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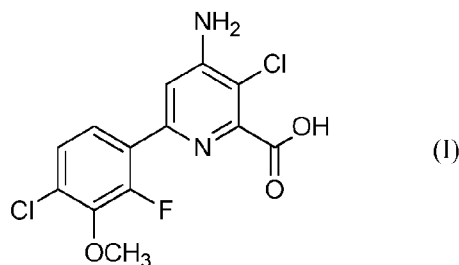
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(54) **Title:** HERBICIDAL COMPOSITIONS CONTAINING 4-AMINO-3-CHLORO-6-(4-CHLORO-2-FLUORO-3-METHOXYPHENYL)PYRIDINE-2-CARBOXYLIC ACID, A TRIAZOLOPYRIMIDINE SULFONAMIDE HERBICIDE AND A CELL MEMBRANE DISRUPTOR HERBICIDE



(57) **Abstract:** Herbicidal compositions and methods using a combination of (a) a compound of formula (I) or an agriculturally acceptable salt or ester thereof, (b) a triazolopyrimidine sulfonamide herbicide or an agriculturally acceptable salt or ester thereof, and (c) a cell membrane disruptor herbicide or an agriculturally acceptable salt or ester thereof provide control of undesirable vegetation in soybean, cotton, sunflower, winter/spring oilseed rape, winter/spring canola, vegetables, ornamentals, rice, wheat, teff, triticale, barley, oats, rye, sorghum, winter/spring oilseed rape, winter/spring canola, corn/maize, sunflower, row crops, pastures, grasslands, rangelands, fallowland, fallow beds, sugarcane, turf, tree and vine orchards, aquatics, forestry, industrial vegetation management (IVM) and rights-of-way; for the burndown and control of weeds in fallow fields and fallow beds between the planting of crops, such as soybean, corn, cotton sunflower, cereals, rice, winter/spring oilseed rape, winter/spring canola, corn/maize and sorghum; and for the control of weeds just prior to or after planting soybeans

HERBICIDAL COMPOSITIONS CONTAINING 4-AMINO-3-CHLORO-6-(4-CHLORO-2-FLUORO-3-METHOXYPHENYL)PYRIDINE-2-CARBOXYLIC ACID, A TRIAZOLOPYRIMIDINE SULFONAMIDE HERBICIDE AND A CELL MEMBRANE DISRUPTOR HERBICIDE

Cross Reference to Related Applications

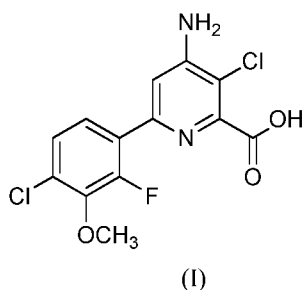
This application claims the benefit of U.S. Provisional Patent Application Serial Nos. 62/215921 filed September 9, 2015 and 62/272308 filed December 29, 2015, which are expressly incorporated by reference herein.

Background

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

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



or an agriculturally acceptable salt or ester of thereof and (b) a triazolopyrimidine sulfonamide herbicide or an agriculturally acceptable salt or ester thereof, and (c) a cell membrane disruptor herbicide or an agriculturally acceptable salt or ester thereof. In some embodiments, the cell membrane disruptor herbicide is selected from phosphorylated amino acid disruptors, photosystem I (PS I) inhibitors, and protoporphyrinogen oxidase (PPO) inhibitors.

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In some embodiments, the triazolopyrimidine sulfonamide herbicide includes, but is not limited to, cloransulam, diclosulam, florasulam, flumetsulam, metosulam, penoxsulam, or pyroxsulam, agriculturally acceptable salts or esters thereof, or combinations thereof.

In some embodiments, (c) is a phosphorylated amino acid disruptor. In some embodiments, the phosphorylated amino acid disruptor includes glufosinate or an agriculturally acceptable salt thereof.

In some embodiments, (c) is a cell membrane disruptor. In some embodiments, the cell membrane disruptor is a photosystem I (PS I) inhibitor. The photosystem I (PS I) inhibitor herbicides include diquat and paraquat, agriculturally acceptable salts thereof, and combinations thereof.

In some embodiments, the cell membrane disruptor is a protoporphyrinogen oxidase (PPO) inhibitor. In some embodiments, the PPO inhibitor includes acifluorfen, bifenox, chlomethoxyfen, fluoroglycofen, fomesafen, halosafen, lactofen, oxyfluorfen, fluazolate, pyraflufen, cinidon, flumioxazin, flumiclorac, fluthiacet, thidiazimin, oxadiazon, oxadiargyl, azafenidin, sulfentrazone, pentoxazone, trifludimoxazin, benzfendizone, butafenacil, saflufenacil, pyraclonil, profluzol, flufenpyr, and agriculturally acceptable salts and esters thereof, and combinations thereof. In some embodiments, the PPO inhibitor is not carfentrazone.

The compositions may also contain one or more agriculturally acceptable safeners, adjuvants and/or carriers. In some embodiments, the activity of the mixtures is greater than the sum of the activity of the individual active components.

The three way mixture can be prepared as a tank mix or premix. For example, a tank mix or premix containing the compound of formula (I) or a salt or ester thereof and a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof can be mixed with a disruptor herbicide or an agriculturally acceptable salt or ester thereof to form the three-component tank mix. In this embodiment, the tank mix, premix or concentrate of the compound of formula (I) and a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof and a disruptor herbicide or an agriculturally acceptable salt or ester thereof can be packaged and sold separately, can be copackaged together in separate containers or can be formulated together in one package.

In other embodiments, a premix or concentrate containing the compound of formula (I) or a salt or ester thereof and a cell membrane disruptor herbicide or an agriculturally acceptable salt or ester thereof can be mixed in a tank or container with a triazolopyrimidine

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sulfonamide herbicide or a salt or ester thereof to form the tank mix. In this embodiment, the premix or concentrate of the compound of formula (I) and a cell membrane disruptor herbicide or an agriculturally acceptable salt or ester thereof and the triazolopyrimidine sulfonamide herbicide can be packaged and sold separately, or can be copackaged together in separate containers, or can be formulated together in one package.

In still other embodiments, a premix containing all three active ingredients can be prepared and sold.

The ratio of the compound of formula (I) to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof in the premix or tank mix is from about 1:200 to 200:1; from about 1:40 to 30:1, or from about 1:15 to about 10:1. The ratio of the compound of formula (I) to diclosulam in the premix is from about 1:200 to 20:1; from about 1:30 to 6:1, and from about 1:6 to about 2:1.

The ratio of the compound of formula (I) to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof to a phosphorylated amino acid disruptor herbicide or an agriculturally acceptable salt thereof in the tank mix is from about 2:1:200 to about 1:2:67, from about 2:1:75 to about 1:2.67:56, and from about 1.67:1:33 to about 1:3.75:20. The ratio of the compound of formula (I) to diclosulam to glufosinate in the tank mix is from about 1:5:100 to about 1:2:67, from about 1:2.5:37.5 to about 1:2:56, and from about 1:2:20 to about 1:1.5:20. The ratio of the compound of formula (I) plus a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof to a phosphorylated amino acid disruptor herbicide or an agriculturally acceptable salt thereof in the premix is from about 1:4480 to about 3:1, from about 1:560 to about 1.5:1, and from about 1:57 to about 0.95:1. The ratio of the compound of formula (I) plus diclosulam to glufosinate in the tank mix is from about 1:1120 to about 3:1, from about 1:240 to about 1.2:1, and from about 1:26.7 to about 0.5:1.

The ratio of the compound of formula (I) to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof to a PS I inhibitor herbicide or an agriculturally acceptable salt in the tank mix is from about 2:1:80 to about 1:2:45, from about 2:1:60 to about 1:2.67:60, and from about 1.67:1:33.3 to about 1:3.75:45. The ratio of the compound of formula (I) to diclosulam to paraquat or any agriculturally acceptable salt in the tank mix is from about 1:5:40 to 1:2:45, from about 1:2.5:30 to about 1:2:60, and from about 1:2:20 to about 1:1.5:20. The ratio of the compound of formula (I) plus a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof to a PS I inhibitor herbicide or an agriculturally acceptable salt in the tank mix is from about 1:2987 to about 7.5:1, from about

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1:600 to about 1.83:1, and from about 1:128 to about 0.95:1. The ratio of the compound of formula (I) to diclosulam to paraquat or any agriculturally acceptable salt in the tank mix is from about 1:747 to about 7.5:1, from about 1:257 to about 1.5:1, and from about 1:26.7 to about 0.5:1.

The ratio of the compound of formula (I) to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof to a PPO inhibitor herbicide or an agriculturally acceptable salt in the tank mix is from about 2:1:2 to about 1:2:48, from about 2:1:1 to about 1:2.67:77, and from about 2.5:1:2.5 to about 1:3.75:100. The ratio of the compound of formula (I) to diclosulam to saflufenacil in the tank mix is from about 1:5:1 to about 1:2:4, from about 2:5:1 to about 1:2:5 and from about 1:2:1.75 to about 1:1.5:2.45. The ratio of the compound of formula (I) plus a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof to a PPO inhibitor herbicide or an agriculturally acceptable salt in the tank mix is from about 1:3200 to about 300:1, from about 1:767 to about 110:1, and from about 1:286 to about 1.9:1. The ratio of the compound of formula (I) plus diclosulam to saflufenacil in the tank mix is from about 1:66.7 to about 300:1, from about 1:21.4 to about 90:1 and from about 1:3.3 to about 5.7:1.

Also provided are methods of controlling undesirable vegetation including applying (a) a compound of formula (I) or an agriculturally acceptable ester or salt thereof, (b) a triazolopyrimidine sulfonamide herbicide or an agriculturally acceptable salt or ester thereof, and (c) a cell membrane disruptor herbicide or an agriculturally acceptable salt or ester thereof.

Detailed Description

I. Definitions

As used herein, control of or controlling undesirable vegetation means killing or preventing the growth of the vegetation, or causing some other adverse modifying effect to the vegetation *e.g.*, necrosis, chlorosis, stunting, deviations from natural growth or development, regulation, desiccation, retardation, and the like.

As used herein, herbicide and herbicidal active ingredient mean a compound that controls undesirable vegetation when applied in an appropriate amount.

As used herein, a herbicidally effective or vegetation controlling amount is an amount of herbicidal active ingredient the application of which controls the relevant undesirable vegetation.

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As used herein, applying a herbicide or herbicidal composition means delivering it directly to the targeted vegetation or to the locus thereof or to the area where control of undesired vegetation is desired. Methods of application include, but are not limited to pre-emergence, post-emergence, foliar and soil applications. Described herein are methods of controlling undesirable vegetation by applying certain herbicide combinations or compositions.

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

As used herein, disruptor herbicides show burning or yellowing of plant tissues and include cell membrane disruptor herbicides and phosphorylated amino acid disruptor herbicides.

As used herein, immature vegetation refers to small vegetative plants prior to reproductive stage, and mature vegetation refers to vegetative plants during and after reproductive stage.

As used herein, glufosinate tolerance refers to soybeans, corn, or cotton that is genetically modified to be tolerant to glufosinate. Glufosinate tolerance can be provided, for example, by the *pat* gene (U.S. Patent 5,276,268 B2) as shown herein; however, glufosinate tolerance could also be conferred within the scope of the 2,4-D- and glufosinate-tolerant soybeans, corn, or cotton described herein by other genes providing transgenic crop tolerance to glufosinate [e.g., *bar* (U.S. Patent 5,561,236 A) and *dsm2* (PCT International Application WO2008070845)].

II. Mixtures

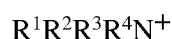
Compositions containing the compound of formula (I) or a salt or ester thereof, a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof, and a disruptor herbicide or an agriculturally acceptable salt or ester thereof are described herein. The composition can be in the form of a tank mix, premix, or co-pack of one or more compositions mixed with one or more separate compositions containing the compound of formula (I) or a salt or ester thereof, a triazolopyrimidine sulfonamide or a salt or ester thereof, and a disruptor herbicide or an agriculturally acceptable salt or ester thereof. The tank mix can be prepared by mixing a premix, co-pack, tank mix or concentrate containing the compound of formula (I) and a triazolopyrimidine sulfonamide herbicide or a disruptor herbicide or an agriculturally acceptable salt or ester thereof. In some embodiments, (b) includes, but is not limited to,

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cloransulam, diclosulam, florasulam, flumetsulam, metosulam, penoxsulam, or pyroxsulam, agriculturally acceptable salts or esters thereof, or combinations thereof.

