leptochloa chinensis* (L.) Nees (Chinese sprangletop, LEFCH), *Leptochloa fascicularis* (Lam.) Gray (bearded sprangletop, LEFFA), *Leptochloa panicoides* (Presl.) Hitchc. (Amazon sprangletop, LEFPA), *Oryza* species (red and weedy rice, ORYSS), *Panicum dichotomiflorum* (L.) Michx. (fall panicum, PANDI), *Paspalum dilatatum* Poir. (dallisgrass, PASDI), *Rottboellia cochinchinensis* (Lour.) W.D. Clayton (itchgrass, ROOEX), *Cyperus* species (CYPSS), *Cyperus difformis* L. (smallflower flatsedge, CYPDI), *Cyperus dubius* Rottb. (MAPDU), *Cyperus esculentus* L. (yellow nutsedge, CYPES), *Cyperus iria* L. (rice flatsedge, CYPIR), *Cyperus rotundus* L. (purple nutsedge, CYPRO), *Cyperus serotinus* Rottb./C.B.Clarke (tidalmarsh flatsedge, CYPSE), *Eleocharis* species (ELOSS), *Fimbristylis miliacea* (L.) Vahl (globe fringerush, FIMMI), *Schoenoplectus* species (SCPSS), *Schoenoplectus juncoides* Roxb. (Japanese bulrush, SPCJU), *Bolboschoenus maritimus* (L.) Palla or *Schoenoplectus maritimus* L. Lye (sea clubrush, SCPMA), *Schoenoplectus mucronatus* L. (ricefield bulrush, SCPMU), *Aeschynomene* species, (jointvetch, AESSS), *Alternanthera philoxeroides* (Mart.) Griseb. (alligatorweed, ALRPH), *Alisma plantago-aquatica* L. (common waterplantain, ALSPA), *Amaranthus* species, (pigweeds and amaranths, AMASS), *Ammannia coccinea* Rottb. (redstem, AMMCO), *Commelina benghalensis* L. (Benghal dayflower, COMBE), *Eclipta alba* (L.) Hassk. (American false daisy, ECLAL), *Heteranthera limosa* (SW.) Willd./Vahl (ducksalad, HETLI), *Heteranthera reniformis* R. & P. (roundleaf mudplantain, HETRE), *Ipomoea* species (morningglories,

IPOSS), *Ipomoea hederacea* (L.) Jacq. (ivyleaf morningglory, IPOHE), *Lindernia dubia* (L.) Pennell (low false pimpernel, LIDDU), *Ludwigia* species (LUDSS), *Ludwigia linifolia* Poir. (southeastern primrose-willow, LUDLI), *Ludwigia octovalvis* (Jacq.) Raven (longfruited primrose-willow, LUDOC), *Monochoria korsakowii* Regel & Maack (monochoria, MOOKA), *Monochoria vaginalis* (Burm. F.) C. Presl ex Kuhth, (monochoria, MOOVA), *Murdannia nudiflora* (L.) Brenan (doveweed, MUDNU), *Polygonum pensylvanicum* L., (Pennsylvania smartweed, POLPY), *Polygonum persicaria* L. (ladysthumb, POLPE), *Polygonum hydropiperoides* Michx. (POLHP, mild smartweed), *Rotala indica* (Willd.) Koehne (Indian toothcup, ROTIN), *Sagittaria* species, (arrowhead, SAGSS), *Sesbania exaltata* (Raf.) Cory/Rydb. Ex Hill (hemp sesbania, SEBEX), or *Sphenoclea zeylanica* Gaertn. (gooseweed, SPDZE).

In some embodiments, the methods provided herein are utilized to control undesirable vegetation in cereals. In certain embodiments, the undesirable vegetation is *Alopecurus myosuroides* Huds. (blackgrass, ALOMY), *Apera spica-venti* (L.) Beauv. (windgrass, APESV), *Avena fatua* L. (wild oat, AVEFA), *Bromus tectorum* L. (downy brome, BROTE), *Lolium multiflorum* Lam. (Italian ryegrass, LOLMU), *Phalaris minor* Retz. (littleseed canarygrass, PHAMI), *Poa annua* L. (annual bluegrass, POANN), *Setaria pumila* (Poir.) Roemer & J.A. Schultes (yellow foxtail, SETLU), *Setaria viridis* (L.) Beauv. (green foxtail, SETVI), *Amaranthus retroflexus* L. (redroot pigweed, AMARE), *Brassica* species (BRSSS), *Chenopodium album* L. (common lambsquarters, CHEAL), *Cirsium arvense* (L.) Scop. (Canada thistle, CIRAR), *Galium aparine* L. (catchweed bedstraw, GALAP), *Kochia scoparia* (L.) Schrad. (kochia, KCHSC), *Lamium purpureum* L. (purple deadnettle , LAMPU), *Matricaria recutita* L. (wild chamomile, MATCH), *Matricaria matricarioides* (Less.) Porter (pineappleweed, MATMT), *Papaver rhoeas* L. (common poppy, PAPRH), *Polygonum convolvulus* L. (wild buckwheat, POLCO), *Salsola tragus* L. (Russian thistle, SASKR), *Sinapis* species (SINSS), *Sinapis arvensis* L. (wild mustard, SINAR), , *Stellaria media* (L.) Vill. (common chickweed, STEME), *Veronica persica* Poir. (Persian speedwell, VERPE), *Viola arvensis* Murr. (field violet, VIOAR), or *Viola tricolor* L. (wild violet, VIOTR).

In some embodiments, the methods provided herein are utilized to control undesirable vegetation in range and pasture, fallowland, IVM and ROW. In certain embodiments, the undesirable vegetation is *Ambrosia artemisiifolia* L. (common ragweed, AMBEL), *Cassia obtusifolia* (sickle pod, CASOB), *Centaurea maculosa* auct. non Lam. (spotted knapweed, CENMA), *Cirsium arvense* (L.) Scop. (Canada thistle, CIRAR), *Convolvulus arvensis* L.

(field bindweed, CONAR), *Daucus carota* L. (wild carrot, DAUCA), *Euphorbia esula* L. (leafy spurge, EPHES), *Lactuca serriola* L./Torn. (prickly lettuce, LACSE), *Plantago lanceolata* L. (buckhorn plantain, PLALA), *Rumex obtusifolius* L. (broadleaf dock, RUMOB), *Sida spinosa* L. (prickly sida, SIDSP), *Sinapis arvensis* L. (wild mustard, SINAR), *Sonchus arvensis* L. (perennial sowthistle, SONAR), *Solidago* species (goldenrod, SOOSS), *Taraxacum officinale* G.H. Weber ex Wiggers (dandelion, TAROF), *Trifolium repens* L. (white clover, TRFRE), or *Urtica dioica* L. (common nettle, URTDI).

In some embodiments, the methods provided herein are utilized to control undesirable vegetation found in row crops, tree and vine crops and perennial crops. In certain embodiments, the undesirable vegetation is *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), *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 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 dichotomiflorum* Michx. (fall panicum, PANDI), *Panicum miliaceum* L. (wild-proso millet, PANMI), *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), *Ambrosia artemisiifolia* L. (common ragweed, AMBEL), *Ambrosia psilostachya* DC. (western ragweed, AMBPS), *Ambrosia trifida* L. (giant ragweed, AMBTR), *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 alata* Aubl. (broadleaf buttonweed, BOILF), *Spermacose latifolia* (broadleaved button weed, BOILF), *Chenopodium album* L. (common lambsquarters, CHEAL), *Cirsium arvense* (L.) Scop. (Canada thistle, CIRAR), *Commelina benghalensis* L.

(tropical spiderwort, COMBE), *Datura stramonium* L. (jimsonweed, DATST), *Daucus carota* L. (wild carrot, DAUCA), *Euphorbia heterophylla* 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. (Canadian fleabane, ERICA), *Conyza sumatrensis* (Retz.) E. H. Walker (tall fleabane, ERIFL), *Helianthus annuus* L. (common sunflower, HELAN), *Jacquemontia tamnifolia* (L.) Griseb. (smallflower morningglory, IAQTA), *Ipomoea hederacea* (L.) Jacq. (ivyleaf morningglory, IPOHE), *Ipomoea lacunosa* L. (white morningglory, IPOLA), *Lactuca serriola* L./Torn. (prickly lettuce, LACSE), *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), *Solanum ptychanthum* Dunal (eastern black nightshade, SOLPT), *Tridax procumbens* L. (coat buttons, TRQPR) or *Xanthium strumarium* L. (common cocklebur, XANST).

