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(54) Title: COMPOSITIONS COMPRISING PYRIDINE CARBOXYLATE HERBICIDES WITH PDS INHIBITOR HERBICIDES

(57) Abstract: Disclosed herein are compositions comprising (a) a pyridine carboxylate herbicide or an agriculturally acceptable N-oxide, salt, or ester thereof and (b) a PDS inhibitor herbicide or an agriculturally acceptable salt or ester thereof. Also disclosed herein are methods of controlling undesirable vegetation, comprising applying to vegetation or an area adjacent the vegetation or applying in soil or water to control the emergence or growth of vegetation (a) a pyridine carboxylate herbicide or an agriculturally acceptable N-oxide, salt, or ester thereof and (b) a PDS inhibitor herbicide or an agriculturally acceptable salt or ester thereof.

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COMPOSITIONS COMPRISING PYRIDINE CARBOXYLATE HERBICIDES WITH PDS INHIBITOR HERBICIDES

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of priority of U.S. Provisional Application No. 62/756,788, filed November 7, 2018, which is incorporated by reference herein in its entirety.

FIELD

[0002] The present disclosure includes compositions comprising (a) a pyridine carboxylate herbicide or an agriculturally acceptable N-oxide, salt, or ester thereof, and (b) a phytoene desaturase (PDS) inhibitor or an agriculturally acceptable salt or ester thereof. The present disclosure also includes methods of controlling undesirable vegetation using the same.

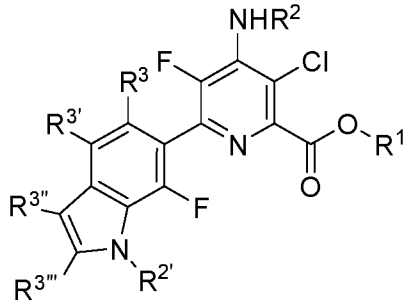
BACKGROUND

[0003] Many recurring problems in agriculture involve controlling the growth of undesirable vegetation that can, for instance, negatively affect the growth of desirable vegetation. To help control undesirable vegetation, researchers have produced a variety of chemicals and chemical formulations effective in controlling such unwanted growth. However, there exists a need for new herbicide compositions and methods to control the growth of undesirable vegetation in desired crops.

SUMMARY

[0004] Disclosed herein are compositions that may be used as herbicides, for example, in crops. The compositions may contain (a) a pyridine carboxylate herbicide or agriculturally acceptable N-oxide, salt, or ester thereof, and (b) a phytoene desaturase (PDS) inhibitor or an agriculturally acceptable salt or ester thereof. The weight ratio of (a) to (b) can be from 1:9000 to 24:1 (*e.g.*, from 1:7000: to 20:5, from 1:280 to 2:1, from 1:30 to 10:10, from 1:24 to 1:18, from 1:16 to 1:12, or from 1:5 to 5:1).

[0005] In some aspects, the composition comprises (a) a pyridine carboxylate herbicide defined by Formula (I):



Formula I

wherein:

R^1 is cyanomethyl or propargyl;

R^2 and $R^{2'}$ are independently hydrogen, C_1-C_6 alkyl, formyl, alkoxycarbonyl, or acyl;

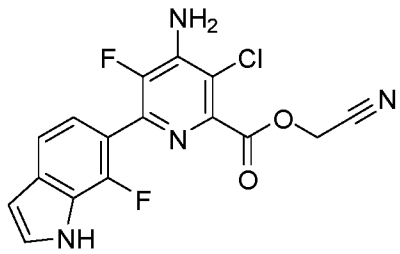
R^3, $R^{3'}$, $R^{3''}$, and $R^{3'''}$ are independently hydrogen, halogen, C_1-C_4 alkyl, C_1-C_4 haloalkyl, C_1-C_3 alkoxy, or C_1-C_3 haloalkoxy;

or an agriculturally acceptable N-oxide, salt, or ester thereof; and

(b) a phytoene desaturase (PDS) inhibitor or an agriculturally acceptable salt or ester thereof.

[0006] In some aspects, the composition comprises:

(a) the pyridine carboxylate herbicide compound cyanomethyl 4-amino-3-chloro-5-fluoro-6-(7-fluoro-1H-indol-6-yl)pyridine-2-carboxylate, referred to hereinafter as Compound A:



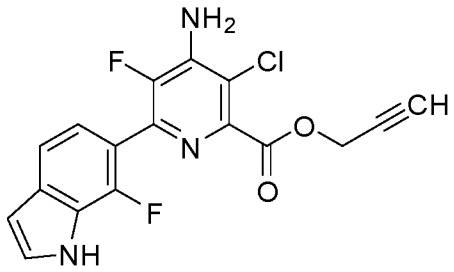
Compound A

or an agriculturally acceptable N-oxide, salt, or ester thereof; and

(b) a phytoene desaturase (PDS) inhibitor or an agriculturally acceptable salt or ester thereof.

[0007] In some aspects, the composition comprises:

(a) the pyridine carboxylate herbicide compound propargyl 4-amino-3-chloro-5-fluoro-6-(7-fluoro-1H-indol-6-yl)pyridine-2-carboxylate, referred to hereinafter as Compound B:



Compound B

or an agriculturally acceptable N-oxide, salt, or ester thereof; and

(b) a phytoene desaturase (PDS) inhibitor or an agriculturally acceptable salt or ester thereof.