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 ammonium cations of the formula:



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

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

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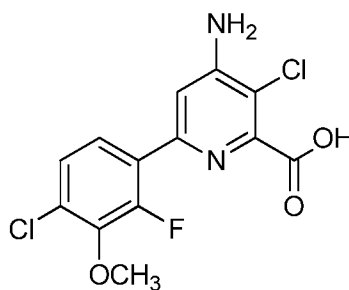
with an appropriate alcohol; by reacting the corresponding acid with an appropriate alcohol in the presence of an acid catalyst or by transesterification.

Weight ratios of mixtures are calculated using the acid equivalent weight(s) of any compounds in the mixture that are salts or esters. Weight ratios are expressed in units of weight to weight (grams (g) to g, grams acid equivalent per hectare (g ae/ha) to g ae/ha, grams acid equivalent per hectare (g ae/ha) to grams active ingredient per hectare (g ai/ha), or grams active ingredient per hectare (g ai/ha) to g ai/ha).

The combination of compound (I) or agriculturally acceptable salt or ester thereof, a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof, and a disruptor herbicide or an agriculturally acceptable salt or ester thereof, may be more effective than the herbicidal active ingredients applied individually.

A. Halauxifen

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)pyridine-2-carboxylic acid and has been described in U.S. Patent 7,314,849 (B2), which is incorporated herein by reference in its entirety. It is also referred to as halauxifen. The methyl ester is known as halauxifen-methyl and is sold commercially as ARYLEX®.

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 arylalkyl or alkyl ester is employed. In certain embodiments, a benzyl, substituted benzyl, or C₁-C₄ alkyl, *e.g.*, methyl or *n*-butyl ester is employed. In certain embodiments, the methyl ester, benzyl ester, or potassium salt is employed.

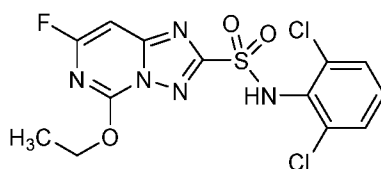
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Exemplary uses of the compound of the formula (I) include controlling undesirable vegetation, including *e.g.*, grass, broadleaf and sedge weeds, in cereal and multiple perennial and non-cropping situations.

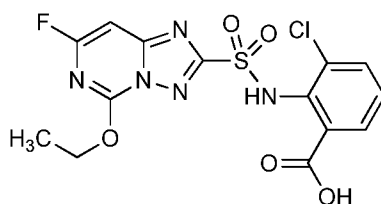
B. Triazolopyrimidine Sulfonamides

Triazolopyrimidine sulfonamides are a chemical class of herbicides having a triazolopyrimidine sulfonamide core structure. Exemplary herbicidal uses of triazolopyrimidine sulfonamides include, but are not limited to, use for control of nuisance sedge, broadleaf and grass weeds.

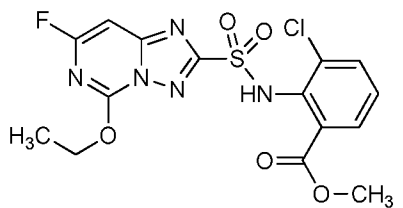
Diclosulam, shown, below, is *N*-(2,6-dichlorophenyl)-5-ethoxy-7-fluoro[1,2,4]triazolo[1,5-*c*]pyrimidine-2-sulfonamide. Its herbicidal activity is exemplified in *The Pesticide Manual*. Exemplary uses of diclosulam include, but are not limited to, broadleaf weed control in peanuts, soybeans and sugar cane.



Cloransulam, shown below, is 3-chloro-2-[[5-ethoxy-7-fluoro[1,2,4]triazolo[1,5-*c*]pyrimidin-2-yl)sulfonyl]amino]benzoic acid.



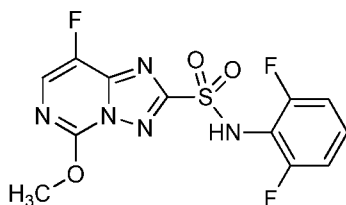
Cloransulam-methyl is methyl 3-chloro-2-[[5-ethoxy-7-fluoro[1,2,4]triazolo[1,5-*c*]pyrimidin-2-yl)sulfonyl]amino]benzoate and has the following structure:



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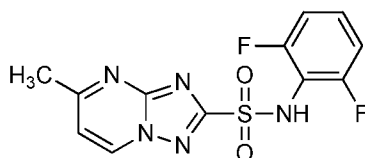
Its herbicidal activity is described in *The Pesticide Manual*. Exemplary uses of cloransulam-methyl include, but are not limited to, post-emergence control of broadleaf weeds in soybeans and other broadleaf crops.

Florasulam, shown below, is *N*-(2,6-difluorophenyl)-8-fluoro-5-methoxy[1,2,4]triazolo[1,5-*c*]pyrimidine-2-sulfonamide and has the following structure:



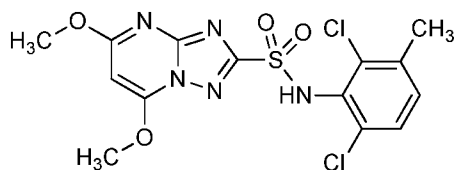
Its herbicidal activity is described in *The Pesticide Manual*. Exemplary uses of florasulam includes, but are not limited to, post-emergence control of broadleaf weeds in cereals and maize.

Flumetsulam, shown below, is *N*-(2,6-difluorophenyl)-5-methyl[1,2,4]triazolo[1,5-*a*]pyrimidine-2-sulfonamide.



Its herbicidal activity is described in *The Pesticide Manual*. Exemplary uses of flumetsulam include, but are not limited to, control of broadleaf weeds and grasses in soybeans, field peas and maize.

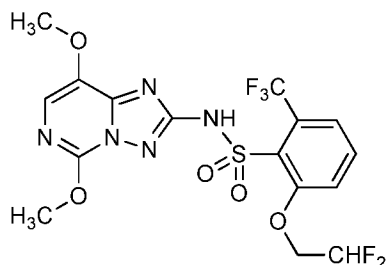
Metosulam, shown below, is *N*-(2,6-dichloro-3-methylphenyl)-5,7-dimethoxy[1,2,4]triazolo[1,5-*a*]pyrimidine-2-sulfonamide.



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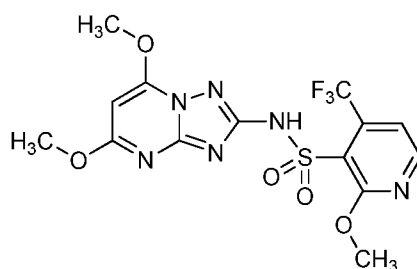
Its herbicidal activity is described in *The Pesticide Manual*. Exemplary uses of metosulam includes, but are not limited to, post-emergence control of broadleaf weeds in wheat, barley and rye, and pre- or post-emergence control of broadleaf weeds in maize.

Penoxsulam, shown below, is 2-(2,2-difluoroethoxy)-*N*-(5,8-dimethoxy[1,2,4]triazolo[1,5-*c*]pyrimidin-2-yl)-6-(trifluoromethyl)benzenesulfonamide.



Its herbicidal activity is described in *The Pesticide Manual*. Exemplary uses of penoxsulam includes, but are not limited to, post-emergence control of *Echinochloa* spp., broadleaf weeds and annual sedge weeds in rice, as well as *Echinochloa* spp. and broadleaf weeds in sorghum, turf, cereals and tree and vine crops. In another example, penoxsulam is used to control aquatic weeds in lakes and ponds.

Pyroxsulam, shown below, is *N*-(5,7-dimethoxy[1,2,4]triazolo[1,5-*a*]pyrimidin-2-yl)-2-methoxy-4-(trifluoromethyl)-3-pyridinesulfonamide.



Its herbicidal activity is described in *The Pesticide Manual*. Exemplary uses of pyroxsulam include, but are not limited to, broad spectrum post-emergence control of annual grass and broadleaf weeds in cereals.

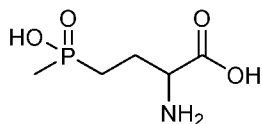
C. Cell membrane Disruptor Herbicides

As used herein, cell membrane disruptor herbicides show burning or yellowing of plant tissues and include cell membrane disruptor herbicides and phosphorylated amino acid disruptor herbicides. In some embodiments, the phosphorylated amino acid disruptor

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herbicide includes glufosinate or an agriculturally acceptable salt thereof. In another embodiment, the cell membrane disruptor herbicides include herbicides that act by the photosystem I (PS I) mode of action and those that act by the protoporphyrinogen oxidase (PPO) mode of action. In another embodiment, the herbicides that act by the photosystem I (PS I) mode of action include diquat and paraquat, and agriculturally acceptable salts thereof, and combinations thereof. In yet another embodiment, the PPO mode of action herbicides include acifluorfen, bifenox, chlomethoxyfen, fluoroglycofen, fomesafen, halosafen, lactofen, oxyfluorfen, fluazolate, pyraflufen, cinidon, flumioxazin, flumiclorac, fluthiacet, thidiazimin, oxadiazon, oxadiargyl, azafenidin, sulfentrazone, pentoxazone, trifludimoxazin, benzfendazole, butafenacil, saflufenacil, pyraclonil, proflumazone, flufenpyr, and agriculturally acceptable salts and esters thereof, and combinations thereof. In some embodiments, the PPO inhibitor is not carfentrazone or a salt or ester thereof.

Glufosinate (also known as phosphinothricin) is a broad-spectrum contact herbicide with little systemic action. It irreversibly inhibits glutamine synthetase, an enzyme necessary for the production of glutamine and for ammonia detoxification. Application of glufosinate to plants leads to reduced glutamine and elevated ammonia levels in tissues, halting photosynthesis, resulting in plant death. Glufosinate has the following structure:



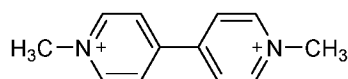
Glufosinate can be used as the free acid, inorganic salts, such as sodium and potassium salts, and organic salts, such as those formed by the reaction of ammonia or primary, secondary, or tertiary amines.

Glufosinate is a broad-spectrum herbicide that is used to control important weeds such as morning glories, hemp sesbania (*Sesbania bispinosa*), Pennsylvania smartweed (*Polygonum pennsylvanicum*) and yellow nutsedge similar to glyphosate. It is typically applied to young plants during early development for full effectiveness. It is sold in formulations under brands including Basta, Rely, Finale, Challenge and Liberty.

Glufosinate can be used as directed sprays for weed control, including in genetically modified crops, as well as for use in crop desiccation to facilitate harvest of the crop. Glufosinate also has shown to provide some protection against various plant diseases, as it also acts to kill fungi and bacteria on contact.

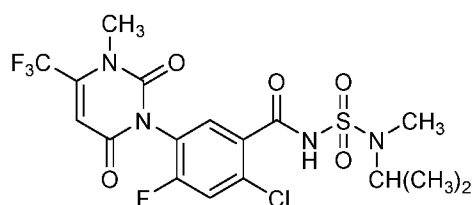
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Paraquat, 1,1'-dimethyl-4,4'-bipyridinediium or 1,1'-dimethyl-4,4'-bipyridylium, is a non-selective contact herbicide, with some translocation in the xylem. Paraquat, which has the following structure:



is used for broad-spectrum control of broadleaf weeds and grasses in a variety of crops; for general weed control on non-crop land; as a defoliant for cotton and hops; for destruction of potato haulms; as a desiccant for pineapples, sugar cane, soybeans and sunflowers; for strawberry runner control; and in pasture renovation. Paraquat dichloride is commercialized in an aqueous solution.