In some embodiments, the methods provided herein are utilized to control undesirable vegetation in turf. In certain embodiments, the undesirable vegetation is *Bellis perennis* L. (English daisy, BELPE), *Cyperus esculentus* L. (yellow nutsedge, CYPES), *Cyperus* species (CYPSS), *Digitaria sanguinalis* (L.) Scop. (large crabgrass, DIGSA), *Diodia virginiana* L. (Virginia buttonweed, DIQVI), *Euphorbia* species (spurge, EPHSS), *Glechoma hederacea* L. (ground ivy, GLEHE), *Hydrocotyle umbellata* L. (dollarweed, HYDUM), *Kyllinga* species (kyllinga, KYLSS), *Lamium amplexicaule* L. (henbit, LAMAM), *Murdannia nudiflora* (L.) Brenan (doveweed, MUDNU), *Oxalis* species (woodsorrel, OXASS), *Plantago major* L. (broadleaf plantain, PLAMA), *Plantago lanceolata* L. (buckhorn/narrowleaf plantain, PLALA), *Phyllanthus urinaria* L. (chamberbitter, PYLTE), *Rumex obtusifolius* L. (broadleaf dock, RUMOB), *Stachys floridana* Shuttlew. (Florida betony, STAFL), *Stellaria media* (L.) Vill. (common chickweed, STEME), *Taraxacum officinale* G.H. Weber ex Wiggers (dandelion, TAROF), *Trifolium repens* L. (white clover, TRFRE), or *Viola* species (wild violet, VIOSS).

In some embodiments, the compositions and methods provided herein are utilized to control undesirable vegetation consisting of grass, broadleaf and sedge weeds. In certain embodiments, the compositions and methods provided herein are utilized to control undesirable vegetation including *Brachiaria* or *Urochloa, Cyperus, Digitaria, Echinochloa, Fimbristylis, Ipomoea, Leptochloa* and *Schoenoplectus*.

The compounds of formula I or agriculturally acceptable salt or ester thereof may be used to control herbicide resistant or tolerant weeds. The methods employing the combination of a compound of formula I 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, sulfonylureas, pyrimidinylthiobenzoates, triazolopyrimidine-suulfonamides, 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, phenoxycarboxylic acids, pyridine carboxylic acids, quinoline carboxylic acids), auxin transport inhibitors (*e.g.*, phthalamates, 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, 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.*, 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 organoarsenicals. Exemplary resistant or tolerant weeds include, but are not limited to, biotypes with resistance or tolerance to multiple herbicides, biotypes with resistance or tolerance to multiple chemical classes, biotypes with resistance or tolerance to multiple herbicide modes-of-action, and biotypes with multiple resistance or tolerance mechanisms (*e.g.*, target site resistance or metabolic resistance).

In some embodiments, the combination of compound (I) or agriculturally acceptable ester or salt thereof and halosulfuron-methyl, pyrazosulfuron-ethyl or esprocarb or an agriculturally acceptable salt or ester thereof is used to control *Brachiaria platyphylla* (Griseb.) Nash (broadleaf signalgrass, BRAPP), *Cyperus iria* L. (rice flatsedge, CYPIR), *Cyperus rotundus* L. (purple nutsedge, CYPRO), *Digitaria sanguinalis* (L.) Scop. (large crabgrass, DIGSA), *Echinochloa colona* (L.) Link (junglerice, ECHCO), *Echinochloa oryzoides* (Ard.) Fritsch (early watergrass, ECHOR), *Echinochloa crus-galli* (L.) Beauv. (barnyardgrass, ECHCG), *Fimbristylis miliacea* (L.) Vahl (globe fringerush, FIMMI), *Ipomoea hederacea* Jacq. (ivyleaf morningglory, IPOHE), *Leptochloa chinensis* (L.) Nees (Chinese sprangletop, LEFCH), *Schoenoplectus juncoides* (Roxb.) Palla (Japanese bulrush, SCPJU) and *Schoenoplectus maritimus* (L.) Lye (sea clubrush, SCPMA).

In some embodiments, an agriculturally acceptable ester or salt of compound (I) is employed. In certain embodiments, an agriculturally acceptable ester is employed. In certain embodiments, the ester is a C_{1-4} alkyl ester. In certain embodiments, the ester is a n-butyl ester. In certain embodiments, the ester is a benzyl ester. In certain embodiments, compound (I), which is a carboxylic acid, is employed.

In some embodiments, an agriculturally acceptable ester or salt of halosulfuron-methyl, pyrazosulfuron-ethyl or esprocarb is employed in the methods or compositions described herein.

In certain embodiments of the compositions and methods described herein, the compound of formula (I) or salt or ester thereof is used in combination with halosulfuron-methyl or salt, ester, carboxylic acid, or carboxylate salt thereof. With regard to the compositions, in some embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to halosulfuron-methyl or salt, ester, carboxylic acid, or carboxylate salt thereof is within the range of from about 1:70 to about 214:1. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to halosulfuron-methyl or salt, ester, carboxylic acid, or carboxylate salt thereof is within the range of from 1:8 to about 20:1. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to halosulfuron-methyl or salt, ester, carboxylic acid, or carboxylate salt thereof is within the range of from 5:1 to about 1:8. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to halosulfuron-methyl or salt, ester, carboxylic acid, or carboxylate salt thereof is within the range of from 2.4:1 to about 1:3.7. In certain embodiments, the composition comprises the compound of formula I and halosulfuron-methyl. In certain embodiments, the composition comprises the compound of

formula I and halosulfuron-methyl, wherein the weight ration of the compound of formula I to halosulfuron-methyl is from about 1:8 to about 5:1. In certain embodiments, the composition comprises the compound of formula I and halosulfuron-methyl, wherein the weight ration of the compound of formula I to halosulfuron-methyl is from about 1:4 to about 2.4:1. In certain embodiments, the composition comprises the benzyl ester of compound of formula I and halosulfuron-methyl. In certain embodiments, the composition comprises the benzyl ester of the compound of formula I and halosulfuron-methyl, wherein the weight ration of the benzyl ester of the compound of formula I to halosulfuron-methyl is from about 4:1 to about 1:8. In certain embodiments, the composition comprises the benzyl ester of the compound of formula I and halosulfuron-methyl, wherein the weight ration of the benzyl ester of the compound of formula I to halosulfuron-methyl is from about 2:1 to about 1:3.7. With respect to the methods, in certain embodiments, the methods comprise contacting the undesirable vegetation or locus thereof or applying to the soil or water to prevent the emergence or growth of vegetation a composition described herein. In some embodiments, the composition is applied at an application rate of from about 3.4 grams active ingredient per hectare (g ai/ha) to about 440 g ai/ha based on the total amount of active ingredients in the composition. In certain embodiments, the composition is applied at an application rate of from about 9 grams active ingredient per hectare (g ai/ha) to about 120 g ai/ha based on the total amount of active ingredients in the composition. In some embodiments, the methods comprise contacting the undesirable vegetation or locus thereof or applying to the soil or water to prevent the emergence or growth of vegetation with a compound of formula (I) or salt or ester thereof and halosulfuron-methyl or salt, ester, carboxylic acid, or carboxylate salt thereof, *e.g.*, sequentially or simultaneously. In some embodiments, the halosulfuron-methyl or salt, ester, carboxylic acid, or carboxylate salt thereof is applied at a rate from about 1.4 g ai/ha to about 140 g ai/ha and the compound of formula (I) of salt or ester thereof is applied at a rate from about 2 g ae/ha to about 300 g ae/ha. In some embodiments, the halosulfuron-methyl or salt, ester, carboxylic acid, or carboxylate salt thereof is applied at a rate from about 4 g ai/ha to about 40 g ai/ha and the compound of formula (I) of salt or ester thereof is applied at a rate from about 4 g ae/ha to about 85 g ae/ha. In certain embodiments, the methods utilize the compound of formula (I) or its benzyl or n-butyl ester and halosulfuron-methyl. In one embodiments, the compound of formula (I) or its benzyl or n-butyl ester is applied at a rate of from about 4 to about 85 g ae/ha, and the halosulfuron methyl is applied at a rate of from about 4 to about 35 g ai /ha. In certain embodiments, the methods and compositions utilizing the compound of formula (I) or salt or ester thereof in

combination with halosulfuron-methyl or salt, ester, carboxylic acid, or carboxylate salt thereof are used to control BRAPP, DIGSA, LEFCH, ECHOR, ECHCG, CYPRO or SCPMA,