[0008] In some aspects, the PDS inhibitor (b) can comprise beflubutamid, diflufenican, fluridone, flurochloridone, flurtamone, norflurazon, picolinafen, or combinations thereof.

[0009] In some aspects, the composition comprises a mixture of the pyridine carboxylate herbicide (a) and the PDS inhibitor (b). In some aspects, the composition comprises a mixture of the pyridine carboxylate herbicides (a) and one or more PDS inhibitors (b). In some aspects, the composition comprises a mixture of one or more pyridine carboxylate herbicides (a) and one or more PDS inhibitors (b). In some aspects, (b) is a mixture of diflufenican and flurtamone.

[0010] In some aspects, the composition can further comprise an agriculturally acceptable adjuvant or carrier, a herbicidal safener, an additional pesticide, or combinations thereof. In some aspects, the only active ingredients in the composition are (a) and (b). In some aspects, the composition can be provided as a herbicidal concentrate.

[0011] Also disclosed herein are methods of controlling undesirable vegetation, comprising applying to vegetation, to an area adjacent the vegetation, or to soil or water to control the emergence or growth of vegetation, a composition comprising (a) a pyridine carboxylate herbicide or an agriculturally acceptable N-oxide, salt, or ester thereof, and (b) a phytoene desaturase (PDS) inhibitor or an agriculturally acceptable salt or ester thereof. In some aspects, (a) and (b) are applied simultaneously. In some aspects, (a) and (b) are applied sequentially. In some aspects, (a) and (b) are applied pre-emergence of the undesirable vegetation. In some aspects, (a) and (b) are applied post-emergence of the undesirable vegetation. In some aspects, the undesirable vegetation is in cereals. In some aspects, the undesirable vegetation is in maize, wheat, barley, rice, sorghum, millet, or oats. In some aspects, the undesirable vegetation is in broadleaf crops. In some aspects, the undesirable vegetation is in canola, flax, sunflower, soy, or cotton.

[0012] In some aspects, the pyridine carboxylate herbicide (a) can be applied in an amount of from 0.1 gram acid equivalent per hectare (g ae/ha) to 300 g ae/ha (*e.g.*, from 30 g ae/ha to 40 g ae/ha). In some aspects, the PDS inhibitor (b) can be applied in an amount of from 12.5 g ai/ha to 4500 g ai/ha (*e.g.*, from 30 g ai/ha to 400 g ai/ha). In some cases, (a) and (b) can be applied in a weight ratio of from 1:9000 to 24:1 (*e.g.*, from 1:1000 to 20:5, from 1:280 to 2:1, from 1:30 to 10:1, from 1:24 to 1:18, or from 1:16 to 1:12).

[0013] The description below sets forth details of one or more aspect of the present disclosure. Other features, objects, and advantages will be apparent from the description and from the claims.

DETAILED DESCRIPTION

[0014] The present disclosure includes compositions comprising (a) a pyridine carboxylate herbicide or an agriculturally acceptable N-oxide, salt, or ester thereof, and (b) a phytoene desaturase (PDS) inhibitor or an agriculturally acceptable salt or ester thereof. The present disclosure also includes methods for controlling undesirable vegetation. In some aspects, the undesirable vegetation is in cereals. In some aspects, the undesirable vegetation is in maize, wheat, barley, rice, sorghum, millet, or oats. In some aspects, the undesirable vegetation is in broadleaf crops. In some aspects, the undesirable vegetation is in canola, flax, sunflower, soy, or cotton.

I. Definitions

[0015] Terms used herein will have their customary meaning in the art unless specified otherwise. The singular forms "a" and "the" include plural references unless stated otherwise. To the extent that the term "or" is employed (*e.g.*, A or B) it is intended to mean "A or B or both." If this disclosure intends to indicate "only A or B but not both" then the term "only A or B but not both" will be employed. Thus, use of the term "or" herein is the inclusive and not the exclusive use.

[0016] The chemical moieties mentioned when defining variable positions within the general formulae described herein (*e.g.*, the term "alkyl") are collective terms for the individual substituents encompassed by the chemical moiety. The prefix C_n-C_m preceding a group or moiety indicates, in each case, the possible number of carbon atoms in the group or moiety that follows.

[0017] As used herein, the terms "herbicide" and "herbicidal active ingredient" may be understood to include an active ingredient that kills, controls, or otherwise adversely modifies

the growth of vegetation, particularly undesirable vegetation such as weed species, when applied in an appropriate amount.

[0018] As used herein, the term “herbicidal effect” may be understood to include an adversely modifying effect of an active ingredient on vegetation, including, for example, a deviation from natural growth or development, killing, regulation, desiccation, growth inhibition, growth reduction, and retardation. The term "herbicidal activity" refers generally to herbicidal effects of an active ingredient. As used herein, the term “prevents” or similar terms such as “preventing” may be understood by a person of ordinary skill to include any combination that shows herbicidal effect.