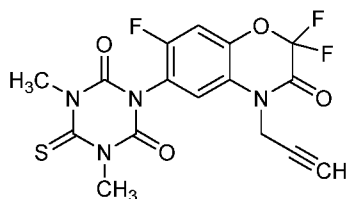
Saflufenacil, 2-chloro-5-[3,6-dihydro-3-methyl-2,6-dioxo-4-(trifluoromethyl)-1(2*H*)-pyrimidinyl]-4-fluoro-*N*-[[methyl(1-methylethyl)amino]sulfonyl]benzamide, is a foliar contact and residual broadleaf weed herbicide. Saflufenacil, which has the following structure:



is used for foliar and residual control of broadleaf weeds, including resistant biotypes. It is absorbed by the foliage and roots, with translocation in the apoplast and limited movement in the phloem. Saflufenacil is applied pre-emergence in corn and sorghum, at 50–125 g/ha; pre-plant for rapid foliar burn-down in soybeans, cereals, cotton, legumes, and post-directed in tree fruit and nuts, at 18–25 g/ha. Saflufenacil's mode of action is to inhibit protoporphyrinogen oxidase (PPO).

Saflufenacil is sold commercially under a number of names – Heat, Sharpen, Treevix, and Eragon (BASF Corporation).

Other examples of PPO inhibitors include those described in US Patent No. 8,754,008 (B2), such as trifludimoxazin, which has the following structure:



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III. Tank Mixes, PreMixes and Co-Packs

Tank mixes, premixes and co-packs containing the compound of formula (I) or a salt or ester thereof, a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof, and a disruptor herbicide or an agriculturally acceptable salt or ester thereof are described herein. In some embodiments, the tank mix is prepared by mixing a premix of the compound of formula (I) or a salt or ester thereof and a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof with a concentrate containing a disruptor herbicide or an agriculturally acceptable salt or ester thereof. In some embodiments, (b) includes, but is not limited to, cloransulam, diclosulam, florasulam, flumetsulam, metosulam, penoxsulam, or pyroxsulam, agriculturally acceptable salts or esters thereof, or combinations thereof. In some embodiments, (c) includes glufosinate or an agriculturally acceptable salt thereof. In some embodiments, (c) includes diquat or paraquat, or agriculturally acceptable salts thereof. In some embodiments, (c) includes, but is not limited to, acifluorfen, bifenox, chlomethoxyfen, fluoroglycofen, fomesafen, halosafen, lactofen, oxyfluorfen, fluazolate, pyraflufen, cinidon, flumioxazin, flumiclorac, fluthiacet, thidiazimin, oxadiazon, oxadiargyl, azafenidin, sulfentrazone, pentoxazone, trifludimoxazin, benzfendizone, butafenacil, saflufenacil, pyraclonil, proflumizole, flufenpyr, or agriculturally acceptable salts or esters thereof. In other embodiments, the tank mix is prepared by mixing the compound of formula (I) or a salt or ester thereof and a disruptor herbicide or an agriculturally acceptable salt or ester thereof with a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof. In still other embodiments, the premix or co-pack contains all three active ingredients which is diluted prior to use/application. The premix or suitable premixes can contain one or more suitable adjuvants and/or carriers.

In some embodiments, compositions provided herein contain 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 premix or tank-mixed.

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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; C₉-C₁₁ alkylpolyglycoside; phosphated alcohol ethoxylate; natural primary alcohol (C₁₂-C₁₆) ethoxylate; di-*sec*-butylphenol EO-PO block copolymer; polysiloxane-methyl cap; nonylphenol ethoxylate + urea ammonium nitrate; emulsified methylated seed oil; tridecyl alcohol (synthetic) ethoxylate (8EO); tallow amine ethoxylate (15 EO); PEG(400) dioleate-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

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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 Corporation: Ridgewood, NJ, 1998 and in *Encyclopedia of Surfactants, Vol. I-III*, Chemical Publishing Company: New York, 1980-81. Surface-active agents include, but are not limited to salts of alkyl sulfates, such as diethanolammonium lauryl sulfate; alkylarylsulfonate salts, such as calcium dodecylbenzenesulfonate; alkylphenol-alkylene oxide addition products, such as nonylphenol-C₁₈ ethoxylate; alcohol-alkylene oxide addition products, such as tridecyl alcohol-C₁₆ ethoxylate; soaps, such as sodium stearate; alkyl-naphthalene-sulfonate salts, such as sodium dibutyl-naphthalenesulfonate; dialkyl esters of sulfosuccinate salts, such as sodium di(2-ethylhexyl) sulfosuccinate; sorbitol esters, such as sorbitol oleate; quaternary amines, such as lauryl trimethylammonium chloride; polyethylene glycol esters of fatty acids, such as polyethylene glycol stearate; block copolymers of 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.

The tank mixes described herein can further contain one or more additional herbicides. The herbicides can be incorporated into the one or more of the premixes, tank mixes or concentrates or can be added at the time the tank mix is prepared by formulation or prior to application. 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

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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, acetonifene, acrolein, alachlor, allidochlor, alloxydim, allyl alcohol, alorac, ametrifone, ametryn, amibuzin, amicarbazone, amidosulfuron, aminocyclopyrachlor, aminopyralid, amiprofos-methyl, amitrole, ammonium sulfamate, anilofos, anisuron, asulam, atraton, atrazine, azimsulfuron, aziprotryne, barban, BCPC, beflubutamid, benazolin, bencarbazone, benfluralin, benfuresate, bensulfuron-methyl, bensulide, benthicarb, bentazon-sodium, benzadox, benzipram, benzobicyclon, benzofenap, benzofluor, benzoylprop, benzthiazuron, bicyclopyrone, bilanafos, bispyribac-sodium, borax, bromacil, bromobonil, bromobutide, bromofenoxim, bromoxynil, brompyrazon, butachlor, butamifos, butenachlor, buthidazole, buthiuron, butralin, butroxydim, buturon, butylate, cacodylic acid, cafenstrole, calcium chlorate, calcium cyanamide, cambendichlor, carbasulam, carbetamide, carboxazole, chlorprocarb, CDEA, CEPC, chloramben, chloranocryl, chlorazifop, chlorazine, chlorbromuron, chlorbufam, chloreturon, chlorfenac, chlorfenprop, chlorflurazole, chlorflurenol, chloridazon, chlorimuron, chlornitrofen, chloropon, chlorotoluron, chloroxuron, chloroxynil, chlorpropham, chlorsulfuron, chlorthal, chlorthiamid, cinmethylin, cinosulfuron, cisanilide, clacyfos, clethodim, clidinate, clodinafop-propargyl, clofop, clomazone, clomeprop, cloprop, cloproxydim, clocyralid, CMA, copper sulfate, CPMF, CPPC, credazine, cresol, cumyluron, cyanatryne, 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, 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, eglinazone, endothal, epronaz, EPTC, erbon, esprocarb, ethalfluralin, ethbenzamide, ethametsulfuron, ethidimuron, ethiolate, ethobenzanid, ethofumesate, ethoxyfen, ethoxysulfuron, etinofen, etniproamid, etobenzanid, EXD, fenasulam, fenoprop, fenoxaprop, fenoxaprop-P-ethyl, fenoxaprop-P-ethyl + isoxadifen-ethyl, fenoxasulfone, fenquinotrione, fenteracol, fenthiaprop, fentrazamide, fenuron, ferrous sulfate, flamprop, flamprop-M,

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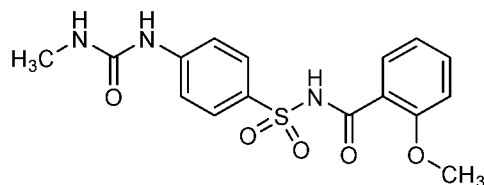
flazasulfuron, florpyrauxifen, fluazifop, fluazifop-P-butyl, flucarbazone, flucetosulfuron, fluchloralin, flufenacet, flufenican, flumezin, flumipropyn, fluometuron, fluorodifen, fluoromidine, fluoronitrofen, fluothiuron, flupoxam, flupropacil, flupropanate, flupyrsulfuron, fluridone, flurochloridone, fluroxypyr, flurtamone, foramsulfuron, fosamine, fumiclorac, furyloxyfen, glyphosate, halosulfuron-methyl, haloxydine, haloxyfop-methyl, haloxyfop-P-methyl, hexachloroacetone, hexaflurate, hexazinone, imazamethabenz, imazamox, imazapic, imazapyr, imazaquin, imazethapyr, imazosulfuron, 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, lancotrione, 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, methyl dymron, metobenzuron, metobromuron, metolachlor, metoxuron, metribuzin, metsulfuron, metsulfuron-methyl, molinate, monalide, monisouron, monochloroacetic acid, monolinuron, monuron, morfamquat, MSMA, naproanilide, napropamide, napropamide-M, naptalam, neburon, nicosulfuron, nipyraclufen, nitralin, nitrofen, nitrofluorfen, norflurazon, noruron, OCH, orbencarb, *ortho*-dichlorobenzene, orthosulfamuron, oryzalin, oxapyrazon, oxasulfuron, oxaziclomefone, paraflufen-ethyl, parafluron, paraquat, pebulate, pelargonic acid, pendimethalin, pentachlorophenol, pentanochlor, 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, pyrasulfotole, pyrazogyl, pyrazolynate, pyrazosulfuron-ethyl, pyrazoxyfen, pyribenzoxim, pyributicarb, pyriclor, pyridafol, pyridate, pyriftalid, pyriminobac, pyrimisulfan, pyriothiobac-sodium, pyroxasulfone, quinclorac, quinmerac, quinoxamine, quinonamid, quizalofop, quizalofop-P-ethyl, rhodethanil, rimsulfuron, S-metolachlor, sebuthylazine, secbumeton, sethoxydim,

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siduron, simazine, simeton, simetryn, SMA, sodium arsenite, sodium azide, sodium chlorate, sulcotrione, sulfallate, sulfometuron, sulfosate, sulfosulfuron, sulfuric acid, sulglycapin, swep, TCA, tebutam, tebuthiuron, tefuryltrione, tembotrione, tepraloxydim, terbacil, terbucarb, terbuchlor, terbumeton, terbuthylazine, terbutryn, tetrafluron, thenylchlor, thiazafluron, thiazopyr, thidiazuron, thiencarbazone-methyl, thifensulfuron, thifensulfuron-methyl, thiobencarb, tiafenacil, tiocarbazil, tioclorim, tolpypalate, 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, choline salts, esters, optically active isomers and mixtures thereof.

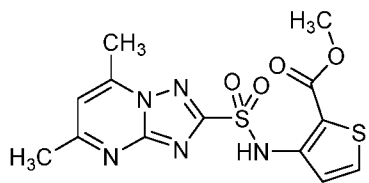
In some embodiments, the compositions described herein are employed in combination with one or more herbicide safeners, such as AD-67 (MON 4660), benoxacor, benthicarb, brassinolide, cloquintocet (mexyl), cyometrinil, cyprosulfamide, daimuron, dichlormid, dicyclonon, dimepiperate, disulfoton, fenchlorazole-ethyl, 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 soybean, cotton, sunflower, rice, canola, oilseed rape, cereals (including but not limited to wheat, barley, oats and rye), sorghum, corn or maize settings.

In some embodiments, the compositions and methods described herein can be used in combination with one or more seed treatments known to be employed in the safening of rice and compounds of formula (I), including naphthalic anhydride and CAS registry number 129531-12-0 (*N*-(2-methoxybenzoyl)-4-[(methylaminocarbonyl)amino]benzenesulfonamide), which has the following structure,



and CAS registry number 98967-94-3 (methyl 3-((5,7-dimethyl-[1,2,4]triazolo[1,5-*a*]pyrimidine)-2-sulfonamido)thiophene-2-carboxylate), which has the following structure,

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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 methods provided herein are used to control undesirable vegetation in crops that are tolerant to glyphosate, glufosinate, dicamba, phenoxy auxins, pyridyloxy auxins, aryloxyphenoxypropionates, acetyl CoA carboxylase (ACCase) inhibitors, imidazolinones, acetolactate synthase (ALS) inhibitors, 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitors, protoporphyrinogen oxidase (PPO) inhibitors, triazines, or bromoxynil. Such herbicide tolerant crops may possess multiple or stacked traits conferring tolerance to multiple herbicides or multiple modes of action.

In some embodiments the methods provided herein are used to control undesirable vegetation that is a herbicide resistant or tolerant weed. Such herbicide resistant or tolerant weed may have a biotype with resistance or tolerance to single or multiple herbicides, single or multiple chemical classes, or single or multiple herbicide modes of action. For example, the herbicide resistant or tolerant weed may have a biotype resistant or tolerant to acetolactate synthase (ALS) inhibitors, photosystem II inhibitors, acetyl CoA carboxylase (ACCase) inhibitors, synthetic auxins, phenoxy auxins, pyridyloxy auxins, photosystem I inhibitors, 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase inhibitors, microtubule assembly inhibitors, 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.