In certain embodiments of the compositions and methods described herein, the compound of formula (I) or salt or ester thereof is used in combination with pyrazosulfuron-ethyl or salt, carboxylic acid, carboxylate salt, or ester thereof. In some embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to pyrazosulfuron-ethyl or salt, carboxylic acid, carboxylate salt, or ester thereof is within the range of from about 1:60 to about 600:1. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to pyrazosulfuron-ethyl or salt, carboxylic acid, carboxylate salt, or ester thereof is within the range of from 1:27 to about 168:1. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to pyrazosulfuron-ethyl or salt, carboxylic acid, carboxylate salt, or ester thereof is within the range of from 4:1 to about 1:28. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to pyrazosulfuron-ethyl or salt, carboxylic acid, carboxylate salt, or ester thereof is within the range of from 2:1 to about 1:14. With respect to the methods, in certain embodiments, the methods comprise contacting the undesirable vegetation or locus thereof or applying to the soil or water to prevent the emergence or growth of vegetation a composition described herein. In some embodiments, the composition is applied at an application rate of from about 2.5 grams active ingredient per hectare (g ai/ha) to about 420 g ai/ha based on the total amount of active ingredients in the composition. In certain embodiments, the composition is applied at an application rate of from about 5 grams active ingredient per hectare (g ai/ha) to about 204 g ai/ha based on the total amount of active ingredients in the composition. In some embodiments, the methods comprise contacting the undesirable vegetation or locus thereof or applying to the soil or water to prevent the emergence or growth of vegetation with a compound of formula (I) or salt or ester thereof and pyrazosulfuron-ethyl or salt, carboxylic acid, carboxylate salt, or ester thereof, *e.g.*, sequentially or simultaneously. In some embodiments, the pyrazosulfuron-ethyl or salt, carboxylic acid, carboxylate salt, or ester thereof is applied at a rate from about 0.5 g ai/ha to about 120 g ai/ha and the compound of formula (I) of salt or ester thereof is applied at a rate from about 2 g ae/ha to about 300 g ae/ha. In some embodiments, the pyrazosulfuron-ethyl or salt, carboxylic acid, carboxylate salt, or ester thereof is applied at a rate from about 2 g ai/ha to about 250 g ai/ha and the compound of formula (I) of salt or ester thereof is applied at a rate from about 2 g acid equivalent per hectare (g ae/ha) to about 160 g ae/ha. In some

embodiments, the pyrazosulfuron-ethyl or salt, carboxylic acid, carboxylate salt, or ester thereof is applied at a rate from about 5 g ai/ha to about 120 g ai/ha and the compound of formula (I) of salt or ester thereof is applied at a rate from about 4 g acid equivalent per hectare (g ae/ha) to about 85 g ae/ha. In certain embodiments, the methods utilize the compound of formula (I) or its benzyl or n-butyl ester and pyrazosulfuron-ethyl. In one embodiment, the methods utilize the compound of formula (I) and pyrazosulfuron-ethyl, wherein the compound of formula (I) is applied at a rate of from about 4 g acid equivalent per hectare (g ae/ha) to about 85 g ae/ha, and the pyrazosulfuron-ethyl is applied at a rate of from about 5 g ai/ha to about 120 g ai/ha. In one embodiment, the methods utilize the benzyl ester of the compound of formula (I) and pyrazosulfuron-ethyl, wherein the benzyl ester of the compound of formula (I) is applied at a rate of from about 4 g acid equivalent per hectare (g ae/ha) to about 35 g ae/ha, and the pyrazosulfuron-ethyl is applied at a rate of from about 5 g ai/ha to about 120 g ai/ha. In one embodiment, the methods utilize the n-butyl ester of the compound of formula (I) and pyrazosulfuron-ethyl, wherein the n-butyl ester of the compound of formula (I) is applied at a rate of from about 18 g acid equivalent per hectare (g ae/ha) to about 50 g ae/ha, and the pyrazosulfuron-ethyl is applied at a rate of from about 7.5 g ai/ha to about 120 g ai/ha. In certain embodiments, the methods and compositions utilizing the compound of formula (I) or salt or ester thereof in combination with pyrazosulfuron-ethyl or salt, carboxylic acid, carboxylate salt, or ester thereof are used to control DIGSA, BRAPP, ECHOR, SCPMA, ECHCG, CYPDI or LEFCH.

In certain embodiments of the compositions and methods described herein, the compound of formula (I) or salt or ester thereof is used in combination with esprocarb or salt thereof. With respect to the compositions, in some embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to esprocarb or salt thereof is within the range of from about 1: 500 to about 6:1. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to esprocarb or salt thereof is within the range of from 1: 48 to about 1:3. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to esprocarb or salt thereof or salt thereof is within the range of from about 1:3 to about 1:100. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to esprocarb or salt thereof is within the range of from about 1:6 to about 1:48. In certain embodiments, the compositions provided herein comprise the compound of formula (I) or its benzyl ester and esprocarb. In one embodiment, the composition comprises the compound of formula (I) and esprocarb, wherein the weight ratio of the compound of formula (I) and esprocarb is about 1:6 to about 1:24. In

one embodiment, the composition comprises the benzyl ester of the compound of formula (I) and esprocarb, wherein the weight ratio of the benzyl ester of the compound of formula (I) and esprocarb is about 1:3 to about 1:48. With respect to the methods, in certain embodiments, the methods comprise contacting the undesirable vegetation or locus thereof or applying to the soil or water to prevent the emergence or growth of vegetation a composition described herein. In some embodiments, the composition is applied at an application rate of from about 55 grams active ingredient per hectare (g ai/ha) to about 1300 g ai/ha based on the total amount of active ingredients in the composition. In certain embodiments, the composition is applied at an application rate of from about 57 grams active ingredient per hectare (g ai/ha) to about 230 g ai/ha based on the total amount of active ingredients in the composition. In some embodiments, the methods comprise contacting the undesirable vegetation or locus thereof or applying to the soil or water to prevent the emergence or growth of vegetation with a compound of formula (I) or salt or ester thereof and esprocarb or salt thereof, *e.g.*, sequentially or simultaneously. In some embodiments, the esprocarb or salt thereof is applied at a rate from about 53 g ai/ha to about 1000 g ai/ha and the compound of formula (I) of salt or ester thereof is applied at a rate from about 2 g ae/ha to about 300 g ae/ha. In some embodiments, the esprocarb or salt thereof is applied at a rate from about 25 g ai/ha to about 450 g ai/ha and the compound of formula (I) of salt or ester thereof is applied at a rate from about 2 g acid equivalent per hectare (g ae/ha) to about 40 g ae/ha. In some embodiments, the esprocarb or salt thereof is applied at a rate from about 50 g ai/ha to about 220 g ai/ha and the compound of formula (I) of salt or ester thereof is applied at a rate from about 4 g acid equivalent per hectare (g ae/ha) to about 20 g ae/ha. In certain embodiments, the methods utilize the compound of formula (I) or its benzyl or ester and esprocarb. In one embodiment, the methods utilize the compound of formula (I) and esprocarb, wherein the compound of formula (I) is applied at a rate of from about 4 g acid equivalent per hectare (g ae/ha) to about 20 g ae/ha, and the esprocarb is applied at a rate of from about 50 g ai/ha to about 210 g ai/ha. In one embodiment, the methods utilize the benzyl ester of the compound of formula (I) and esprocarb, wherein the benzyl ester of the compound of formula (I) is applied at a rate of from about 4 g acid equivalent per hectare (g ae/ha) to about 10 g ae/ha, and the esprocarb is applied at a rate of from about 50 g ai/ha to about 220 g ai/ha. In certain embodiments, the methods and compositions utilizing the compound of formula (I) or salt or ester thereof in combination with esprocarb thereof are used to control BRAPP, ECHCO, CYPIR, SCPJU, CYPRO, or FIMMI.

The components of the mixtures described herein can be applied either separately or as part of a multipart herbicidal system.