[0019] As used herein, "applying" a herbicide or herbicidal composition refers to delivering it directly to the targeted vegetation or to the locus thereof or to the area where control of undesirable vegetation is desired. Methods of application include, but are not limited to, pre-emergently contacting soil or water, post-emergently contacting the undesirable vegetation, or contacting the area adjacent to the undesirable vegetation.

[0020] As used herein, the term “vegetation” can include, for instance, dormant seeds, germinating seeds, emerging seedlings, plants propagating from vegetative propagules, immature vegetation, and established vegetation.

[0021] As used herein, the term "crop" refers to desired vegetation, for instance, plants that are grown to provide food, shelter, pasture, erosion control, etc. Example crops include cereals, legumes, vegetables, orchard and timber trees, grapevines, etc. Preferably, herbicides or herbicidal compositions have zero or minimal herbicidal effect on crops.

[0022] As used herein, the term "undesirable vegetation" refers to vegetation that is not wanted in a given area, for instance, weed species. Herbicides or herbicidal compositions are used to control undesirable vegetation. Preferably, herbicides or herbicidal compositions have a large or complete herbicidal effect on undesirable vegetation.

[0023] As used herein, "active ingredient" or "ai" may be understood to include a chemical compound or composition that has an effect on vegetation, for example, a herbicidal effect or a safening effect on the vegetation.

[0024] As used herein, "acid equivalent" or "ae" may be understood to include the amount of the acid form of an active ingredient that is calculated from the amount of a salt or ester form of that active ingredient. For example, if the acid form of an active ingredient "*Z*" has a molecular

weight of 100 Dalton, and the salt form of ***Z*** has a molecular weight of 130 Dalton, an application of 130 g ai/ha of the ***Z*** salt would be equal to applying 100 g ae/ha of the acid form of ***Z***:

130 g ai/ha ***Z*** salt * (100 Da ***Z*** acid / 130 Da ***Z*** salt) = 100 g ae/ha ***Z*** acid.

[0025] As used herein, unless otherwise specified, the term "acyl" may be understood to include a group of formula –C(O)R, where "C(O)" is short-hand notation for C=O. In the acyl group, the R may be alkyl (*e.g.*, C_1-C_6 alkyl), haloalkyl (*e.g.*, C_1-C_6 haloalkyl), alkenyl (*e.g.*, C_2-C_6 alkenyl), haloalkenyl (*e.g.*, C_2-C_6 haloalkenyl), alkynyl (*e.g.*, C_2-C_6 alkynyl), aryl or heteroaryl, or arylalkyl (*e.g.*, C_7-C_{10} arylalkyl).

[0026] As used herein, the term "alkyl" may be understood to include saturated straight-chained, branched, or cyclic saturated hydrocarbon moieties. Unless otherwise specified, C_1-C_{20} (*e.g.*, C_1-C_{12}, C_1-C_{10}, C_1-C_8, C_1-C_6, or C_1-C_4) alkyl groups are intended. Examples of alkyl groups include methyl, ethyl, propyl, cyclopropyl, 1-methyl-ethyl, butyl, cyclobutyl, 1-methyl-propyl, 2-methyl-propyl, 1,1-dimethyl-ethyl, pentyl, cyclopentyl, 1-methyl-butyl, 2-methyl-butyl, 3-methyl-butyl, 2,2-dimethyl-propyl, 1-ethyl-propyl, hexyl, cyclohexyl, 1,1-dimethyl-propyl, 1,2-dimethyl-propyl, 1-methyl-pentyl, 2-methyl-pentyl, 3-methyl-pentyl, 4-methyl-pentyl, 1,1-dimethyl-butyl, 1,2-dimethyl-butyl, 1,3-dimethyl-butyl, 2,2-dimethyl-butyl, 2,3-dimethyl-butyl, 3,3-dimethyl-butyl, 1-ethyl-butyl, 2-ethyl-butyl, 1,1,2-trimethyl-propyl, 1,2,2-trimethyl-propyl, 1-ethyl-1-methyl-propyl, and 1-ethyl-2-methyl-propyl. Alkyl substituents may also be substituted with one or more chemical moieties. Examples of suitable substituents include, for example, hydroxy, nitro, cyano, formyl, C_1-C_6 alkoxy, C_1-C_6 haloalkoxy, C_1-C_6 acyl, C_1-C_6 alkylthio, C_1-C_6 haloalkylthio, C_1-C_6 alkylsulfinyl, C_1-C_6 haloalkylsulfinyl, C_1-C_6 alkylsulfonyl, C_1-C_6 haloalkylsulfonyl, C_1-C_6 alkoxycarbonyl, C_1-C_6 haloalkoxycarbonyl, C_1-C_6 carbamoyl, C_1-C_6 halocarbamoyl, hydroxycarbonyl, C_1-C_6 alkylcarbonyl, C_1-C_6 haloalkylcarbonyl, aminocarbonyl, C_1-C_6 alkylaminocarbonyl, haloalkylaminocarbonyl, C_1-C_6 dialkylaminocarbonyl, and C_1-C_6 dihaloalkylaminocarbonyl, provided that the substituents are sterically compatible and the rules of chemical bonding and strain energy are satisfied. Preferred substituents include cyano and C_1-C_6 alkoxy.