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 embodiments about 0.5 to

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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 0.0003 to 10.0 weight percent active ingredient and in certain embodiments contain about 0.0008 to 5.0 weight percent.

IV. Methods of Use

Herbicidal activity (control of undesirable vegetation in a crop or non-crop situation) is exhibited by the herbicidal compositions when they are applied directly to the plant or to the locus of the plant at any stage of growth, or to the area where control of vegetation is desired. 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 to the crop and undesirable vegetation, pre-emergence application to the crop and post-emergence to the undesirable vegetation, and as multiple post-emergence applications 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 soybean, cotton, sunflower, winter/spring oilseed rape, winter/spring canola, vegetables, ornamentals, rice, wheat, teff, triticale, barley, oats, rye, sorghum, corn/maize, sunflower, row crops, pastures, grasslands, rangelands, fallowland, sugarcane, turf, tree and vine orchards, aquatics, forestry, industrial vegetation management (IVM) and rights-of-way. In some embodiments, the compositions are used in the burndown and control of weeds in fallow fields and fallow beds between the planting of crops, such as soybean, corn, cotton, sunflower, cereals, rice, winter/spring oilseed rape, winter/spring canola, corn/maize and sorghum. In other embodiments, the compositions are used to control weeds just prior to or after planting soybeans.

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 soybean, cotton, oilseed rape, peanuts, canola, vegetables, ornamentals, rice, wheat, teff, triticale, barley, oats, rye, sorghum, corn/maize, sunflower, winter/spring oilseed rape,

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winter/spring canola, row crops, pastures, grasslands, rangelands, fallowland, fallow bed, sugarcane, turf, tree and vine orchards, forestry, IVM and rights-of-way.

In some embodiments, the methods provided herein are utilized to control undesirable vegetation in fallow fields and fallow beds between crops, before planting soybean, cotton, corn/maize, sunflower, oilseed rape, canola, drilled crops and cereal crops, and after planting tolerant crops such as soybeans and other row crops. 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), *Lolium rigidum* (rigid ryegrass, LOLRI), *Lolium multiflorum subsp. Gaudini* (annual ryegrass, LOLMG), *Phalaris minor* Retz. (littleseed canarygrass, PHAMI), *Poa annua* L. (annual bluegrass, POAAN), *Setaria pumila* (Poir.) Roemer & J.A. Schultes (yellow foxtail, SETLU), *Setaria viridis* (L.) Beauv. (green foxtail, SETVI), *Cirsium arvense* (L.) Scop. (Canada thistle, CIRAR), *Commelina benghalensis* L. (tropical spiderwort, COMBE), *Conyza canadensis* (horseweed/marestail, ERICA), *Conyza bonariensis* (fleabane, ERIBO), *Echinochloa crus-galli* (L.) P. Beauv. (barnyardgrass, ECHCG), *Euphorbia heterophylla* L. (wild poinsettia, EPHHL), *Conyza* species (fleabane, ERISS), *Conyza sumatrensis* (Guernsey fleabane, ERISU), *Ipomoea grandifolia* (Corda-de-viola, IAQGR), *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), *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 compositions and methods provided herein are utilized to control undesirable vegetation in fallow fields and fallow beds between crops or before planting in rice. In certain embodiments, the undesirable vegetation is *Brachiaria platyphylla* (Groseb.) Nash (broadleaf signalgrass, BRAPP), *Digitaria sanguinalis* (L.) Scop. (large crabgrass, DIGSA), *Echinochloa crus-galli* (L.) P. Beauv. (barnyardgrass, ECHCG), *Echinochloa colonum* (L.) LINK (junglerice, ECHCO), *Echinochloa oryzoides* (Ard.) Fritsch (early watergrass, ECHOR), *Echinochloa oryzicola* (Vasinger) Vasinger (late watergrass, ECHPH), *Conyza* species (fleabane, ERISS), *Ischaemum rugosum* Salisb. (saramollagrass,

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ISCRU), *Leptochloa chinensis* (L.) Nees (Chinese sprangletop, LEFCH), *Leptochloa fascicularis* (Lam.) Gray (bearded sprangletop, LEFFA), *Leptochloa panicoides* (Presl.) Hitchc. (Amazon sprangletop, LEFPA), *Panicum dichotomiflorum* (L.) Michx. (Fall panicum, PANDI), *Paspalum dilatatum* Poir. (dallisgrass, PASDI), *Cyperus difformis* L. (smallflower flatsedge, CYPDI), *Cyperus esculentus* L. (yellow nutsedge, CYPES), *Cyperus iria* L. (rice flatsedge, CYPRI), *Cyperus rotundus* L. (purple nutsedge, CYPRO), *Eleocharis* species (ELOSS), *Fimbristylis miliacea* (L.) Vahl (globe fringerush, FIMMI), *Schoenoplectus juncooides* Roxb. (Japanese bulrush, SPCJU), *Schoenoplectus maritimus* L. (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), *Eclipta alba* (L.) Hassk. (American false daisy, ECLAL), *Heteranthera limosa* (SW.) Willd./Vahl (ducksalad, HETLI), *Heteranthera reniformis* R. & P. (roundleaf mudplantain, HETRE), *Ipomoea hederacea* (L.) Jacq. (ivy leaf morningglory, IPOHE), *Lindernia dubia* (L.) Pennell (low false pimpernel, LIDDU), *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. (lady thumb, POLPE), *Polygonum hydropiperoides* Michx. (mild smartweed, POLHP), *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 compositions and methods provided herein are utilized to control undesirable vegetation in fallow fields and fallow beds between crops or before planting range and pasture and forestry. 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), *Commelina benghalensis* L. (tropical spiderwort, COMBE), *Conyza canadensis* (horseweed/marestail, ERICA), *Conyza bonariensis* (fleabane, ERIBO), *Echinochloa crus-galli* (L.) P. Beauv. (barnyardgrass, ECHCG), *Euphorbia heterophylla* L. (wild poinsettia, EPHHL), *Conyza* species (fleabane, ERISS), *Conyza sumatrensis* (Guernsey fleabane, ERISU), *Ipomoea grandifolia* (Corda-de-

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viola, IAQGR), *Convolvulus arvensis* L. (field bindweed, CONAR), *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 compositions and methods provided herein are utilized to control undesirable vegetation in fallow fields and fallow beds between crops, before planting crops, or within row crops and vegetable crops. In certain embodiments, the undesirable vegetation is *Alopecurus myosuroides* Huds. (blackgrass, ALOMY), *Avena fatua* L. (wild oat, AVEFA), *Brachiaria platyphylla* (Groseb.) Nash (broadleaf signalgrass, BRAPP), *Commelina benghalensis* L. (tropical spiderwort, COMBE), *Conyza* species (fleabane, ERISS), *Conyza sumatrensis* (Guernsey fleabane, ERISU), *Ipomoea grandifolia* (Corda-de-viola, IAQGR), *Digitaria sanguinalis* (L.) Scop. (large crabgrass, DIGSA), *Echinochloa crus-galli* (L.) P. Beauv. (barnyardgrass, ECHCG), *Echinochloa colonum* (L.) Link (junglerice, ECHCO), *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), *Asclepias syriaca* L. (common milkweed, ASCSY), *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), *Erigeron bonariensis* L. (hairy fleabane, ERIBO), *Erigeron canadensis* L. (Canadian fleabane, ERICA), *Helianthus annuus* L. (common sunflower, HELAN), *Jacquemontia tamnifolia* (L.) Griseb. (smallflower morningglory, IAQTA), *Ipomoea hederacea* (L.) Jacq. (ivy-leaf morningglory, IPOHE), *Ipomoea lacunosa* L. (white morningglory, IPOLA),

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Lactuca serriola L./Torn. (prickly lettuce, LACSE), *Portulaca oleracea* L. (common purslane, POROL), *Sida spinosa* L. (prickly sida, SIDSP), *Sinapis arvensis* L. (wild mustard, SINAR), *Solanum ptychanthum* Dunal (eastern black nightshade, SOLPT), or *Xanthium strumarium* L. (common cocklebur, XANST).

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 of the compositions and methods described herein, the compound of formula (I) or salt or ester thereof is used in combination with a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof and a phosphorylated amino acid disruptor herbicide or an agriculturally acceptable salt or ester thereof. With regard to the compositions, in some embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to a triazolopyrimidine sulfonamide herbicide or a salt or ester to a phosphorylated amino acid disruptor herbicide or an agriculturally acceptable salt or ester thereof is within the range from about 2:1:200 to about 1:2:67. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof to a phosphorylated amino acid disruptor herbicide or an agriculturally acceptable salt or ester thereof is within the range from about 2:1:75 to 1:2.67:56. In certain embodiments, the compositions provided herein contain the methyl ester of the compound of formula (I). In one embodiment, the composition contains the methyl ester of the compound of formula (I), a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof and a phosphorylated amino acid disruptor herbicide or an agriculturally acceptable salt or ester thereof wherein the weight ratio of the compound of formula (I) to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof to a phosphorylated amino acid disruptor herbicide or an agriculturally acceptable salt or ester thereof is from about 1.67:1:33 to 1:3.75:20. In one embodiment, the composition contains the methyl ester of the compound of formula (I), a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof and a phosphorylated amino acid disruptor herbicide or an agriculturally acceptable salt or ester thereof wherein the weight ratio of the methyl ester of the compound of formula (I) to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is from about 1:200 to about 200:1. In one embodiment, the composition contains the methyl ester of the compound of formula (I), a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof and a phosphorylated amino acid disruptor herbicide or an agriculturally acceptable salt or ester thereof wherein the weight ratio of the methyl ester of the compound

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of formula (I) to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is from about 1:40 to about 30:1. In another embodiment, the composition contains the methyl ester of the compound of formula (I), a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof and a phosphorylated amino acid disruptor herbicide or an agriculturally acceptable salt or ester thereof wherein the weight ratio of the methyl ester of the compound of formula (I) to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is from about 1:15 to about 10:1.

In certain embodiments of the compositions and methods described herein, the compound of formula (I) or salt or ester thereof plus a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is used in combination with a phosphorylated amino acid disruptor herbicide or an agriculturally acceptable salt or ester thereof. With regard to the compositions, in some embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof plus a triazolopyrimidine sulfonamide herbicide or a salt or ester to a phosphorylated amino acid disruptor herbicide or an agriculturally acceptable salt or ester thereof is within the range from about 1:4480 to about 3:1. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof plus a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof to a phosphorylated amino acid disruptor herbicide or an agriculturally acceptable salt or ester thereof is within the range from about 1:560 to 1.5:1. In certain embodiments, the compositions provided herein contain the methyl ester of the compound of formula (I). In one embodiment, the composition contains the methyl ester of the compound of formula (I) plus a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof and a phosphorylated amino acid disruptor herbicide or an agriculturally acceptable salt or ester thereof wherein the weight ratio of the compound of formula (I) to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof to a phosphorylated amino acid disruptor herbicide or an agriculturally acceptable salt or ester thereof is from about 1:57 to 0.95:1. In one embodiment, the composition contains the methyl ester of the compound of formula (I) plus a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof and a phosphorylated amino acid disruptor herbicide or an agriculturally acceptable salt or ester thereof wherein the weight ratio of the methyl ester of the compound of formula (I) to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is from about 1:200 to about 200:1. In one embodiment, the composition contains the methyl ester of the compound of formula (I) plus a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof and a phosphorylated amino acid disruptor herbicide or an agriculturally acceptable

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salt or ester thereof wherein the weight ratio of the methyl ester of the compound of formula (I) to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is from about 1:40 to about 30:1. In another embodiment, the composition contains the methyl ester of the compound of formula (I) plus a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof and a phosphorylated amino acid disruptor herbicide or an agriculturally acceptable salt or ester thereof wherein the weight ratio of the methyl ester of the compound of formula (I) to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is from about 1:15 to about 10:1.

With respect to the methods, in certain embodiments, the methods include 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 from about 50 grams active ingredient per hectare (g ai/ha) to about 3510 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 from about 78 g ai/ha to about 1790 g ai/ha based on the total amount of active ingredients in the composition. In other embodiments, the composition is applied at an application rate from about 107 g ai/ha to about 495 g ai/ha based on the total amount of active ingredients in the composition.