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, alloxydim, allyl alcohol, alorac, ametridione, ametryn, amibuzin, amicarbazone, amidosulfuron, aminocyclopyrachlor, aminopyralid, amiprofos-methyl, amitrole, ammonium sulfamate, anilofos, anisuron, asulam, atraton, atrazine, azafenidin, azimsulfuron, aziprotryne, barban, BCPC, beflubutamid, benazolin, bencarbazone, benfluralin, benfuresate, bensulfuron-methyl, bensulide, benthiocarb, 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 chlorprocarb, carfentrazone-ethyl, CDEA, CEPC, chlomethoxyfen, chloramben, chloranocryl, chlorazifop, chlorazine, chlorbromuron, chlorbufam, chloreturon, chlorfenac, chlorfenprop, chlorflurazole, chlorflurenol, chloridazon, chlorimuron, chlornitrofen, chloropon, chlorotoluron, chloroxuron, chloroxynil, chlorpropham, chlorsulfuron, chlorthal, chlorthiamid, cinidon-ethyl, cinmethylin, cinosulfuron, cisanilide, clethodim, cliodinate, clodinafop-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, 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, endothal, epronaz, EPTC, erbon, 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, fenteracol, fenthiaprop, fentrazamide, fenuron, ferrous sulfate, flamprop, flamprop-M, 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, fluroxypyr, fluroxypyr-meptyl, flurtamone, fluthiacet, fomesafen, foramsulfuron, fosamine, fumiclorac, furyloxyfen, glufosinate, glufosinate-ammonium, glufosinate-P-ammonium, glyphosate, halauxifen, halauxifen-methyl, halosafen, 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, 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, metobromuron, metolachlor, metosulam, metoxuron, metribuzin, metsulfuron, metsulfuron-methyl, molinate, monalide, monisouron, monochloroacetic acid, monolinuron, monuron, morfamquat, MSMA, naproanilide, napropamide, naptalam, neburon, nicosulfuron, nipyraclofen, nitralin, nitrofen, nitrofluorfen, norflurazon, noruron, OCH, orbencarb, *ortho*-dichlorobenzene, orthosulfamuron, oryzalin, oxadiargyl, oxadiazon, 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, 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, pyrazoxyfen, pyribenzoxim, pyributicarb, pyriclor, pyridafol, pyridate, pyriftalid, pyriminobac, pyrimisulfan, pyrithiobac-sodium, pyroxasulfone, pyroxsulam, quinclorac, quinmerac, quinoclamine, quinonamid, quizalofop, quizalofop-P-ethyl, rhodethanil, rimsulfuron, saflufenacil, S-metolachlor, sebuthylazine, secbumeton, sethoxydim, siduron, simazine, simeton, simetryn, SMA, sodium arsenite, sodium azide, sodium chlorate, sulcotrione, sulfallate, sulfentrazone, sulfometuron, sulfosate, sulfosulfuron, sulfuric acid, sulglycapin, swep, SYN-523, TCA, tebutam, tebuthiuron, tefuryltrione, tembotrione, tepraloxydim, terbacil, terbucarb, terbuchlor, terbumeton, terbuthylazine, terbutryn, tetrafluron, thenylchlor, thiazafluron, thiazopyr, thidiazimin, thidiazuron, thiencarbazone-methyl, thifensulfuron, thifensulfurn-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.

The compositions and methods described herein, can further be used in conjunction with glyphosate, 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase inhibitors, glufosinate, glutamine synthetase inhibitors, dicamba, phenoxy auxins, pyridyloxy auxins, synthetic auxins, auxin transport inhibitors, aryloxyphenoxypropionates, cyclohexanediones, phenylpyrazolines, acetyl CoA carboxylase (ACCase) inhibitors, imidazolinones, sulfonylureas, pyrimidinylthiobenzoates, triazolopyrimidine-sulfonamides, sulfonylaminocarbonyltriazolinones, acetolactate synthase (ALS) or acetohydroxy acid synthase (AHAS) inhibitors, 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitors, phytoene desaturase inhibitors, carotenoid biosynthesis inhibitors, protoporphyrinogen oxidase (PPO) inhibitors, cellulose biosynthesis inhibitors, mitosis inhibitors, microtubule inhibitors, very long chain fatty acid inhibitors, fatty acid and lipid biosynthesis inhibitors, photosystem I inhibitors, photosystem II inhibitors, triazines, and bromoxynil on glyphosate-tolerant, EPSP synthase inhibitor-tolerant, glufosinate-tolerant, glutamine synthetase inhibitor-tolerant, dicamba-tolerant, phenoxy auxin-tolerant, pyridyloxy auxin-tolerant,

auxin-tolerant, auxin transport inhibitor-tolerant, aryloxyphenoxypropionate-tolerant, cyclohexanedione-tolerant, phenylpyrazoline-tolerant, ACCase-tolerant, imidazolinone-tolerant, sulfonylurea-tolerant, pyrimidinylthiobenzoate-tolerant, triazolopyrimidine-sulfonamide-tolerant, sulfonylaminocarbonyltriazolinone-tolerant, ALS- or AHAS-tolerant, HPPD-tolerant, phytoene desaturase inhibitor-tolerant, carotenoid biosynthesis inhibitor tolerant, PPO-tolerant, cellulose biosynthesis inhibitor-tolerant, mitosis inhibitor-tolerant, microtubule inhibitor-tolerant, very long chain fatty acid inhibitor-tolerant, fatty acid and lipid biosynthesis inhibitor-tolerant, photosystem I inhibitor-tolerant, photosystem II inhibitor-tolerant, triazine-tolerant, bromoxynil-tolerant, and crops possessing multiple or stacked traits conferring tolerance to multiple chemistries and/or multiple modes of action via single and/or multiple resistance mechanisms. In some embodiments, the compound of formula (I) or salt or ester thereof and 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, as a tank mix, or as a sequential application.

In some embodiments, the compositions described herein are employed in combination with one or more herbicide safeners, such as AD-67 (MON 4660), benoxacor, benthiocarb, 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, to enhance their selectivity. In some embodiments, the safeners are employed in rice, cereal, corn, or maize settings. 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 on rice and cereals. In some embodiments, the safener is cloquintocet (mexyl).

In some embodiments, the compositions described herein are employed in combination with one or more plant growth regulators, such as 2,3,5-tri-iodobenzoic acid, IAA, IBA, naphthaleneacetamide, α-naphthaleneacetic acids, benzyladenine, 4-hydroxyphenethyl alcohol, kinetin, zeatin, endothal, ethephon, pentachlorophenol, thidiazuron, tribufos, aviglycine, maleic hydrazide, gibberellins, gibberellic acid, abscisic acid, ancymidol, fosamine, glyphosine, isopyrimol, jasmonic acid, mepiquat, 2,3,5-tri-

iodobenzoic acid, morphactins, dichlorflurenol, flurprimidol, mefluidide, paclobutrazol, tetcyclacis, uniconazole, brassinolide, brassinolide-ethyl, cycloheximide, ethylene, methasulfocarb, prohexadione, triapenthenol and trinexapac.

In some embodiments, the plant growth regulators are employed in one or more crops or settings, such as rice, cereal crops, corn, maize, broadleaf crops, oilseed rape/canola, turf, pineapple, sugarcane, sunflower, pastures, grasslands, rangelands, fallowland, tree and vine orchards, plantation crops, vegetables, and non-crop (ornamentals) settings. In some embodiments, the plant growth regulator is mixed with the compound of formula (I), or mixed with the compound of formula (I) and halosulfuron-methyl, pyrazosulfuron-ethyl or esprocarb to cause a preferentially advantageous effect on plants.

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 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; blend of petroleum hydrocarbon, alkyl esters, organic acid, and anionic surfactant; C_9-C_{11} alkylpolyglycoside; phosphated alcohol ethoxylate; natural primary alcohol (C_{12}-C_{16}) 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-99.

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, 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 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, 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, pyrophyllite clay, silica, attapulgus clay, kaolin clay, kieselguhr, chalk, diatomaceous earth, lime, calcium carbonate, bentonite clay, Fuller's earth, cottonseed hulls, wheat flour, soybean flour, pumice, wood 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 Publishing Corp., Ridgewood, New Jersey, 1998 and in "Encyclopedia of Surfactants," Vol. I-III, Chemical Publishing Co., 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-C_{18} ethoxylate; alcohol-alkylene oxide addition products, such as tridecyl alcohol-C_{16} ethoxylate; soaps, such as sodium stearate; alkyl-naphthalene-sulfonate salts, such as sodium dibutylnaphthalenesulfonate; dialkyl esters of sulfosuccinate salts, such as sodium di(2-ethylhexyl) sulfosuccinate; sorbitol esters, such as sorbitol oleate; quaternary amines, such as lauryl trimethylammonium chloride; polyethylene glycol esters of fatty acids, such as polyethylene glycol stearate; block copolymers of ethylene oxide and propylene oxide; 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.

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 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 such as ammonium nitrate, urea and the like.

In some embodiments, the concentration of the active ingredients in the compositions described herein is from about 0.0005 to 98 percent by weight. In some embodiments, the concentration is from about 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 about 0.1 to 98 weight percent, and in certain embodiment's about 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 weeds contain, in certain embodiments, about 0.0006 to 3.0 weight percent active ingredient and in certain embodiments contain about 0.01 to 1.0 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 or paddy water, and by other conventional means known to those skilled in the art.

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.

Examples

Results in Examples I and II are greenhouse trial results.