[0027] As used herein, the term "haloalkyl" may be understood to include alkyl groups wherein the hydrogen atoms may partially or entirely be substituted with halogen atoms. Unless otherwise specified, C_1-C_{20} (*e.g.*, C_1-C_{12}, C_1-C_{10}, C_1-C_8, C_1-C_6, or C_1-C_4) alkyl groups are intended. Examples include chloromethyl, bromomethyl, dichloromethyl, trichloromethyl, fluoromethyl, difluoromethyl, trifluoromethyl, chlorofluoromethyl, dichlorofluoromethyl, chlorodifluoromethyl, 1-chloroethyl, 1-bromoethyl, 1-fluoroethyl, 2-fluoroethyl, 2,2-

difluoroethyl, 2,2,2-trifluoroethyl, 2-chloro-2-fluoroethyl, 2-chloro-2,2-difluoroethyl, 2,2-dichloro-2-fluoroethyl, 2,2,2-trichloroethyl, pentafluoroethyl, and 1,1,1-trifluoroprop-2-yl. Haloalkyl substituents may also be substituted with one or more chemical moieties. Examples of suitable substituents include, for example, hydroxy, nitro, cyano, formyl, C_1-C_6 alkoxy, C_1-C_6 haloalkoxy, C_1-C_6 acyl, C_1-C_6 alkylthio, C_1-C_6 haloalkylthio, C_1-C_6 alkylsulfinyl, C_1-C_6 haloalkylsulfinyl, C_1-C_6 alkylsulfonyl, C_1-C_6 haloalkylsulfonyl, C_1-C_6 alkoxycarbonyl, C_1-C_6 haloalkoxycarbonyl, C_1-C_6 carbamoyl, C_1-C_6 halocarbamoyl, hydroxycarbonyl, C_1-C_6 alkylcarbonyl, C_1-C_6 haloalkylcarbonyl, aminocarbonyl, C_1-C_6 alkylaminocarbonyl, haloalkylaminocarbonyl, C_1-C_6 dialkylaminocarbonyl, and C_1-C_6 dihaloalkylaminocarbonyl, provided that the substituents are sterically compatible and the rules of chemical bonding and strain energy are satisfied. Preferred substituents include cyano and C_1-C_6 alkoxy.

[0028] As used herein, the term “alkoxy” may be understood to include a group of the formula R-O-, where R is unsubstituted or substituted alkyl as defined above. Unless otherwise specified, alkoxy groups wherein R is a C_1-C_{20} (*e.g.*, C_1-C_{12}, C_1-C_{10}, C_1-C_8, C_1-C_6, or C_1-C_4) alkyl group are intended. Examples include methoxy, ethoxy, propoxy, 1-methyl-ethoxy, butoxy, 1-methyl-propoxy, 2-methyl-propoxy, 1,1-dimethyl-ethoxy, pentoxy, 1-methyl-butyloxy, 2-methyl-butoxy, 3-methyl-butoxy, 2,2-dimethyl-propoxy, 1-ethyl-propoxy, hexoxy, 1,1-dimethyl-propoxy, 1,2-dimethyl-propoxy, 1-methyl-pentoxy, 2-methyl-pentoxy, 3-methyl-pentoxy, 4-methyl-penoxy, 1,1-dimethyl-butoxy, 1,2-dimethyl-butoxy, 1,3-dimethyl-butoxy, 2,2-dimethyl-butoxy, 2,3-dimethyl-butoxy, 3,3-dimethyl-butoxy, 1-ethyl-butoxy, 2-ethylbutoxy, 1,1,2-trimethyl-propoxy, 1,2,2-trimethyl-propoxy, 1-ethyl-1-methyl-propoxy, and 1-ethyl-2-methyl-propoxy.

[0029] As used herein, the term "alkoxycarbonyl" may be understood to include a group of the formula -C(O)OR, where R is an unsubstituted or substituted alkyl as defined above. Unless otherwise specified, alkoxycarbonyl groups wherein R is a C_1-C_{20} (*e.g.*, C_1-C_{12}, C_1-C_{10}, C_1-C_8, C_1-C_6, or C_1-C_4) alkyl group are intended. Examples include methoxycarbonyl, ethoxycarbonyl, propoxycarbonyl, 1-methyl-ethoxycarbonyl, butoxycarbonyl, 1-methyl-propoxycarbonyl, 2-methyl-propoxycarbonyl, 1,1-dimethyl-ethoxycarbonyl, pentoxycarbonyl, 1-methyl-butoxycarbonyl, 2-methyl-butoxycarbonyl, 3-methyl-butoxycarbonyl, 2,2-dimethyl-propoxycarbonyl, 1-ethyl-propoxycarbonyl, hexoxycarbonyl, 1,1-dimethyl-propoxycarbonyl, 1,2-dimethyl-propoxycarbonyl, 1-methyl-pentoxycarbonyl, 2-methyl-pentoxycarbonyl, 3-methyl-pentoxycarbonyl, 4-methyl-penoxycarbonyl, 1,1-dimethyl-butoxycarbonyl, 1,2-dimethyl-butoxycarbonyl, 1,3-dimethyl-butoxycarbonyl, 2,2-dimethyl-butoxycarbonyl, 2,3-

dimethyl-butoxycarbonyl, 3,3-dimethyl-butoxycarbonyl, 1-ethyl-butoxycarbonyl, 2-ethylbutoxycarbonyl, 1,1,2-trimethyl-propoxycarbonyl, 1,2,2-trimethyl-propoxycarbonyl, 1-ethyl-1-methyl-propoxycarbonyl, and 1-ethyl-2-methyl-propoxycarbonyl.