In some embodiments, the methods include 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, a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof, and a phosphorylated amino acid cell membrane disruptor herbicide or an agriculturally acceptable salt or ester thereof *e.g.*, sequentially or simultaneously. In some embodiments, the triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is applied at a rate from about 0.25 g ai/ha to about 100 g ai/ha, the compound of formula (I) or salt or ester thereof is applied at a rate from about 0.5 grams acid equivalent per hectare (g ae/ha) to about 50 g ae/ha, and the phosphorylated amino acid cell membrane disruptor herbicide or an agriculturally acceptable salt or ester thereof is applied at a rate from about 50 g ai/ha to about 3360 g ai/ha. In some embodiments, the triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is applied at a rate from about 1 g ai/ha to about 80 g ai/ha, the compound of formula (I) or salt or ester thereof is applied at a rate from about 2 g ae/ha to about 30 g ae/ha, and the phosphorylated amino acid cell membrane disruptor herbicide or an agriculturally acceptable salt or ester thereof is

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applied at a rate from about 75 g ai/ha to about 1680 g ai/ha. In certain embodiments, the methods utilize the compound of formula (I), or its methyl ester, a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof, and a phosphorylated amino acid cell membrane disruptor herbicide or an agriculturally acceptable salt or ester thereof. In one embodiment, the methods utilize the methyl ester of the compound of formula (I), a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof and a phosphorylated amino acid cell membrane disruptor herbicide or an agriculturally acceptable salt or ester thereof, wherein the methyl ester of the compound of formula (I) is applied at a rate from about 5 g ae/ha to about 20 g ae/ha, a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is applied at a rate from about 3 g ai/ha to about 75 g ai/ha, and a phosphorylated amino acid cell membrane disruptor herbicide or an agriculturally acceptable salt or ester thereof is applied at a rate from about 100 g ai/ha to about 400 g ai/ha.

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 diclosulam and glufosinate. With regard to the compositions, in some embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to diclosulam to glufosinate is within the range from about 1:5:100 to about 1:2:67. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to diclosulam is within the range from about 1:200 to about 20:1. In certain embodiments, the compositions provided herein contain the methyl ester of the compound of formula (I), diclosulam, and glufosinate. In one embodiment, the composition comprises the methyl ester of the compound of formula (I), diclosulam, and glufosinate wherein the weight ratio of the compound of formula (I) to diclosulam to glufosinate is from about 1:2.5:37.5 to about 1:2:56. In one embodiment, the composition comprises the methyl ester of the compound of formula (I), diclosulam, and glufosinate, wherein the weight ratio of the methyl ester of the compound of formula (I) to diclosulam is from about 1:30 to about 6:1. In one embodiment, the composition contains the methyl ester of the compound of formula (I), diclosulam, and glufosinate wherein the weight ratio of the methyl ester of the compound of formula (I) to diclosulam to glufosinate is from about 1:2:20 to about 1:1.5:20. In one embodiment, the composition contains the methyl ester of the compound of formula (I), diclosulam, and glufosinate wherein the weight ratio of the methyl ester of the compound of formula (I) to diclosulam is from about 1:6 to about 2:1.

In certain embodiments of the compositions and methods described herein, the compound of formula (I) or salt or ester thereof plus diclosulam is used in combination with

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glufosinate. With regard to the compositions, in some embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof plus diclosulam to glufosinate is within the range from about 1:1120 to about 3:1. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to diclosulam is within the range from about 1:200 to about 20:1. In certain embodiments, the compositions provided herein contain the methyl ester of the compound of formula (I), diclosulam, and glufosinate. In one embodiment, the composition comprises the methyl ester of the compound of formula (I) plus diclosulam and glufosinate wherein the weight ratio of the compound of formula (I) plus diclosulam to glufosinate is from about 1:240 to about 1.2:1. In one embodiment, the composition comprises the methyl ester of the compound of formula (I) plus diclosulam and glufosinate, wherein the weight ratio of the methyl ester of the compound of formula (I) to diclosulam is from about 1:30 to about 6:1. In one embodiment, the composition contains the methyl ester of the compound of formula (I), diclosulam, and glufosinate wherein the weight ratio of the methyl ester of the compound of formula (I) plus diclosulam to glufosinate is from about 1:26.7 to about 0.5:1. In one embodiment, the composition contains the methyl ester of the compound of formula (I), diclosulam, and glufosinate wherein the weight ratio of the methyl ester of the compound of formula (I) to diclosulam is from about 1:6 to about 2:1.

With respect to the methods, in certain embodiments, the methods include 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 from about 53 grams active ingredient per hectare (g ai/ha) to about 3510 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 from about 82 g ai/ha to about 1770 g ai/ha based on the total amount of active ingredients in the composition. In other embodiments, the composition is applied at an application rate from about 115 g ai/ha to about 450 g ai/ha based on the total amount of active ingredients in the composition.

In some embodiments, the methods include 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, diclosulam, and glufosinate *e.g.*, sequentially or simultaneously. In some embodiments, the diclosulam is applied at a rate from about 2.5 g ai/ha to about 100 g ai/ha and the compound of formula (I) or salt or ester thereof is applied at a rate from about 0.5 grams acid equivalent per hectare (g

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ae/ha) to about 50 g ae/ha and the glufosinate is applied at a rate from about 50 g ai/ha to 3360 g ai/ha. In some embodiments, the diclosulam is applied at a rate from about 5 g ai/ha to about 60 g ai/ha, the compound of formula (I) or salt or ester thereof is applied at a rate from about 2 g ae/ha to about 30 g ae/ha, and the glufosinate is applied at a rate from about 75 g ai/ha to about 1680 g ai/ha. In certain embodiments, the methods utilize the compound of formula (I) or its methyl ester and diclosulam. In one embodiment, the methods utilize the methyl ester of the compound of formula (I), diclosulam, and glufosinate, wherein the methyl ester of the compound of formula (I) is applied at a rate from about 10 g ae/ha to about 30 g ae/ha, diclosulam is applied at a rate from about 5 g ai/ha to about 20 g ai/ha, and the glufosinate is applied at a rate from about 100 g ai/ha to about 400 g ai/ha.

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 a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof and a photosystem I (PS I) inhibitor herbicide or an agriculturally acceptable 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 a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof to a photosystem I (PS I) inhibitor herbicide or an agriculturally acceptable salt thereof is within the range from about 2:1:80 to about 1:2:45. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is within the range from about 1:200 to about 200:1. In certain embodiments, the compositions provided herein contain the methyl ester of the compound of formula (I), a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof, and a photosystem I (PS I) inhibitor herbicide or an agriculturally acceptable salt thereof. In one embodiment, the composition comprises the methyl ester of the compound of formula (I), a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof, and a photosystem I (PS I) inhibitor herbicide or an agriculturally acceptable salt thereof wherein the weight ratio of the compound of formula (I) to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof to a photosystem I (PS I) inhibitor herbicide or an agriculturally acceptable salt thereof is from about 2:1:60 to about 1:2.67:60. In one embodiment, the composition comprises the methyl ester of the compound of formula (I), a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof, and a photosystem I (PS I) inhibitor herbicide or an agriculturally acceptable salt thereof, wherein the weight ratio of the methyl ester of the compound of formula (I) to a triazolopyrimidine sulfonamide herbicide or a salt or ester

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thereof is from about 1:40 to about 30:1. In one embodiment, the composition contains the methyl ester of the compound of formula (I), a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof, and a photosystem I (PS I) inhibitor herbicide or an agriculturally acceptable salt thereof wherein the weight ratio of the methyl ester of the compound of formula (I) to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof to a photosystem I (PS I) inhibitor herbicide or an agriculturally acceptable salt thereof is from about 1.67:1.33 to about 1:3.75:45. In one embodiment, the composition contains the methyl ester of the compound of formula (I), a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof, and a photosystem I (PS I) inhibitor herbicide or an agriculturally acceptable salt thereof wherein the weight ratio of the methyl ester of the compound of formula (I) to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is from about 1:15 to about 10:1.

In certain embodiments of the compositions and methods described herein, the compound of formula (I) or salt or ester thereof plus a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is used in combination with a photosystem I (PS I) inhibitor herbicide or an agriculturally acceptable salt thereof. With regard to the compositions, in some embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof plus a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof to a photosystem I (PS I) inhibitor herbicide or an agriculturally acceptable salt thereof is within the range from about 1:2987 to about 7.5:1. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is within the range from about 1:200 to about 200:1. In certain embodiments, the compositions provided herein contain the methyl ester of the compound of formula (I) plus a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof and a photosystem I (PS I) inhibitor herbicide or an agriculturally acceptable salt thereof. In one embodiment, the composition comprises the methyl ester of the compound of formula (I) plus a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof and a photosystem I (PS I) inhibitor herbicide or an agriculturally acceptable salt thereof wherein the weight ratio of the compound of formula (I) plus a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof to a photosystem I (PS I) inhibitor herbicide or an agriculturally acceptable salt thereof is from about 1:600 to about 1.83:1. In one embodiment, the composition comprises the methyl ester of the compound of formula (I) plus a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof, and a photosystem I (PS I) inhibitor herbicide or an

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agriculturally acceptable salt thereof, wherein the weight ratio of the methyl ester of the compound of formula (I) to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is from about 1:40 to about 30:1. In one embodiment, the composition contains the methyl ester of the compound of formula (I) plus a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof, and a photosystem I (PS I) inhibitor herbicide or an agriculturally acceptable salt thereof wherein the weight ratio of the methyl ester of the compound of formula (I) plus a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof to a photosystem I (PS I) inhibitor herbicide or an agriculturally acceptable salt thereof is from about 1:128 to about 0.95:1. In one embodiment, the composition contains the methyl ester of the compound of formula (I), a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof, and a photosystem I (PS I) inhibitor herbicide or an agriculturally acceptable salt thereof wherein the weight ratio of the methyl ester of the compound of formula (I) to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is from about 1:15 to about 10:1.

With respect to the methods, in certain embodiments, the methods include 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 from about 20 grams active ingredient per hectare (g ai/ha) to about 2390 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 from about 63 g ai/ha to about 1910 g ai/ha based on the total amount of active ingredients in the composition. In other embodiments, the composition is applied at an application rate from about 107 g ai/ha to about 995 g ai/ha based on the total amount of active ingredients in the composition.

In some embodiments, the methods include 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, a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof, and a PS I inhibitor herbicide or an agriculturally acceptable salt thereof *e.g.*, sequentially or simultaneously. In some embodiments, the triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is applied at a rate from about 0.25 g ai/ha to about 100 g ai/ha and the compound of formula (I) or salt or ester thereof is applied at a rate from about 0.5 grams acid equivalent per hectare (g ae/ha) to about 50 g ae/ha and the PS I inhibitor herbicide or an agriculturally acceptable salt

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thereof is applied at a rate from about 20 g ai/ha to 2240 g ai/ha. In some embodiments, the triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is applied at a rate from about 1 g ai/ha to about 80 g ai/ha, the compound of formula (I) or salt or ester thereof is applied at a rate from about 2 g ae/ha to about 30 g ae/ha, and the PS I inhibitor herbicide or an agriculturally acceptable salt thereof is applied at a rate from about 60 g ai/ha to 1800 g ai/ha. In certain embodiments, the methods utilize the compound of formula (I) or its methyl ester and a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof. In one embodiment, the methods utilize the methyl ester of the compound of formula (I), a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof, and a PS I inhibitor herbicide or an agriculturally acceptable salt thereof, wherein the methyl ester of the compound of formula (I) is applied at a rate from about 5 g ae/ha to about 20 g ae/ha, a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is applied at a rate from about 3 g ai/ha to about 75 g ai/ha, and the PS I inhibitor herbicide or an agriculturally acceptable salt thereof is applied at a rate from about 100 g ai/ha to about 900 g ai/ha.