Example I. Evaluation of Post-Emergence Foliar-Applied Herbicidal Mixtures for Weed Control in Direct Seeded Rice

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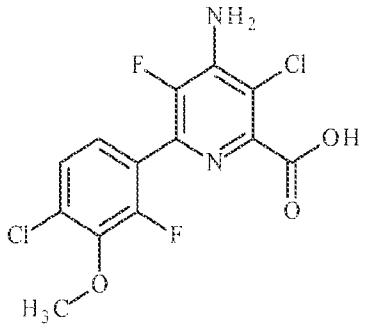
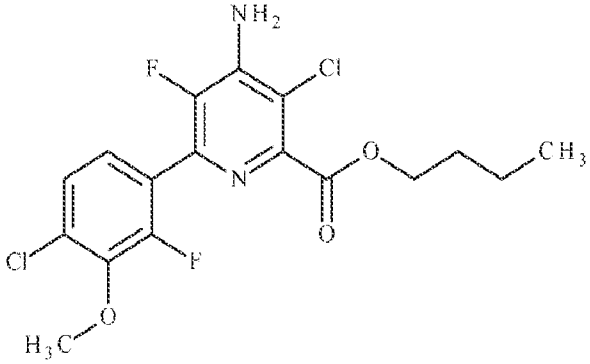
Seeds or nutlets of the desired test plant species were planted in a soil matrix prepared by mixing a loam or sandy loam soil (*e.g.*, 28.6 percent silt, 18.8 percent clay, and 52.6 percent sand, with a pH of about 5.8 and an organic matter content of about 1.8 percent) and calcareous grit in an 80 to 20 ratio. The soil matrix was contained in plastic pots with a volume of 1 quart and a surface area of 83.6 square centimeters (cm^2). When required to ensure good germination and healthy plants, a fungicide treatment and/or other chemical or physical treatment was applied. The plants were grown for 8-22 days in a greenhouse with an approximate 14 hr. photoperiod which was maintained at about 29° C during the day and 26° C during the night. Nutrients (Peters Excel® 15-5-15 5-Ca 2-Mg and iron chelate) were applied in the irrigation solution as needed and water was added on a regular basis. Supplemental lighting was provided with overhead metal halide 1000-Watt lamps as necessary. The plants were employed for testing when they reached the first through fourth true leaf stage.

Treatments consisted of the acid or esters of 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxy-phenyl)pyridine-2-carboxylic acid (Compound A), each formulated as an SC (suspension concentrate), and various herbicidal components alone and in combination. Forms of compound A were applied on an acid equivalent basis.

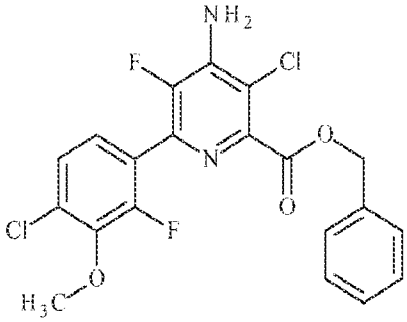
Forms of compound A (compound of formula I) tested include:



Compound A Acid



Compound A n-Butyl Ester



Compound A Benzyl Ester

Other herbicidal components were applied on an active ingredient basis and included the acetolactate synthase (ALS)-inhibiting herbicides halosulfuron-methyl formulated as Permit® 75 WDG, pyrazosulfuron-ethyl formulated as Agreen® WG or Sirius® G, and the VLCFA inhibiting herbicide esprocarb (technical grade material).

Treatment requirements were calculated based upon the rates being tested, the concentration of active ingredient or acid equivalent in the formulation, and a 12 mL application volume at a rate of 187 L/ha.

For treatments comprised of formulated compounds, measured amounts of compounds were placed individually in 25 mL glass vials and diluted in a volume of 1.25% (v/v) Agri-Dex® crop oil concentrated to obtain 12X stock solutions. If a test compound did

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not dissolve readily, the mixture was warmed and/or sonicated. Application solutions were prepared by adding an appropriate amount of each stock solution (e.g., 1 ml,) and diluted to the appropriate final concentrations with the addition of 10 ml of an aqueous mixture of 1.25% (v/v) crop oil concentrate so that the final spray solutions contained 1.25+/-0.05% (v/v) crop oil concentrate.

For treatments comprised of technical compounds, weighed amounts can be placed individually in 25 mL glass vials and dissolved in a volume of 97:3 v/v acetone/DMSO to obtain 12X stock solutions. If a test compound does not dissolve readily, the mixture can be warmed and/or sonicated. Application solutions can be prepared by adding an appropriate amount of each stock solution (e.g., 1 ml) and diluted to the appropriate final concentrations with the addition of 10 mL of an aqueous mixture of 1.5% (v/v) crop oil concentrate so that the final spray solutions contain 1.25% (v/v) crop oil concentrate. When technical materials are used, the concentrated stock solutions can be added to the spray solutions so that the final acetone and DMSO concentrations of the application solutions are 16.2% and 0.5%, respectively.

For treatments comprised of formulated and technical compounds, weighed amounts of the technical materials were placed individually in 25 ml glass vials and dissolved in a volume of 97:3 v/v acetone/DMSO to obtain 12X stock solutions, and measured amounts of the formulated compounds were placed individually in 25 mL glass vials and diluted in a volume of 1.5% (v/v) crop oil concentrate or water to obtain 12X stock solutions. If a test compound did not dissolve readily, the mixture was warmed and/or sonicated. Application solutions were prepared by adding an appropriate amount of each stock solution (e.g., 1 mL) and diluted to the appropriate final concentrations with the addition of an appropriate amount of an aqueous mixture of 1.5% (v/v) crop oil concentrate so that the final spray solutions contained 1.25% (v/v) crop oil concentrate. As required, additional water and/or 97:3 v/v acetone/DMSO was added to individual application solutions so that the final acetone and DMSO concentrations of the application solutions being compared were 8.1% and 0.25%, respectively.

All stock solutions and applications solutions were visually inspected for compound compatibility prior to application. Spray solutions were applied to the plant material with an overhead Mandel track sprayer equipped with a 8002E nozzles calibrated to deliver 187 L/ha over an application area of 0.503 m^2 at a spray height of 18 to 20 inches (46 to 50 cm) above average plant canopy height. Control plants were sprayed in the same manner with the solvent blank.

The treated plants and control plants were placed in a greenhouse as described above and watered by sub-irrigation to prevent wash-off of the test compounds. After approximately 3 weeks, the condition of the test plants as compared with that of the untreated plants was determined visually and scored on a scale of 0 to 100 percent where 0 corresponds to no injury or growth inhibition and 100 corresponds to complete kill.

Colby's equation was used to determine the herbicidal effects expected from the mixtures (Colby, S.R. 1967. Calculation of the synergistic and antagonistic response of herbicide combinations. Weeds 15:20-22.) .

The following equation was used to calculate the expected activity of mixtures containing two active ingredients, A and B:

$$\text{Expected} = A + B - (A \times B/100)$$

A = observed efficacy of active ingredient A at the same concentration as used in the mixture.

B = observed efficacy of active ingredient B at the same concentration as used in the mixture.

The compounds tested, application rates employed, plant species tested, and results are given in Tables 1-8.

Table 1. Synergistic Activity of Foliar-Applied Compound A Acid and Halosulfuron-methyl Herbicidal Compositions on Weed Control in a Rice Cropping System.

Compound A Acid	Halosulfuron-methyl	Visual Weed Control (%) - 20 DAA	
		BRAPP	
g ae/ha	g ai/ha	Obs	Exp
4.38	0	50	-
0	4.38	0	-
0	8.75	0	-
0	17.5	0	-
4.38	4.38	65	50
4.38	8.75	60	50
4.38	17.5	60	50
Compound A Acid	Halosulfuron-methyl	Visual Weed Control (%) - 20 DAA	
		DIGSA	
g ae/ha	g ai/ha	Obs	Exp
21.2	0	10	-
42.4	0	25	-
0	35	10	-
21.2	35	10	19
42.4	35	53	33

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Table 2. Synergistic Activity of Foliar-Applied Compound A Benzyl Ester and Halosulfuron-methyl Herbicidal Compositions on Weed Control in a Rice Cropping System.

Compound A Benzyl Ester	Halosulfuron-methyl	Visual Weed Control (%) - 20 DAA	
		BRAPP	
g ae/ha	g ai/ha	Obs	Exp
4.38	0	40	-
8.75	0	70	-
0	4.38	0	-
0	8.75	0	-
0	17.5	0	-
4.38	4.38	65	40
8.75	4.38	75	70
4.38	8.75	70	40
8.75	8.75	80	70
4.38	17.5	60	40
8.75	17.5	75	70

Compound A Benzyl Ester	Halosulfuron-methyl	Visual Weed Control (%) - 20 DAA	
		LEFCH	
g ae/ha	g ai/ha	Obs	Exp
4.38	0	0	-
8.75	0	20	-
17.5	0	40	-
0	8.75	0	-
0	17.5	0	-
4.38	8.75	15	0
8.75	8.75	15	20
17.5	8.75	60	40
4.38	17.5	15	0
8.75	17.5	20	20
17.5	17.5	35	40

Table 3. Synergistic Activity of Foliar-Applied Compound A n-Butyl Ester and Halosulfuron-methyl Herbicidal Compositions on Weed Control in a Rice Cropping System.

Compound A n-Butyl Ester	Halosulfuron-methyl	Visual Weed Control (%) - 20 DAA	
		LEFCH	
g ae/ha	g ai/ha	Obs	Exp
35	0	48	-
0	35	5	-
35	35	68	50

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Table 4. Synergistic Activity of Foliar-Applied Compound A Acid and Pyrazosulfuron-ethyl (Agreen® WG) Herbicidal Compositions on Weed Control in a Rice Cropping System.