[0030] As used herein, the term "haloalkoxy" may be understood to include a group of the formula R-O-, where R is unsubstituted or substituted haloalkyl as defined above. Unless otherwise specified, haloalkoxy groups wherein R is a C_1-C_{20} (*e.g.*, C_1-C_{12}, C_1-C_{10}, C_1-C_8, C_1-C_6, or C_1-C_4) alkyl group are intended. Examples include chloromethoxy, bromomethoxy, dichloromethoxy, trichloromethoxy, fluoromethoxy, difluoromethoxy, trifluoromethoxy, chlorofluoromethoxy, dichlorofluoromethoxy, chlorodifluoromethoxy, 1-chloroethoxy, 1-bromoethoxy, 1-fluoroethoxy, 2-fluoroethoxy, 2,2-difluoroethoxy, 2,2,2-trifluoroethoxy, 2-chloro-2-fluoroethoxy, 2-chloro-2,2-difluoroethoxy, 2,2-dichloro-2-fluoroethoxy, 2,2,2-trichloroethoxy, pentafluoroethoxy, and 1,1,1-trifluoroprop-2-oxy.

[0031] As used herein, the term "aryl," as well as derivative terms such as aryloxy, may be understood to include groups that include a monovalent aromatic carbocyclic group of from 6 to 14 carbon atoms. Aryl groups can include a single ring or multiple condensed rings. In some aspects, aryl groups include C_6-C_{10} aryl groups. Examples of aryl groups include, but are not limited to, phenyl, biphenyl, naphthyl, tetrahydronaphthyl, phenylcyclopropyl, and indanyl. In some aspects, the aryl group can be a phenyl, indanyl or naphthyl group.

[0032] As used herein, the term "heteroaryl," as well as derivative terms such as "heteroaryloxy," may be understood to include a 5- or 6-membered aromatic ring containing one or more heteroatoms, for example, N, O or S. Heteroaryl rings may be fused to other aromatic systems. The aryl or heteroaryl substituents may also be substituted with one or more chemical moieties. Examples of suitable substituents include, for example, hydroxy, nitro, cyano, formyl, C_1-C_6 alkyl, C_2-C_6 alkenyl, C_2-C_6 alkynyl, C_1-C_6 alkoxy, C_1-C_6 haloalkyl, C_1-C_6 haloalkoxy, C_1-C_6 acyl, C_1-C_6 alkylthio, C_1-C_6 alkylsulfinyl, C_1-C_6 alkylsulfonyl, C_1-C_6 alkoxycarbonyl, C_1-C_6 carbamoyl, hydroxycarbonyl, C_1-C_6 alkylcarbonyl, aminocarbonyl, C_1-C_6 alkylaminocarbonyl, C_1-C_6 dialkylaminocarbonyl, provided that the substituents are sterically compatible and the rules of chemical bonding and strain energy are satisfied. Preferred substituents include halogen, C_1-C_4 alkyl and C_1-C_4 haloalkyl.

[0033] As used herein, the term "halogen," including derivative terms such as "halo," refers to fluorine, chlorine, bromine and iodine.

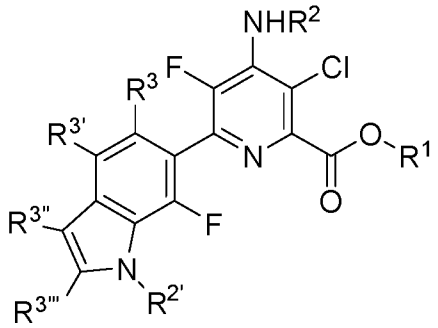
[0034] As used herein, agriculturally acceptable salts and esters may be understood to include salts and esters that exhibit herbicidal activity, or that are or can be converted in plants,

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.

[0035] Compounds described herein can include N-oxides. Pyridine N-oxides can be obtained by oxidation of the corresponding pyridines. Suitable oxidation methods are described, for example, in Houben-Weyl, *Methoden der organischen Chemie* [*Methods in organic chemistry*], expanded and subsequent volumes to the 4th edition, volume E 7b, p. 565 f.

II. Pyridine carboxylate Herbicides

[0036] Compositions and methods of the present disclosure include a composition comprising (a) a pyridine carboxylate herbicide defined by Formula (I):



Formula I

wherein:

R^1 is cyanomethyl or propargyl;

R^2 and $R^{2'}$ are independently hydrogen, C_1-C_6 alkyl, formyl, alkoxycarbonyl, or acyl;

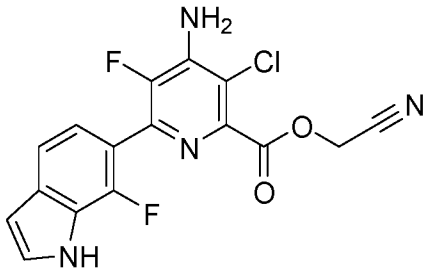
R^3, $R^{3'}$, $R^{3''}$, and $R^{3'''}$ are independently hydrogen, halogen, C_1-C_4 alkyl, C_1-C_4 haloalkyl, C_1-C_3 alkoxy, or C_1-C_3 haloalkoxy;

or an agriculturally acceptable N-oxide, salt, or ester thereof; and

(b) a phytoene desaturase (PDS) inhibitor or an agriculturally acceptable salt or ester thereof.