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 diclosulam and paraquat or an agriculturally acceptable 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 diclosulam to paraquat or an agriculturally acceptable salt thereof is within the range from about 1:5:40 to about 1:2:45. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to diclosulam is within the range from about 1:200 to about 20:1. In certain embodiments, the compositions provided herein contain the methyl ester of the compound of formula (I), diclosulam, and paraquat or an agriculturally acceptable salt thereof. In one embodiment, the composition comprises the methyl ester of the compound of formula (I), diclosulam, and paraquat or an agriculturally acceptable salt thereof wherein the weight ratio of the compound of formula (I) to diclosulam to paraquat or an agriculturally acceptable salt thereof is from about 1:2.5:30 to about 1:2:60. In one embodiment, the composition comprises the methyl ester of the compound of formula (I), diclosulam, and paraquat or an agriculturally acceptable salt thereof, wherein the weight ratio of the methyl ester of the compound of formula (I) to diclosulam is from about 1:30 to about 6:1. In one embodiment, the composition contains the methyl ester of the compound of formula (I), diclosulam, and paraquat or an agriculturally acceptable salt thereof wherein the weight ratio of the methyl ester of the compound of formula (I) to diclosulam to paraquat or an

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agriculturally acceptable salt thereof is from about 1:2:20 to about 1:1.5:20. In one embodiment, the composition contains the methyl ester of the compound of formula (I), diclosulam, and paraquat or an agriculturally acceptable salt thereof wherein the weight ratio of the methyl ester of the compound of formula (I) to diclosulam is from about 1:6 to about 2:1.

In certain embodiments of the compositions and methods described herein, the compound of formula (I) or salt or ester thereof plus diclosulam is used in combination with paraquat or an agriculturally acceptable salt thereof. With regard to the compositions, in some embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof plus diclosulam to paraquat or an agriculturally acceptable salt thereof is within the range from about 1:747 to about 7.5:1. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to diclosulam is within the range from about 1:200 to about 20:1. In certain embodiments, the compositions provided herein contain the methyl ester of the compound of formula (I), diclosulam, and paraquat or an agriculturally acceptable salt thereof. In one embodiment, the composition comprises the methyl ester of the compound of formula (I) plus diclosulam, and paraquat or an agriculturally acceptable salt thereof wherein the weight ratio of the compound of formula (I) plus diclosulam to paraquat or an agriculturally acceptable salt thereof is from about 1:257 to about 1.5:1. In one embodiment, the composition comprises the methyl ester of the compound of formula (I), diclosulam, and paraquat or an agriculturally acceptable salt thereof, wherein the weight ratio of the methyl ester of the compound of formula (I) to diclosulam is from about 1:30 to about 6:1. In one embodiment, the composition contains the methyl ester of the compound of formula (I) plus diclosulam, and paraquat or an agriculturally acceptable salt thereof wherein the weight ratio of the methyl ester of the compound of formula (I) plus diclosulam to paraquat or an agriculturally acceptable salt thereof is from about 1:26.7 to about 0.5:1. In one embodiment, the composition contains the methyl ester of the compound of formula (I), diclosulam, and paraquat or an agriculturally acceptable salt thereof wherein the weight ratio of the methyl ester of the compound of formula (I) to diclosulam is from about 1:6 to about 2:1.

With respect to the methods, in certain embodiments, the methods include 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 from about 23 grams active ingredient per hectare (g ai/ha) to about 2390 g ai/ha based on the total amount of active ingredients in the

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composition. In certain embodiments, the composition is applied at an application rate from about 67 g ai/ha to about 1890 g ai/ha based on the total amount of active ingredients in the composition. In other embodiments, the composition is applied at an application rate from about 115 g ai/ha to about 450 g ai/ha based on the total amount of active ingredients in the composition.

In some embodiments, the methods include 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, diclosulam, and paraquat or an agriculturally acceptable salt thereof *e.g.*, sequentially or simultaneously. In some embodiments, the diclosulam is applied at a rate from about 2.5 g ai/ha to about 100 g ai/ha and the compound of formula (I) or salt or ester thereof is applied at a rate from about 0.5 grams acid equivalent per hectare (g ae/ha) to about 50 g ae/ha and the paraquat is applied at a rate from about 20 g ai/ha to 2240 g ai/ha. In some embodiments, the diclosulam is applied at a rate from about 5 g ai/ha to about 60 g ai/ha, the compound of formula (I) or salt or ester thereof is applied at a rate from about 2 g ae/ha to about 30 g ae/ha, and the paraquat or an agriculturally acceptable salt thereof is applied at a rate from about 60 g ai/ha to 1800 g ai/ha. In certain embodiments, the methods utilize the compound of formula (I) or its methyl ester and diclosulam. In one embodiment, the methods utilize the methyl ester of the compound of formula (I), diclosulam, and paraquat or an agriculturally acceptable salt thereof, wherein the methyl ester of the compound of formula (I) is applied at a rate from about 5 g ae/ha to about 20 g ae/ha, diclosulam is applied at a rate from about 10 g ai/ha to about 30 g ai/ha, and the paraquat or an agriculturally acceptable salt thereof is applied at a rate from about 100 g ai/ha to about 400 g ai/ha.

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 a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof and a protoporphyrinogen oxidase (PPO) inhibitor herbicide or an agriculturally acceptable salt or ester thereof. With regard to the compositions, in some embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof to a PPO inhibitor herbicide or an agriculturally acceptable salt or ester thereof is within the range from about 2:1:2 to about 1:2:48. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is within the range from about 1:200 to about 200:1. In

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certain embodiments, the compositions provided herein contain the methyl ester of the compound of formula (I), a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof, and a PPO inhibitor herbicide or an agriculturally acceptable salt or ester thereof. In one embodiment, the composition comprises the methyl ester of the compound of formula (I), a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof, and a PPO inhibitor herbicide or an agriculturally acceptable salt or ester thereof wherein the weight ratio of the compound of formula (I) to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof to a PPO inhibitor herbicide or an agriculturally acceptable salt or ester thereof is from about 2:1:1 to about 1:2.67:77. In one embodiment, the composition comprises the methyl ester of the compound of formula (I), a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof, and a PPO inhibitor herbicide or an agriculturally acceptable salt or ester thereof, wherein the weight ratio of the methyl ester of the compound of formula (I) to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is from about 1:40 to about 30:1. In one embodiment, the composition contains the methyl ester of the compound of formula (I), a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof, and a PPO inhibitor herbicide or an agriculturally acceptable salt or ester thereof wherein the weight ratio of the methyl ester of the compound of formula (I) to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof to a PPO inhibitor herbicide or an agriculturally acceptable salt or ester thereof is from about 2.5:1:2.5 to about 1:3.75:100. In one embodiment, the composition contains the methyl ester of the compound of formula (I), a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof, and a PPO inhibitor herbicide or an agriculturally acceptable salt or ester thereof wherein the weight ratio of the methyl ester of the compound of formula (I) to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is from about 1:15 to about 10:1.

In certain embodiments of the compositions and methods described herein, the compound of formula (I) or salt or ester thereof plus a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is used in combination with a protoporphyrinogen oxidase (PPO) inhibitor herbicide or an agriculturally acceptable salt or ester thereof. With regard to the compositions, in some embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof plus a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof to a PPO inhibitor herbicide or an agriculturally acceptable salt or ester thereof is within the range from about 1:3200 to about 300:1. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to a triazolopyrimidine sulfonamide herbicide

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or a salt or ester thereof is within the range from about 1:200 to about 200:1. In certain embodiments, the compositions provided herein contain the methyl ester of the compound of formula (I) plus a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof, and a PPO inhibitor herbicide or an agriculturally acceptable salt or ester thereof. In one embodiment, the composition comprises the methyl ester of the compound of formula (I) plus a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof and a PPO inhibitor herbicide or an agriculturally acceptable salt or ester thereof wherein the weight ratio of the compound of formula (I) plus a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof to a PPO inhibitor herbicide or an agriculturally acceptable salt or ester thereof is from about 1:767 to about 110:1. In one embodiment, the composition comprises the methyl ester of the compound of formula (I), a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof, and a PPO inhibitor herbicide or an agriculturally acceptable salt or ester thereof, wherein the weight ratio of the methyl ester of the compound of formula (I) to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is from about 1:40 to about 30:1. In one embodiment, the composition contains the methyl ester of the compound of formula (I) plus a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof, and a PPO inhibitor herbicide or an agriculturally acceptable salt or ester thereof wherein the weight ratio of the methyl ester of the compound of formula (I) plus a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof to a PPO inhibitor herbicide or an agriculturally acceptable salt or ester thereof is from about 1:285 to about 1.9:1. In one embodiment, the composition contains the methyl ester of the compound of formula (I), a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof, and a PPO inhibitor herbicide or an agriculturally acceptable salt or ester thereof wherein the weight ratio of the methyl ester of the compound of formula (I) to a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is from about 1:15 to about 10:1.

With respect to the methods, in certain embodiments, the methods include 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 from about 1.25 grams active ingredient per hectare (g ai/ha) to about 2550 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 from about 4 g ai/ha to about 2410 g ai/ha based on the total amount of active ingredients in the composition. In other embodiments, the composition is applied at an application rate from

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about 57 g ai/ha to about 2095 g ai/ha based on the total amount of active ingredients in the composition.

In some embodiments, the methods include 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, a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof, and a PPO inhibitor herbicide or an agriculturally acceptable salt or ester thereof *e.g.*, sequentially or simultaneously. In some embodiments, the triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is applied at a rate from about 0.25 g ai/ha to about 100 g ai/ha and the compound of formula (I) or salt or ester thereof is applied at a rate from about 0.5 grams acid equivalent per hectare (g ae/ha) to about 50 g ae/ha and the PPO inhibitor herbicide or an agriculturally acceptable salt or ester thereof is applied at a rate from about 0.5 g ai/ha to 2400 g ai/ha. In some embodiments, the triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is applied at a rate from about 1 g ai/ha to about 80 g ai/ha, the compound of formula (I) or salt or ester thereof is applied at a rate from about 2 g ae/ha to about 30 g ae/ha, and the a PPO inhibitor herbicide or an agriculturally acceptable salt or ester thereof is applied at a rate from about 1 g ai/ha to about 2300 g ai/ha. In certain embodiments, the methods utilize the compound of formula (I) or its methyl ester and a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof. In one embodiment, the methods utilize the methyl ester of the compound of formula (I), a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof, and a PPO inhibitor herbicide or an agriculturally acceptable salt or ester thereof, wherein the methyl ester of the compound of formula (I) is applied at a rate from about 5 g ae/ha to about 20 g ae/ha, a triazolopyrimidine sulfonamide herbicide or a salt or ester thereof is applied at a rate from about 2 g ai/ha to about 75 g ai/ha, and a PPO inhibitor herbicide or an agriculturally acceptable salt or ester thereof is applied at a rate from about 5 g ai/ha to about 2000 g ai/ha.

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 diclosulam and saflufenacil. With regard to the compositions, in some embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to diclosulam to saflufenacil is within the range from about 1:5:1 to about 1:2:4. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to diclosulam is within the range from about 1:200 to about 20:1. In certain embodiments, the compositions provided herein contain the

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methyl ester of the compound of formula (I), diclosulam, and saflufenacil. In one embodiment, the composition comprises the methyl ester of the compound of formula (I), diclosulam, and saflufenacil wherein the weight ratio of the compound of formula (I) to diclosulam to saflufenacil is from about 2:5:1 to about 1:2:5. In one embodiment, the composition comprises the methyl ester of the compound of formula (I), diclosulam, and saflufenacil, wherein the weight ratio of the methyl ester of the compound of formula (I) to diclosulam is from about 1:30 to about 6:1. In one embodiment, the composition contains the methyl ester of the compound of formula (I), diclosulam, and saflufenacil wherein the weight ratio of the methyl ester of the compound of formula (I) to diclosulam to saflufenacil is from about 1:2:1.75 to about 1:1.5:2.45. In one embodiment, the composition contains the methyl ester of the compound of formula (I), diclosulam, and saflufenacil wherein the weight ratio of the methyl ester of the compound of formula (I) to diclosulam is from about 1:6 to about 2:1.