Compound A Acid	Pyrazosulfuron-ethyl	Visual Weed Control (%) - 20 DAA	
		DIGSA	
g ae/ha	g ai/ha	Obs	Exp
21.2	0	10	-
0	120	23	-
21.2	120	63	30

Table 5. Synergistic Activity of Foliar-Applied Compound A Benzyl Ester and Pyrazosulfuron-ethyl (Agreen® WG) Herbicidal Compositions on Weed Control in a Rice Cropping System.

Compound A Benzyl Ester	Pyrazosulfuron-ethyl	Visual Weed Control (%) - 21 DAA	
		BRAPP	
g ae/ha	g ai/ha	Obs	Exp
4.38	0	50	-
0	15	0	-
0	30	0	-
0	60	10	-
4.38	15	80	50
4.38	30	70	50
4.38	60	70	55

Compound A Benzyl Ester	Pyrazosulfuron-ethyl	Visual Weed Control (%) - 21 DAA	
		DIGSA	
g ae/ha	g ai/ha	Obs	Exp
17.5	0	23	-
35	0	38	-
0	120	23	-
17.5	120	63	40
35	120	53	52

Table 6. Synergistic Activity of Foliar-Applied Compound A n-Butyl Ester and Pyrazosulfuron-ethyl (Agreen® WG) Herbicidal Compositions on Weed Control in a Rice Cropping System.

Compound A n-Butyl Ester	Pyrazosulfuron-ethyl	Visual Weed Control (%) - 20 DAA	
		DIGSA	
g ae/ha	g ai/ha	Obs	Exp
17.5	0	13	-
0	120	23	-
17.5	120	45	32

Table 7. Synergistic Activity of Foliar-Applied Compound A Acid and Esprocarb Herbicidal Compositions on Weed Control in a Rice Cropping System.

Compound A Acid	Esprocarb	Visual Weed Control (%) - 22 DAA	
		BRAPP	
g ae/ha	g ai/ha	Obs	Exp
4.38	0	45	-
0	52.5	0	-
0	105	0	-
4.38	52.5	65	45
4.38	105	55	45

Compound A Acid	Esprocarb	Visual Weed Control (%) - 22 DAA	
		ECHCO	
g ae/ha	g ai/ha	Obs	Exp
4.38	0	65	-
8.75	0	80	-
0	105	0	-
4.38	105	80	65
8.75	105	85	80

Table 8. Synergistic Activity of Foliar-Applied Compound A Benzyl Ester and Esprocarb Herbicidal Compositions on Weed Control in a Rice Cropping System.

Compound A Benzyl Ester	Esprocarb	Visual Weed Control (%) - 22 DAA	
		CYPIR	
g ae/ha	g ai/ha	Obs	Exp
4.38	0	25	-
8.75	0	50	-
0	52.5	0	-
0	105	0	-
4.38	52.5	95	25
8.75	52.5	100	50
4.38	105	99	25
8.75	105	100	50

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Compound A Benzyl Ester	Esprocarb	Visual Weed Control (%) - 22 DAA	
		SCPJU	
g ae/ha	g ai/ha	Obs	Exp
8.75	0	80	-
0	52.5	0	-
0	105	0	-
8.75	52.5	100	80
8.75	105	100	80

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BRAPP	*Urochloa platyphylla* (Nash) R.D. Webster or *Brachiaria platyphylla* (Griseb.) Nash	signalgrass, broadleaf
CYPIR	*Cyperus iria* L.	flatsedge, rice
DIGSA	*Digitaria sanguinalis* (L.) Scop.	crabgrass, large
ECHCO	*Echinochloa colona* (L.) Link	junglerice
LEFCH	*Leptochloa chinensis* (L.) Nees	sprangletop, Chinese
SCPJU	*Schoenoplectus juncoides* (Roxb.) Palla	bulrush, Japanese

g ae/ha = grams acid equivalent per hectare

g ai/ha = grams active ingredient per hectare

Obs = observed value

Exp = expected value as calculated by Colby's equation

DAA = days after application

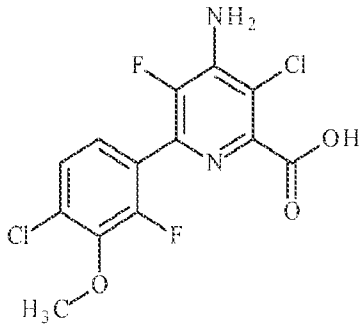
Example II. Evaluation of In-Water Applied Herbicidal Mixtures for Weed Control in Transplanted Paddy Rice

Weed seeds or nutlets of the desired test plant species were planted in puddled soil (mud) prepared by mixing a shredded, non-sterilized mineral soil (50.5 percent silt, 25.5 percent clay, and 24 percent sand, with a pH of about 7.6 and an organic matter content of about 2.9 percent) and water at a 1:1 volumetric ratio. The prepared mud was dispensed in 365 mL aliquots into 16-ounce (oz.) non-perforated plastic pots with a surface area of 86.59 square centimeters (cm^2) leaving a headspace of 3 centimeters (cm) in each pot Mud was allowed to dry overnight prior to planting or transplanting. Rice seeds were planted in Sun Gro MetroMix® 306 planting mixture, which typically has a pH of 6.0 to 6.8 and an organic matter content of about 30 percent, in plastic plug trays. Seedlings at the second or third leaf stage of growth were transplanted into 840 mL of mud contained in 32-oz. non-perforated plastic pots with a surface area of 86.59 cm^2 4 days prior to herbicide application. The paddy was created by filling the headspace of the pots with 2.5 to 3 cm of water. When required to ensure good germination and healthy plants, a fungicide treatment and/or other chemical or physical treatment was applied. The plants were grown for 4-22 days in a greenhouse with an approximate 14 hr. photoperiod which was maintained at about 29°C during the day and 26°C during the night. Nutrients were added as Osmocote® (19:6:12, N:P:K + minor nutrients) at 2 g per 16-oz. pot and 4 g per 32-oz. pot. Water was added on a regular basis to maintain the paddy flood, and supplemental lighting was provided with overhead metal

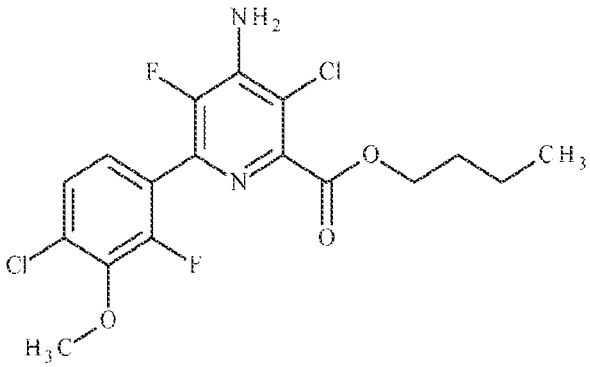
halide 1000-Watt lamps as necessary. The plants were employed for testing when they reached the first through fourth true leaf stage.

Treatments consisted of the acid or esters of 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxy-phenyl)pyridine-2-carboxylic acid (compound A) each formulated as an SC (suspension concentrate) and various herbicidal components alone and in combination. Forms of compound A were applied on an acid equivalent basis.

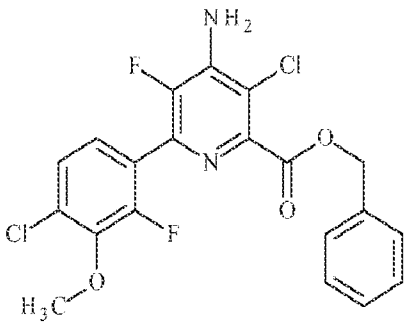
Forms of compound A (compound of formula I) tested include:



Compound A Acid



Compound A n-Butyl Ester



Compound A Benzyl Ester

Other herbicidal components were applied on an active ingredient basis and included acetolactate synthase (ALS)-inhibiting herbicides formulated as Permit® 75 WDG,

pyrazosulfuron-ethyl formulated as Agreen® WG or Sirius® G, and VLCFA inhibiting herbicide esprocarb (technical grade material).

Treatment requirements for each compound or herbicidal component were calculated based upon the rates being tested, the concentration of active ingredient or acid equivalent in the formulation, an application volume of 2 mL per component per pot, and an application area of 86.59 cm^2 per pot.

For formulated compounds, a measured amount was placed in an individual 100 or 200 mL glass vial and was dissolved in a volume of 1.25% (v/v) Agri-Dex® crop oil concentrate to obtain application solutions. If the test compound did not dissolve readily, the mixture was warmed and/or sonicated.

For technical grade compounds, a weighed amount was placed in an individual 100 to 200 mL glass vial and was dissolved in a volume of acetone to obtain concentrated stock solutions. If the test compound did not dissolve readily, the mixture was warmed and/or sonicated. The concentrated stock solutions obtained were diluted with an equivalent volume of an aqueous mixture containing 2.5% (v/v) crop oil concentrate so that the final application solutions contained 1.25% (v/v) crop oil concentrate.