[0037] In some aspects, the composition comprises:

(a) the pyridine carboxylate herbicide compound cyanomethyl 4-amino-3-chloro-5-fluoro-6-(7-fluoro-1H-indol-6-yl)pyridine-2-carboxylate, referred to hereinafter as Compound A:



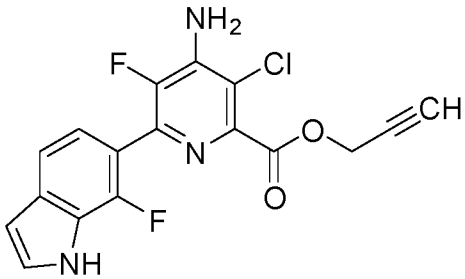
Compound A

or an agriculturally acceptable N-oxide, salt, or ester thereof; and

(b) a phytoene desaturase (PDS) inhibitor or an agriculturally acceptable salt or ester thereof.

[0038] In some aspects, the composition comprises:

(a) the pyridine carboxylate herbicide compound propargyl 4-amino-3-chloro-5-fluoro-6-(7-fluoro-1H-indol-6-yl)pyridine-2-carboxylate, referred to hereinafter as Compound B:



Compound B

or an agriculturally acceptable N-oxide, salt, or ester thereof; and

(b) a phytoene desaturase (PDS) inhibitor or an agriculturally acceptable salt or ester thereof.

[0039] Pyridine carboxylate herbicides defined by Formula (I), as well as methods of making these pyridine carboxylate herbicides, are disclosed in application PCT/US2018/031004, filed May 4, 2018, the entire disclosure of which is hereby expressly incorporated by reference.

[0040] In some aspects, the pyridine carboxylate herbicide can be provided as an agriculturally acceptable salt. Exemplary agriculturally acceptable salts of the pyridine carboxylate herbicides include, but are not limited to: sodium salts; potassium salts; ammonium salts or substituted ammonium salts, in particular mono-, di- and tri-C_1-C_8–alkylammonium salts such as methyl ammonium, dimethylammonium and isopropylammonium; mono-, di- and tri-hydroxy-C_2-C_8-alkylammonium salts such as hydroxyethylammonium, di(hydroxyethyl)ammonium, tri(hydroxyethyl)ammonium, hydroxypropylammonium,

di(hydroxypropyl)ammonium and tri(hydroxypropyl)- ammonium salts; olamine salts; diglycolamine salts; choline salts; and quaternary ammonium salts such as those represented by the formula $R^9R^{10}R^{11}R^{12}N^+$ and wherein R^9, R^{10}, R^{11} and R^{12} (*e.g.*, R^9-R^{12}) each independently can represent hydrogen, C_1-C_{10} alkyl, C_2-C_8 alkenyl, C_2-C_8 alkynyl, C_1-C_8 alkoxy, C_1-C_8 alkylthio, or aryl groups, provided that R^9-R^{12} are sterically compatible.

[0041] In some aspects, the pyridine carboxylate herbicide can be provided as an agriculturally acceptable ester. Exemplary agriculturally acceptable esters of the pyridine carboxylate herbicides include, but are not limited to: methyl, ethyl, propyl, 1-methyl-ethyl, butyl, 1-methyl-propyl, 2-methyl-propyl, pentyl, 1-methyl-butyl, 2-methyl-butyl, 3-methyl-butyl, 1-ethyl-propyl, hexyl, 1-methyl-hexyl (mexyl), 2-ethylhexyl, heptyl, 1-methyl-heptyl (meptyl), octyl, isooctyl (isoctyl), butoxyethyl (butotyl), and benzyl.