In certain embodiments of the compositions and methods described herein, the compound of formula (I) or salt or ester thereof plus diclosulam is used in combination with saflufenacil. With regard to the compositions, in some embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof plus diclosulam to saflufenacil is within the range from about 1:66.7 to about 300:1. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to diclosulam is within the range from about 1:200 to about 20:1. In certain embodiments, the compositions provided herein contain the methyl ester of the compound of formula (I), diclosulam, and saflufenacil. In one embodiment, the composition comprises the methyl ester of the compound of formula (I), diclosulam, and saflufenacil wherein the weight ratio of the compound of formula (I) plus diclosulam to saflufenacil is from about 1:21.4 to about 90:1. In one embodiment, the composition comprises the methyl ester of the compound of formula (I), diclosulam, and saflufenacil, wherein the weight ratio of the methyl ester of the compound of formula (I) to diclosulam is from about 1:30 to about 6:1. In one embodiment, the composition contains the methyl ester of the compound of formula (I), diclosulam, and saflufenacil wherein the weight ratio of the methyl ester of the compound of formula (I) plus diclosulam to saflufenacil is from about 1:3.3 to about 1:5.7. In one embodiment, the composition contains the methyl ester of the compound of formula (I), diclosulam, and saflufenacil wherein the weight ratio of the methyl ester of the compound of formula (I) to diclosulam is from about 1:6 to about 2:1.

With respect to the methods, in certain embodiments, the methods include contacting the undesirable vegetation or locus thereof or applying to the soil or water to prevent the

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emergence or growth of vegetation a composition described herein. In some embodiments, the composition is applied at an application rate from about 3.5 grams active ingredient per hectare (g ai/ha) to about 350 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 from about 8 g ai/ha to about 240 g ai/ha based on the total amount of active ingredients in the composition. In other embodiments, the composition is applied at an application rate from about 23 g ai/ha to about 99 g ai/ha based on the total amount of active ingredients in the composition.

In some embodiments, the methods include 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, diclosulam, and saflufenacil *e.g.*, sequentially or simultaneously. In some embodiments, the diclosulam is applied at a rate from about 2.5 g ai/ha to about 100 g ai/ha and the compound of formula (I) or salt or ester thereof is applied at a rate from about 0.5 grams acid equivalent per hectare (g ae/ha) to about 50 g ae/ha and the saflufenacil is applied at a rate from about 0.5 g ai/ha to 200 g ai/ha. In some embodiments, the diclosulam is applied at a rate from about 5 g ai/ha to about 60 g ai/ha, the compound of formula (I) or salt or ester thereof is applied at a rate from about 2 g ae/ha to about 30 g ae/ha, and the saflufenacil is applied at a rate from about 1 g ai/ha to 150 g ai/ha. In certain embodiments, the methods utilize the compound of formula (I) or its methyl ester and diclosulam. In one embodiment, the methods utilize the methyl ester of the compound of formula (I), diclosulam, and saflufenacil, wherein the methyl ester of the compound of formula (I) is applied at a rate from about 5 g ae/ha to about 20 g ae/ha, diclosulam is applied at a rate from about 10 g ai/ha to about 30 g ai/ha, and the saflufenacil is applied at a rate from about 8.75 g ai/ha to about 49 g ai/ha.

The components of the mixtures described herein can be applied either separately or as part of a multipart herbicidal system. In some embodiments of the methods described herein, the active ingredients are applied simultaneously, including, *e.g.*, in the form of a composition. In some embodiments, the active ingredients are applied sequentially, *e.g.*, within 5, 10, 15, or 30 minutes of each other; or 1, 2, 3, 4, 5, 10, 12, 24, 48, 72 hour(s) of each other; or 1 week of each other.

The present compositions can be applied to weeds and other undesirable vegetation, or to their locus thereof by the use of conventional ground or aerial dusters, sprayers, and granule applicators and by other conventional means known to those skilled in the art.

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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.

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Examples

Example 1. Evaluation of Postemergence Herbicidal Activity

Treatments consisted of the methyl ester of 4-amino-3-chloro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid (Cmpd 1, halauxifen-methyl) and diclosulam in combination as GF-3220. The form of compound of formula (I) was applied on an acid equivalent basis, and diclosulam was applied on an active ingredient basis. Glufosinate-ammonium salt was applied as various commercial formulations containing 480 grams acid equivalent per liter (g ae/L). Saflufenacil was applied as a commercial formulation containing 700 grams per kilogram (g/kg). Paraquat was applied as a commercial formulation containing 200 g/L.

Field trials were conducted under standard field conditions. Plot sizes varied from 2-4 meters (m) wide by 2-5 m long. Treatments were applied with small plot backpack sprayers, using pressurized carbon dioxide (CO₂) as propellant. Pressure varied from 22-40 pounds per square inch (PSI), with spray tips typically of a Flat Fan type applying water diluent at 100-150 liters per hectare (L/ha). Boom sizes varied from 2-4 m in width. Weed sizes varied, but all treatments were applied as post-emergence treatments to weeds from 2 leaf to 2 tiller growth stages varying from 2-15 inches in height. No additional adjuvant was mixed with the treatments applied in the field.

Results in Tables 1 to 7 are field trial results for foliar applied compositions. The values reported are percent (%) control visually rated. The predicted percent (%) weed control was determined using Colby's equation.

The compositions tested, application rates employed, plant species tested, and results are given in Tables 1 to 7.

The following abbreviations are used in Tables 1 to 7:

ERISS = *Conyza* species (fleabane, ERISS)

ERISU = *Conyza sumatrensis* (Guernsey fleabane)

EPHHL = *Euphorbia heterophylla* L. (wild poinsettia)

IAQGR = *Ipomoea grandifolia* (Corda-de-viola)

ERIBO = *Conyza bonariensis* (fleabane)

g ae/ha = grams acid equivalent per hectare

g ai/ha = grams active ingredient per hectare

Mean % weed control = observed value of percent (%) control rated visually

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Predicted mean % weed control = expected value of percent (%) control as calculated by Colby's equation

Cmpd 1 = methyl 4-amino-3-chloro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylate, halauxifen-methyl, or ARYLEX®

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Table 1: Weed control from post-emergent application of Cmpd 1 and diclosulam premix when tank-mixed with glufosinate-ammonium

Weed Bayer	Evaluation Interval	Cmpd 1 + Diclosulam		Glufosinate ammonium		Combination	
		g ai/ha	Mean % weed control	g ai/ha	Mean % weed control	Measured mean % weed control	Predicted mean % weed control
ERISU	17DAA	30.6	36.25	366	58.75	86.2	73.8
ERISU	28DAA	30.6	66.25	366	71.25	100	90.3
ERISU	43DAA	30.6	72.5	366	78.75	100	94.1
ERISU	17DAA	30.6	40	366	71.25	93.8	82.4

Table 2: Weed control from post-emergent application of Cmpd 1 and diclosulam premix when tank-mixed with saflufenacil

Weed Bayer	Evaluation Interval	Cmpd 1 + Diclosulam		Saflufenacil		Combination	
		g ai/ha	Mean % weed control	g ai/ha	Mean % weed control	Measured mean % weed control	Predicted mean % weed control
ERISS	17DAA	30.6	36.3	49	52.5	90.0	69.9
ERISS	28DAA	30.6	66.3	49	66.3	97.5	88.6
ERISS	43DAA	30.6	72.5	49	77.5	97.5	93.8
ERISS	17DAA	30.6	40.0	49	66.3	93.8	79.8

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Table 3: Weed control from post-emergent application of Cmpd 1 and diclosulam premix when tank-mixed with paraquat

Weed Bayer	Evaluation Interval	Cmpd 1 + Diclosulam		Paraquat		Combination	
		g ai/ha	Mean % weed control	g ai/ha	Mean % weed control	Measured mean % weed control	Predicted mean % weed control
ERISS	17DAA	30.6	36.3	400	32.5	82.5	56.8
ERISS	28DAA	30.6	66.3	400	52.5	88.75	83.8
ERISS	43DAA	30.6	72.5	400	60	91.75	88.9
ERISS	17DAA	30.6	40.0	400	52.5	85	71.6
ERISS	28DAA	30.6	57.5	400	55	88.25	80.9
ERISS	43DAA	30.6	76.3	400	65	100	91.8
ERISS	17DAA	30.6	36.3	400	32.5	82.5	56.8
ERISS	28DAA	30.6	66.3	400	52.5	88.75	83.8
ERISS	43DAA	30.6	72.5	400	60	91.75	88.9
ERISS	17DAA	30.6	40.0	400	52.5	85	71.6
ERISS	28DAA	30.6	57.5	400	55	88.25	80.9
ERISS	43DAA	30.6	76.3	400	65	100	91.8

Table 4: Weed control from post-emergent application of Cmpd 1 and diclosulam premix when tank-mixed with paraquat

Weed Bayer	Evaluation Interval	Cmpd 1 + Diclosulam		Paraquat		Combination	
		g ai/ha	Mean % weed control	g ai/ha	Mean % weed control	Measured mean % weed control	Predicted mean % weed control
EPHHL	14DAA	30.6	65	300	81.8	98	93.5
EPHHL	21DAA	30.6	70	100	56	93	86.6
EPHHL	21DAA	30.6	70	300	82.8	99.8	94.7
EPHHL	30DAA	30.6	74.3	100	48.3	93.8	86.6
EPHHL	30DAA	38.2	79.3	100	48.3	95.3	89.0
EPHHL	30DAA	30.6	74.3	300	81.8	99	95.1

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Table 5: Weed control from post-emergent application of Cmpd 1 and diclosulam premix when tank-mixed with paraquat

Weed Bayer	Evaluation Interval	Cmpd 1 + Diclosulam		Paraquat		Combination	
		g ai/ha	Mean % weed control	g ai/ha	Mean % weed control	Measured mean % weed control	Predicted mean % weed control
IAQGR	14DAA	30.6	66	300	54.3	95	84.3
IAQGR	21DAA	30.6	71.8	300	45	96.8	84.6
IAQGR	30DAA	30.6	78.3	300	39.8	99.8	87.6

Table 6: Weed control from post-emergent application of Cmpd 1 and diclosulam premix when tank-mixed with paraquat

Weed Bayer	Evaluation Interval	Cmpd 1 + Diclosulam		Paraquat		Combination	
		g ai/ha	Mean % weed control	g ai/ha	Mean % weed control	Measured mean % weed control	Predicted mean % weed control
ERISU	13DAA	30.6	28.8	100	26.3	61.3	47.7
ERISU	13DAA	38.2	23.8	100	26.3	69	43.8
ERISU	13DAA	30.6	28.8	200	40	70.8	57.3
ERISU	22DAA	30.6	42.5	100	41.3	85	66.1
ERISU	22DAA	38.2	30	100	41.1	78.5	58.6
ERISU	22DAA	30.6	42.5	200	56.3	92.5	73.9
ERISU	28DAA	30.6	32.5	100	47.5	85	64.6
ERISU	28DAA	38.2	28.8	100	47.5	81.3	62.3
ERISU	28DAA	30.6	32.5	200	61.3	91.3	73.3

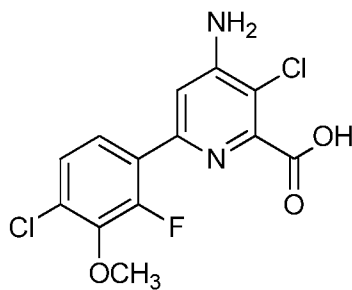
Table 7: Weed control from post-emergent application of Cmpd 1 and diclosulam premix when tank-mixed with paraquat

Weed Bayer	Evaluation Interval	Cmpd 1 + Diclosulam		Paraquat		Combination	
		g ai/ha	Mean % weed control	g ai/ha	Mean % weed control	Measured mean % weed control	Predicted mean % weed control
ERIBO	21DAA	38.2	40	200	28.3	67.7	57

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WHAT IS CLAIMED IS:

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



(I)

- (halauxifen-methyl) or an agriculturally acceptable salt or ester thereof (b) a triazolopyrimidine sulfonamide herbicide or an agriculturally acceptable salt or ester thereof, and (c) a cell membrane disruptor herbicide or an agriculturally acceptable salt or ester thereof, wherein (c) is not carfentrazone or an agriculturally acceptable salt or ester thereof.
2. The composition of claim 1, wherein no additional herbicidal active ingredients are present in the composition.
3. The composition of claim 1 or 2, wherein (a) is a C₁-C₄ alkyl or benzyl ester of compound (I).
4. The composition of claim 3, wherein (a) is a methyl ester of compound (I).
5. The composition of claim 1 or 2, wherein (a) is the carboxylic acid of formula (I).
6. The composition of claim 1 or 2, wherein (a) is the methyl ester of the compound of formula (I) and (b) is selected from the group consisting of florasulam, cloransulam, diclosulam, flumetsulam, metosulam, penoxsulam, pyroxsulam, and agriculturally acceptable salts and esters thereof, and combinations thereof.
7. The composition of any of claims 1-6, wherein (c) is a phosphorylated amino acid cell membrane disruptor selected from glufosinate or an agriculturally acceptable salt thereof.
8. The composition of claim 7, wherein the weight ratio of (a) plus (b) to (c) is from about 1:4480 to about 3:1, from about 1:560 to about 1.5:1, or from about 1:57 to about 0.95:1.