Applications were made by injecting with a pipetter appropriate amounts of the application solutions, individually and sequentially, into the aqueous layer of the paddy. Control plants were treated in the same manner with the solvent blank. Applications were made so that all treated plant material received the same concentrations of acetone and crop oil concentrate.

The treated plants and control plants were placed in a greenhouse as described above and water was added as needed to maintain a paddy flood. After approximately 3 weeks the condition of the test plants as compared with that of the untreated plants was determined visually and scored on a scale of 0 to 100 percent where 0 corresponds to no injury or growth inhibition and 100 corresponds to complete kill.

Colby's equation was used to determine the herbicidal effects expected from the mixtures (Colby, S.R. 1967. Calculation of the synergistic and antagonistic response of herbicide combinations. Weeds 15:20-22.).

The following equation was used to calculate the expected activity of mixtures containing two active ingredients, A and B:

$$\text{Expected} = A + B - (A \times B/100)$$

A = observed efficacy of active ingredient A at the same concentration as used in the mixture.

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B=observed efficacy of active ingredient B at the same concentration as used in the mixture.

Some of the compounds tested, application rates employed, plant species tested, and results are given in Tables 9-18.

Table 9. Synergistic Activity of In-Water Application of Compound A Acid and Halosulfuron-methyl Hebicidal Compositions on Weed Control in a Rice Cropping System.

Compound A Acid	Halosulfuron-methyl	Visual Weed Control (%) - 20 DAA			
		ECHOR		SCPMA	
g ae/ha	g ai/ha	Obs	Exp	Obs	Exp
42.4	0	18	-	0	-
84.8	0	33	-	0	-
0	35	0	-	65	-
42.4	35	58	18	100	65
84.8	35	73	33	100	65

Compound A Acid	Halosulfuron-methyl	Visual Weed Control (%) - 21 DAA	
		ECHCG	
g ae/ha	g ai/ha	Obs	Exp
8.75	0	0	-
17.5	0	30	-
0	17.5	0	-
8.75	17.5	30	0
17.5	17.5	85	30

Compound A Acid	Halosulfuron-methyl	Visual Weed Control (%) - 21 DAA	
		CYPRO	
g ae/ha	g ai/ha	Obs	Exp
8.75	0	30	-
17.5	0	50	-
35	0	65	-
0	8.75	60	-
8.75	8.75	100	72
17.5	8.75	100	80
35	8.75	100	86

Table 10. Synergistic Activity of In-Water Applications of Compound A Benzyl Ester and Halosulfuron-methyl Herbicidal Compositions on Weed Control in a Rice Cropping System.

Compound A Benzyl Ester	Halosulfuron-methyl	Visual Weed Control (%) - 20 DAA	
		ECHOR	
g ae/ha	g ai/ha	Obs	Exp
35	0	73	-
0	35	0	-
35	35	88	73

Compound A Benzyl Ester	Halosulfuron-methyl	Visual Weed Control (%) - 20 DAA	
		SCPMA	
g ae/ha	g ai/ha	Obs	Exp
70	0	0	-
0	35	65	-
70	35	98	65

Compound A Benzyl Ester	Halosulfuron-methyl	Visual Weed Control (%) - 21 DAA	
		ECHOR	
g ae/ha	g ai/ha	Obs	Exp
4.38		0	-
8.75		10	-
0	8.75	0	-
0	17.5	0	-
4.38	8.75	10	0
8.75	8.75	15	10
4.38	17.5	15	0
8.75	17.5	15	10

Compound A Benzyl Ester	Halosulfuron-methyl	Visual Weed Control (%) - 21 DAA	
		CYPRO	
g ae/ha	g ai/ha	Obs	Exp
4.38	0	20	-
8.75	0	65	-
0	8.75	60	-
4.38	8.75	70	68
8.75	8.75	100	86

Table 11. Synergistic Activity of In-Water Applications of Compound A n-Butyl Ester and Halosulfuron-methyl Herbicidal Compositions on Weed Control in a Rice Cropping System.

Compound A n-Butyl Ester	Halosulfuron-methyl	Visual Weed Control (%) - 20 DAA			
		ECHOR		SCPMA	
g ae/ha	g ai/ha	Obs	Exp	Obs	Exp
35	0	35	-	0	-
70	0	40	-	0	-
0	35	0	-	65	-
35	35	55	35	80	65
70	35	83	40	95	65

Table 12. Synergistic Activity of In-Water Applications of Compound A Acid and Pyrazosulfuron-ethyl (Sirius® G) Herbicidal Compositions on Weed Control in a Rice Cropping System.

Compound A Acid	Pyrazosulfuron-ethyl	Visual Weed Control (%) - 20 DAA	
		ECHOR	
g ae/ha	g ai/ha	Obs	Exp
42.4	0	18	-
84.8	0	33	-
0	70	70	-
42.4	70	93	75
84.8	70	98	80

Compound A Acid	Pyrazosulfuron-ethyl	Visual Weed Control (%) - 22 DAA			
		ECHOR		SCPMA	
g ae/ha	g ai/ha	Obs	Exp	Obs	Exp
8.75	0	0	-	0	-
17.5	0	0	-	0	-
35	0	20	-	0	-
0	17.5	0	-	80	-
0	35	0	-	70	-
8.75	17.5	20	0	85	80
17.5	17.5	40	0	85	80
35	17.5	40	20	95	80
8.75	35	50	0	99	70
17.5	35	30	0	95	70
35	35	10	20	100	70

Table 13. Synergistic Activity of In-Water Applications of Compound A Acid and Pyrazosulfuron-ethyl (Agreen® WG) Herbicidal Compositions on Weed Control in a Rice Cropping System.

Compound A Acid	Pyrazosulfuron-ethyl	Visual Weed Control (%) - 22 DAA	
		ECHCG	
g ae/ha	g ai/ha	Obs	Exp
16	0	20	-
32	0	25	-
0	7.5	20	-
0	15	20	-
16	7.5	70	36
32	7.5	85	40
16	15	70	36
32	15	70	40

Compound A Acid	Pyrazosulfuron-ethyl	Visual Weed Control (%) - 21 DAA	
		CYPDI	
g ae/ha	g ai/ha	Obs	Exp
16	0	30	-
32	0	90	-
0	7.5	70	-
0	15	80	-
16	7.5	100	79
32	7.5	100	97
16	15	100	86
32	15	100	98

Table 14. Synergistic Activity of In-Water Applications of Compound A n-Butyl Ester and Pyrazosulfuron-ethyl (Sirius® G) Herbicidal Compositions on Weed Control in a Rice Cropping System.

Compound A n-Butyl Ester	Pyrazosulfuron-ethyl	Visual Weed Control (%) - 20 DAA	
		ECHOR	
g ae/ha	g ai/ha	Obs	Exp
35	0	35	-
70	0	40	-

0	70	70	-
35	70	90	81
70	70	88	82

Table 15. Synergistic Activity of In-Water Applications of Compound A Benzyl Ester and Pyrazosulfuron-ethyl (Sirius® G) Herbicidal Compositions on Weed Control in a Rice Cropping System.

Compound A Benzyl Ester	Pyrazosulfuron-ethyl	Visual Weed Control (%) - 20 DAA	
		ECHOR	
g ae/ha	g ai/ha	Obs	Exp
35	0	73	-
0	70	70	-
35	70	100	92

Compound A Benzyl Ester	Pyrazosulfuron-ethyl	Visual Weed Control (%) - 22 DAA	
		LEFCH	
g ae/ha	g ai/ha	Obs	Exp
4.38	0	0	-
0	17.5	0	-
0	35	0	-
4.38	17.5	85	0
4.38	35	70	0

Compound A Benzyl Ester	Pyrazosulfuron-ethyl	Visual Weed Control (%) - 22 DAA	
		SCPMA	
g ae/ha	g ai/ha	Obs	Exp
4.38	0	0	-
8.75	0	0	-
17.5	0	0	-
0	17.5	80	-
0	35	70	-
4.38	17.5	100	80
8.75	17.5	85	80
17.5	17.5	90	80
4.38	35	85	70
8.75	35	95	70

17.5	35	95	70

Table 16. Synergistic Activity of In-Water Applications of Compound A Benzyl Ester and Pyrazosulfuron-ethyl (Agreen® WG) Herbicidal Compositions on Weed Control in a Rice Cropping System.