[0042] The pyridine carboxylate herbicide, or an agriculturally acceptable N-oxide, salt, or ester thereof, can be applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount sufficient to induce a herbicidal effect. In some aspects, the pyridine carboxylate herbicide, or an agriculturally acceptable N-oxide, salt, or ester thereof, is applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount of 0.1 grams acid equivalent per hectare (g ae/ha) or greater, such as 0.2 g ae/ha or greater, 0.3 g ae/ha or greater, 0.4 g ae/ha or greater, 0.5 g ae/ha or greater, 0.6 g ae/ha or greater, 0.7 g ae/ha or greater, 0.8 g ae/ha or greater, 0.9 g ae/ha or greater, 1 g ae/ha or greater, 1.1 g ae/ha or greater, 1.2 g ae/ha or greater, 1.3 g ae/ha or greater, 1.4 g ae/ha or greater, 1.5 g ae/ha or greater, 1.6 g ae/ha or greater, 1.7 g ae/ha or greater, 1.8 g ae/ha or greater, 1.9 g ae/ha or greater, 2 g ae/ha or greater, 2.25 g ae/ha or greater, 2.5 g ae/ha or greater, 2.75 g ae/ha or greater, 3 g ae/ha or greater, 4 g ae/ha or greater, 5 g ae/ha or greater, 6 g ae/ha or greater, 7 g ae/ha or greater, 8 g ae/ha or greater, 9 g ae/ha or greater, 10 g ae/ha or greater, 11 g ae/ha or greater, 12 g ae/ha or greater, 13 g ae/ha or greater, 14 g ae/ha or greater, 15 g ae/ha or greater, 16 g ae/ha or greater, 17 g ae/ha or greater, 18 g ae/ha or greater, 19 g ae/ha or greater, 20 g ae/ha or greater, 22 g ae/ha or greater, 24 g ae/ha or greater, 25 g ae/ha or greater, 26 g ae/ha or greater, 28 g ae/ha or greater, 30 g ae/ha or greater, 32 g ae/ha or greater, 34 g ae/ha or greater, 35 g ae/ha or greater, 36 g ae/ha or greater, 38 g ae/ha or greater, 40 g ae/ha or greater, 42.5 g ae/ha or greater, 45 g ae/ha or greater, 47.5 g ae/ha or greater, 50 g ae/ha or greater, 52.5 g ae/ha or greater, 55 g ae/ha or greater, 57.5 g ae/ha or greater, 60 g ae/ha or greater, 65 g ae/ha or greater, 70 g ae/ha or greater, 75 g ae/ha or greater, 80 g ae/ha or greater, 85 g ae/ha or greater, 90 g ae/ha or greater,

95 g ae/ha or greater, 100 g ae/ha or greater, 110 g ae/ha or greater, 120 g ae/ha or greater, 130 g ae/ha or greater, 140 g ae/ha or greater, 150 g ae/ha or greater, 160 g ae/ha or greater, 170 g ae/ha or greater, 180 g ae/ha or greater, 190 g ae/ha or greater, 200 g ae/ha or greater, 210 g ae/ha or greater, 220 g ae/ha or greater, 230 g ae/ha or greater, 240 g ae/ha or greater, 250 g ae/ha or greater, 260 g ae/ha or greater, 270 g ae/ha or greater, 280 g ae/ha or greater, or 290 g ae/ha or greater; in an amount of 300 g ae/ha or less, such as 290 g ae/ha or less, 280 g ae/ha or less, 270 g ae/ha or less, 260 g ae/ha or less, 250 g ae/ha or less, 240 g ae/ha or less, 230 g ae/ha or less, 220 g ae/ha or less, 210 g ae/ha or less, 200 g ae/ha or less, 190 g ae/ha or less, 180 g ae/ha or less, 170 g ae/ha or less, 160 g ae/ha or less, 150 g ae/ha or less, 140 g ae/ha or less, 130 g ae/ha or less, 120 g ae/ha or less, 110 g ae/ha or less, 100 g ae/ha or less, 95 g ae/ha or less, 90 g ae/ha or less, 85 g ae/ha or less, 80 g ae/ha or less, 75 g ae/ha or less, 70 g ae/ha or less, 65 g ae/ha or less, 60 g ae/ha or less, 57.5 g ae/ha or less, 55 g ae/ha or less, 52.5 g ae/ha or less, 50 g ae/ha or less, 47.5 g ae/ha or less, 45 g ae/ha or less, 42.5 g ae/ha or less, 40 g ae/ha or less, 38 g ae/ha or less, 36 g ae/ha or less, 35 g ae/ha or less, 34 g ae/ha or less, 32 g ae/ha or less, 30 g ae/ha or less, 28 g ae/ha or less, 26 g ae/ha or less, 25 g ae/ha or less, 24 g ae/ha or less, 22 g ae/ha or less, 20 g ae/ha or less, 19 g ae/ha or less, 18 g ae/ha or less, 17 g ae/ha or less, 16 g ae/ha or less, 15 g ae/ha or less, 14 g ae/ha or less, 13 g ae/ha or less, 12 g ae/ha or less, 11 g ae/ha or less, 10 g ae/ha or less, 9 g ae/ha or less, 8 g ae/ha or less, 7 g ae/ha or less, 6 g ae/ha or less, 5 g ae/ha or less, 4 g ae/ha or less, 3 g ae/ha or less, 2.75 g ae/ha or less, 2.5 g ae/ha or less, 2.25 g ae/ha or less, 2 g ae/ha or less, 1.9 g ae/ha or less, 1.8 g ae/ha or less, 1.7 g ae/ha or less, 1.6 g ae/ha or less, 1.5 g ae/ha or less, 1.4 g ae/ha or less, 1.3 g ae/ha or less, 1.2 g ae/ha or less, 1.1 g ae/ha or less, 1 g ae/ha or less, 0.9 g ae/ha or less, 0.8 g ae/ha or less, 0.7 g ae/ha or less, 0.6 g ae/ha or less, 0.5 g ae/ha or less, 0.4 g ae/ha or less, 0.3 g ae/ha or less, or 0.2 g ae/ha or less; or in an amount within any range defined between any pair of the preceding values, such as 0.1-300 g ae/ha, 1-150 g ae/ha, 10-200 g ae/ha, 25 g ae/ha-75 g ae/ha, or 40-100 g ae/ha.