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about 1:57 to about 0.95:1.

9. The composition of claim 7, wherein the weight ratio of (a) to (b) to (c) is from about 2:1:200 to about 1:2:67, from about 2:1:75 to about 1:2.67:56, or from about 1.67:1:33 to about 1:3.75:20.

10. The composition of claim 7, wherein (b) is diclosulam or an agriculturally acceptable salt thereof and (c) is glufosinate or an agriculturally acceptable salt and the weight ratio of the compound of (a) plus (b) to (c) is from about 1:1120 to about 3:1, from about 1:240 to about 1.2:1, or from about 1:26.7 to about 0.5:1.

11. The composition of claim 7, wherein (b) is diclosulam or an agriculturally acceptable salt thereof and (c) is glufosinate or an agriculturally acceptable salt and the weight ratio of the compound of (a) to (b) to (c) is from about 1:5:100 to about 1:2:67, from about 1:2.5:37.5 to about 1:2:56, or from about 1:2:20 to about 1:1.5:20.

12. The composition of any of claims 1-6, wherein (c) is a cell membrane disruptor and the cell membrane disruptor is a photosystem I (PS I) inhibitor or an agriculturally acceptable salt thereof.

13. The composition of claim 12, wherein the PS I inhibitor is diquat or paraquat, or an agriculturally acceptable salt thereof.

14. The composition of claim 13, wherein the weight ratio of (a) plus (b) to (c) is from about 1:2987 to about 7.5:1, from about 1:600 to about 1.83:1, or from about 1:128 to about 0.95:1.

15. The composition of claim 13, wherein the weight ratio of (a) to (b) to (c) is from about 2:1:80 to about 1:2:45, from about 2:1:60 to about 1:2.67:60, or from about 1.67:1:33.3 to about 1:3.75:45.

16. The composition of claim 13, wherein (b) is diclosulam or an agriculturally acceptable salt thereof and (c) is paraquat or an agriculturally acceptable salt and the weight ratio of (a) plus (b) to (c) is from about 1:747 to about 7.5:1, from about 1:257 to about 1.5:1, or from about 1:26.7 to about 0.5:1.

17. The composition of claim 21, wherein (b) is diclosulam or an agriculturally acceptable salt thereof and (c) is paraquat or an agriculturally acceptable salt and the weight

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ratio of (a) to (b) to (c) is from about 1:5:40 to about 1:2:45, from about 1:2.5:30 to about 1:2:60, or from about 1:2:20 to about 1:1.5:20.

18. The composition of any of claims 1-6, wherein (c) is a cell membrane disruptor and the cell membrane disruptor is a protoporphyrinogen oxidase (PPO) inhibitor or an agriculturally acceptable salt or ester thereof.

19. The composition of claim 18, wherein the PPO inhibitor is selected from the group consisting of acifluorfen, bifenoxy, chlorthaloxifen, fluoroglycofen, fomesafen, halosafen, lactofen, oxyfluorfen, fluazolate, pyraflufen, cinidon, flumioxazin, flumiclorac, fluthiacet, thidiazimin, oxadiazon, oxadiargyl, azafenidin, sulfentrazone, pentoxazone, trifludimoxazin, benzfendazole, butafenacil, saflufenacil, pyraclonil, proflumazone, flufenpyr, and agriculturally acceptable salts or esters thereof.

20. The composition of claim 19, wherein the weight ratio of (a) plus (b) to (c) is from about 1:3200 to about 300:1, from about 1:767 to about 110:1, or from about 1:286 to about 1.9:1.

21. The composition of claim 19, wherein the weight ratio of (a) to (b) to (c) is from about 2:1:2 to about 1:2:48, from about 2:1:1 to about 1:2.67:77, or from about 2.5:1:2.5 to about 1:3.75:100.

22. The composition of claim 19, wherein (b) is diclosulam or an agriculturally acceptable salt thereof and (c) is saflufenacil and the weight ratio of (a) plus (b) to (c) is from about 1:66.7 to about 300:1, from about 1:21.4 to about 90:1, or from about 1:3.3 to about 5.7:1.

23. The composition of claim 19, wherein (b) is diclosulam or an agriculturally acceptable salt thereof and (c) is saflufenacil and the weight ratio of (a) to (b) to (c) is from about 1:5:1 to about 1:2:4, from about 2:5:1 to about 1:2:5, or from about 1:2:1.75 to about 1:1.5:2.45.

24. The composition of any of claims 1-23, further comprising a herbicide safener.

25. The composition of any of claims 1-24, further comprising an agriculturally acceptable adjuvant or carrier.

26. A method of controlling undesirable vegetation which comprises applying the composition of any of claims 1-25.

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27. The method of claim 26 wherein the undesirable vegetation is controlled in soybean, cotton, sunflower, winter/spring oilseed rape, winter/spring canola, vegetables, ornamentals, rice, wheat, teff, triticale, barley, oats, rye, sorghum, corn/maize, sunflower, row crops, pastures, grasslands, rangelands, fallowland, fallow bed, sugarcane, turf, tree and vine orchards, aquatics, forestry, industrial vegetation management (IVM) and rights-of-way; burndown and control of weeds in fallow fields and fallow beds between the planting of crops, such as soybean, corn, cotton, sunflower, cereals, rice, winter/spring oilseed rape, winter/spring canola, corn/maize and sorghum.
28. The method of claim 26 or 27, wherein the composition is applied for burndown and control of undesirable vegetation in fallow beds.
29. The method of claim 26, wherein the composition is used to control weeds just prior to or after planting soybeans.
30. The method of any of claims 26-29, wherein the undesirable vegetation is immature.
31. The method of any of claims 26-30, wherein the (a), (b), and (c) are applied pre-emergence.
32. The method of any of claims 26-30, wherein the (a), (b), and (c) are applied post-emergence.
33. The method of any one of claims 26-32 wherein the undesirable vegetation is controlled in a crop that is tolerant to glyphosate, glufosinate, dicamba, phenoxy auxins, pyridyloxy auxins, aryloxyphenoxypropionates, acetyl CoA carboxylase (ACCase) inhibitors, imidazolinones, acetolactate synthase (ALS) inhibitors, 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitors, protoporphyrinogen oxidase (PPO) inhibitors, triazines, or bromoxynil.
34. The method of claim 33, wherein the tolerant crop possesses single or multiple or stacked traits conferring tolerance to single or multiple herbicides or single or multiple modes of action.
35. The method of any one of claims 26-34, wherein the undesirable vegetation comprises a herbicide resistant or tolerant weed.

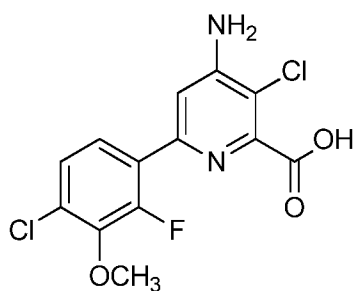
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36. The method of claim 35, wherein the resistant or tolerant weed is a biotype with resistance or tolerance to single or multiple herbicides, single or multiple chemical classes, or single or multiple herbicide modes of action.

37. The method of claim 36, wherein the resistant or tolerant weed is a biotype resistant or tolerant to acetolactate synthase (ALS) inhibitors, photosystem II inhibitors, acetyl CoA carboxylase (ACCase) inhibitors, synthetic auxins, photosystem I inhibitors, 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase inhibitors, microtubule assembly inhibitors, 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.

38. The method of any one of claims 26-37, wherein the undesirable vegetation is *Conyza sumatrensis* (Guernsey fleabane, ERISU), *Conyza* species (fleabane, ERISS), *Euphorbia heterophylla* L. (wild poinsettia, EPHHL), *Ipomoea grandifolia* (Corda-de-viola, IAQGR), and *Conyza bonariensis* (fleabane, ERIBO).

39. A herbicidal system comprising a first container comprising a premix or concentrate comprising a compound of formula (I)



(I)

or an agriculturally acceptable salt or ester thereof and a triazolopyrimidine sulfonamide herbicide or an agriculturally acceptable salt or ester thereof, and a second container comprising a concentrate of a cell membrane disruptor herbicide or an agriculturally acceptable salt or ester thereof.

40. The system of claim 39, wherein the first and/or second container contains one or more adjuvants and/or carriers.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US16/50710

A. CLASSIFICATION OF SUBJECT MATTER IPC(8) - A01N 43/40, 43/54 (2016.01) CPC - A01N 33/22, 43/40, 43/90 According to International Patent Classification (IPC) or to both national classification and IPC														
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) IPC(8): A01N 43/40, 43/54 (2016.01) CPC: A01N 33/22, 43/40, 43/90 USPC: 504/136, 260; 546/318 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) PATSEER (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, Other Countries (INPADOC), RU, AT, CH, TH, BR, PH); EBSCO; Google Scholar; IP.com; KEYWORDS: 4 aminopicolin*, herbicide*, herbicid* composition*, 4 amino 3 chloro 6, 4 chloro 2 fluoro 3 methoxyphenyl, pyridine 2 carboxylic acid, penoxsulam, oxyfluorfen, tank mix*, herbicid* system*, halauxifen, first container														
C. DOCUMENTS CONSIDERED TO BE RELEVANT <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>Y</td> <td>US 2007/0179060 A1 (BALKO, TW et al.) 02 August 2007; paragraphs [0005]-[0022], [0040], [0042], [0077], [0313], [0374]</td> <td>1-2, 3/1-2, 4/3/1-2, 5/1-2, 6/1-2</td> </tr> <tr> <td>Y</td> <td>US 2011/0190134 A1 (JOUSSEAUME, C et al.) 04 August 2011; paragraphs [0002], [0006]-[0007], [0017]-[0018]</td> <td>1-2, 3/1-2, 4/3/1-2, 5/1-2, 6/1-2, 39-40</td> </tr> <tr> <td>Y</td> <td>US 2015/0196030 A1 (DOW AGROSCIENCES LLC) 16 July 2015; paragraphs [0010]-[0011], [0040], [0048], [0055]-[0056]</td> <td>39-40</td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	Y	US 2007/0179060 A1 (BALKO, TW et al.) 02 August 2007; paragraphs [0005]-[0022], [0040], [0042], [0077], [0313], [0374]	1-2, 3/1-2, 4/3/1-2, 5/1-2, 6/1-2	Y	US 2011/0190134 A1 (JOUSSEAUME, C et al.) 04 August 2011; paragraphs [0002], [0006]-[0007], [0017]-[0018]	1-2, 3/1-2, 4/3/1-2, 5/1-2, 6/1-2, 39-40	Y	US 2015/0196030 A1 (DOW AGROSCIENCES LLC) 16 July 2015; paragraphs [0010]-[0011], [0040], [0048], [0055]-[0056]	39-40
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Y	US 2007/0179060 A1 (BALKO, TW et al.) 02 August 2007; paragraphs [0005]-[0022], [0040], [0042], [0077], [0313], [0374]	1-2, 3/1-2, 4/3/1-2, 5/1-2, 6/1-2												
Y	US 2011/0190134 A1 (JOUSSEAUME, C et al.) 04 August 2011; paragraphs [0002], [0006]-[0007], [0017]-[0018]	1-2, 3/1-2, 4/3/1-2, 5/1-2, 6/1-2, 39-40												
Y	US 2015/0196030 A1 (DOW AGROSCIENCES LLC) 16 July 2015; paragraphs [0010]-[0011], [0040], [0048], [0055]-[0056]	39-40												
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.														
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family														
Date of the actual completion of the international search 17 October 2016 (17.10.2016)		Date of mailing of the international search report 08 NOV 2016												
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300		Authorized officer Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774												

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US16/50710

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

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

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

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

3. ☒ Claims Nos.: 7-38
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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

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

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

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

Remark on Protest

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