Compound A Benzyl Ester	Pyrazosulfuron-ethyl	Visual Weed Control (%) - 22 DAA	
		ECHCG	
g ae/ha	g ai/ha	Obs	Exp
8	0	50	-
16	0	60	-
0	15	20	-
8	15	70	60
16	15	80	68

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Compound A Benzyl Ester	Pyrazosulfuron-ethyl	Visual Weed Control (%) - 19 DAA	
		ECHCG	
g ae/ha	g ai/ha	Obs	Exp
8	0	35	-
0	5	0	-
0	10	0	-
0	20	30	-
8	5	50	35
8	10	50	35
8	20	80	55

Compound A Benzyl Ester	Pyrazosulfuron-ethyl	Visual Weed Control (%) - 19 DAA	
		ECHOR	
g ae/ha	g ai/ha	Obs	Exp
8	0	10	-
16	0	25	-
32	0	35	-
0	5	0	-
0	10	0	-
8	5	20	10
16	5	30	25

32	5	45	35
8	10	40	10
16	10	25	25
32	10	45	35

Table 17. Synergistic Activity of In-Water Applications of Compound A Acid and Esprocarb Herbicidal Compositions on Weed Control in a Rice Cropping System.

Compound A Acid	Esprocarb	Visual Weed Control (%) - 21 DAA			
		FIMMI		SCPJU	
g ae/ha	g ai/ha	Obs	Exp	Obs	Exp
8.75	0	0	-	40	-
17.5	0	95	-	60	-
0	105	0	-	0	-
0	210	0	-	0	-
8.75	105	99	0	75	40
17.5	105	100	95	85	60
8.75	210	50	0	85	40
17.5	210	100	95	85	60

Table 18. Synergistic Activity of In-Water Applications of Compound A Benzyl Ester and Esprocarb Herbicidal Compositions on Weed Control in a Rice Cropping System.

Compound A Benzyl Ester	Esprocarb	Visual Weed Control (%) - 21 DAA	
		CYPRO	
g ae/ha	g ai/ha	Obs	Exp
4.38	0	30	-
8.75	0	60	-
0	105	0	-
0	210	50	-
4.38	105	80	30
8.75	105	85	60
4.38	210	85	65
8.75	210	70	80

Compound A Benzyl Ester	Esprocarb	Visual Weed Control (%) - 21 DAA	
		FIMMI	
g ae/ha	g ai/ha	Obs	Exp
4.38	0	20	-
0	105	0	-
0	210	0	-
4.38	105	100	20
4.38	210	95	20

CYPDI	*Cyperus difformis* L.	flatsedge, smallflower
CYPRO	*Cyperus rotundus* L.	nutsedge, purple
ECHCG	*Echinochloa crus-galli* (L.) P. Beauv.	barnyardgrass
ECHOR	*Echinochloa oryzoides* (Ard.) Fritsch	watergrass, early
FIMMI	*Fimbristylis miliacea* (L.) Vahl	fringerush, globe
LEFCH	*Leptochloa chinensis* (L.) Nees	sprangletop, Chinese
SCPJU	*Schoenoplectus juncoides* (Roxb.) Palla	bulrush, Japanese
SCPMA	*Bolboschoenus maritimus* (L.) Palla or *Schoenoplectus maritimus* (L.) Lye	clubrush, sea

g ae/ha = grams acid equivalent per hectare

g ai/ha = grams active ingredient per hectare

Obs = observed value

Exp = expected value as calculated by Colby's equation

DAA = days after application

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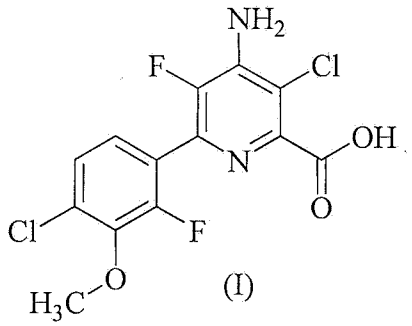
WHAT IS CLAIMED IS:

1. A synergistic herbicidal composition comprising a herbicidally effective amount of (a) a compound of the formula (I):



(I)

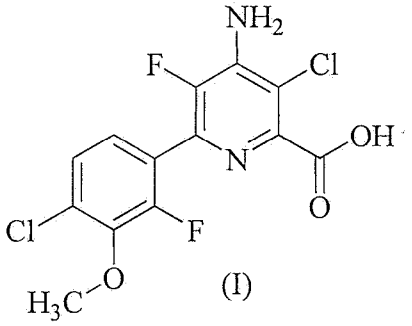
or an agriculturally acceptable salt or ester thereof and (b) at least one compound, or an agriculturally acceptable salt, carboxylic acid, carboxylate salt, or ester thereof, selected from the group consisting of: halosulfuron-methyl, pyrazosulfuron-ethyl and esprocarb, wherein (a) and (b) are present in the composition in a ratio such that the composition exhibits herbicidal synergy, and wherein the ratio between (a) and (b) is from about 6.4:1 to about 1:48.

2. The composition of claim 1, wherein (a) is the compound of formula (I), a C_{1-4} alkyl ester of the compound of formula (I), or a benzyl ester of the compound of formula (I).

3. The composition of any one of claims 1-2, further comprising an agriculturally acceptable adjuvant or carrier.

4. The composition of any one of claims 1-3, further comprising a herbicide safener.

5. A method of controlling undesirable vegetation, comprising the steps of: contacting a plant, wherein the plant is undesirable vegetation or the locus thereof, soil or water, wherein the soil or the water allows for the growth of the undesirable vegetation, with a herbicidally effective amount of a combination comprising (a) a compound of the formula (I):



(I)

or an agriculturally acceptable salt or ester thereof and (b) at least one compound, or an agriculturally acceptable salt, carboxylic acid, carboxylate salt, or ester thereof, selected from the group consisting of: halosulfuron-methyl, pyrazosulfuron-ethyl and esprocarb, wherein

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(a) and (b) are present in the composition in a ratio such that the composition exhibits herbicidal synergy, and wherein the ratio between (a) and (b) is from about 6.4:1 to about 1:48.

6. The method of claim 5, wherein (a) is the compound of formula (I), a C_{1-4} alkyl ester of the compound of formula (I), or a benzyl ester of the compound of formula (I).

7. The method of any one of claims 5-6, wherein the undesirable vegetation is controlled in direct-seeded, water-seeded and transplanted rice, cereals, wheat, barley, oats, rye, sorghum, corn/maize, sugarcane, sunflower, oilseed rape, canola, sugar beet, soybean, cotton, pineapple, pastures, grasslands, rangelands, fallowland, turf, tree and vine orchards, aquatics, industrial vegetation management (IVM) or rights of way (ROW).

8. The method of any one of claims 5-7, wherein the (a) and (b) are applied pre-emergently to the plant or the crop.

9. The method of any one of claims 5-8, wherein the undesirable vegetation is controlled in glyphosate-, 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase inhibitor-, glufosinate-, glutamine synthetase inhibitor-, dicamba-, phenoxy auxin-, pyridyloxy auxin-, synthetic auxin-, auxin transport inhibitor-, aryloxyphenoxypropionate-, cyclohexanedione-, phenylpyrazoline-, acetyl CoA carboxylase (ACCase) inhibitor-, imidazolinone-, sulfonylurea-, pyrimidinylthiobenzoate-, triazolopyrimidine-, sulfonylaminocarbonyltriazolinone-, acetolactate synthase (ALS) or acetohydroxy acid synthase (AHAS) inhibitors-, 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitor-, phytoene desaturase inhibitor-, carotenoid biosynthesis inhibitor-, protoporphyrinogen oxidase (PPO) inhibitor-, cellulose biosynthesis inhibitor-, mitosis inhibitor-, microtubule inhibitor-, very long chain fatty acid inhibitor-, fatty acid and lipid biosynthesis inhibitor-, photosystem I inhibitor-, photosystem II inhibitor-, triazine-, or bromoxynil- tolerant crops.

10. The method of claim 9, wherein the tolerant crop possesses multiple or stacked traits conferring tolerance to multiple herbicides or multiple modes of action.

11. The method of any one of claims 5-10, wherein the undesirable vegetation comprises a herbicide resistant or tolerant plant.

12. The composition of any one of claims 1 to 4, wherein (b) is halosulfuron-methyl, and the weight ratio of (a) to (b) is from about 4:1 to about 1:4.

13. The composition of any one of claims 1 to 4, wherein (b) is pyrazosulfuron-ethyl, and the weight ratio of (a) to (b) is from about 6.4:1 to about 1:13.7.

14. The composition of any one of claims 1 to 4, wherein (b) is esprocarb, and the weight ratio of (a) to (b) is from about 1:6 to about 1:48.

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15. The method of any one of claims 5 to 11, wherein (b) is halosulfuron-methyl, and the weight ratio of (a) to (b) is from about 4:1 to about 1:4.

16. The method of any one of claims 5 to 11, wherein (b) is pyrazosulfuron-ethyl, and the weight ratio of (a) to (b) is from about 6.4:1 to about 1:13.7.

17. The method of any one of claims 5 to 11, wherein (b) is esprocarb, and the weight ratio of (a) to (b) is from about 1:6 to about 1:48.