III. PDS Inhibitor Herbicides

[0043] In addition to the pyridine carboxylate herbicide or agriculturally acceptable N-oxide, salt or ester thereof, the compositions can include a phytoene desaturase (PDS) inhibitor herbicide or agriculturally acceptable salt or ester thereof. PDS inhibitors block carotenoid biosynthesis by inhibition of phytoene desaturase, a key enzyme in the carotenoid biosynthesis pathway. An absence of carotenoids leads to destruction of membrane fatty acid and chlorophyll by excessive energy. Examples of PDS inhibitors include, but are not limited to, beflubutamid, diflufenican, fluridone, flurochloridone, flurtamone, norflurazon, and picolinafen.

[0044] In some aspects, the composition can include a PDS inhibitor herbicide selected from the group consisting of beflubutamid, diflufenican, fluridone, flurochloridone, flurtamone, norflurazon, picolinafen, agriculturally acceptable salts and esters thereof, and combinations thereof.

[0045] The PDS inhibitor herbicide or agriculturally acceptable salt or ester thereof can be applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount sufficient to induce a herbicidal effect. In some aspects, the PDS inhibitor herbicide or agriculturally acceptable salt or ester thereof is applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount of 12.5 gram active ingredient per hectare (g ai/ha) or more, such as 15 g ai/ha or more, 20 g ai/ha or more, 25 g ai/ha or more, 30 g ai/ha or more, 35 g ai/ha or more, 40 g ai/ha or more, 45 g ai/ha or more, 50 g ai/ha or more, 55 g ai/ha or more, 60 g ai/ha or more, 65 g ai/ha or more, 70 g ai/ha or more, 75 g ai/ha or more, 80 g ai/ha or more, 85 g ai/ha or more, 90 g ai/ha or more, 95 g ai/ha or more, 100 g ai/ha or more, 110 g ai/ha or more, 120 g ai/ha or more, 130 g ai/ha or more, 140 g ai/ha or more, 150 g ai/ha or more, 160 g ai/ha or more, 170 g ai/ha or more, 180 g ai/ha or more, 190 g ai/ha or more, 200 g ai/ha or more, 220 g ai/ha or more, 240 g ai/ha or more, 250 g ai/ha or more, 260 g ai/ha or more, 280 g ai/ha or more, 300 g ai/ha or more, 320 g ai/ha or more, 340 g ai/ha or more, 350 g ai/ha or more, 360 g ai/ha or more, 380 g ai/ha or more, 400 g ai/ha or more, 450 g ai/ha or more, 500 g ai/ha or more, 550 g ai/ha or more, 600 g ai/ha or more, 650 g ai/ha or more, 700 g ai/ha or more, 750 g ai/ha or more, 800 g ai/ha or more, 850 g ai/ha or more, 900 g ai/ha or more, 950 g ai/ha or more, 1000 g ai/ha or more, 1050 g ai/ha or more, 1100 g ai/ha or more, 1150 g ai/ha or more, 1200 g ai/ha or more, 1250 g ai/ha or more, 1300 g ai/ha or more, 1350 g ai/ha or more, 1400 g ai/ha or more, 1450 g ai/ha or more, 1500 g ai/ha or more, 1600 g ai/ha or more, 1700 g ai/ha or more, 1800 g ai/ha or more, 1900 g ai/ha or more, 2000 g ai/ha or more, 2050 g ai/ha or more, 2100 g ai/ha or more, 2150 g ai/ha or more, 2200 g ai/ha or more, 2240 g ai/ha or more, 2250 g ai/ha or more, 2300 g ai/ha or more, 2350 g ai/ha or more, 2400 g ai/ha or more, 2450 g ai/ha or more, 2500 g ai/ha or more, 2600 g ai/ha or more, 2700 g ai/ha or more, 2750 g ai/ha or more, 2800 g ai/ha or more, 2900 g ai/ha or more, 3000 g ai/ha or more, 3100 g ai/ha or more, 3200 g ai/ha or more, 3250 g ai/ha or more, 3300 g ai/ha or more, 3400 g ai/ha or more, 3500 g ai/ha or more, 3600 g ai/ha or more, 3700 g ai/ha or more, 3750 g ai/ha or more, 3800 g ai/ha or more, 3900 g ai/ha or more, 3950 g ai/ha or more, 4000 g ai/ha or more, 4100 g ai/ha or more, 4200 g ai/ha or more, 4250 g ai/ha or more, 4300 g ai/ha or more, 4400 g ai/ha or more, or 4450 g ai/ha or more; in an amount of 4500 g ai/ha or less, such as 4450 g ai/ha or less, 4400 g ai/ha or less, 4300 g ai/ha or less,

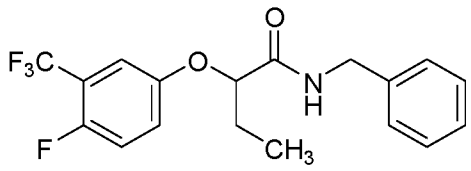
4250 g ai/ha or less, 4100 g ai/ha or less, 4000 g ai/ha or less, 3950 g ai/ha or less, 3900 g ai/ha or less, 3800 g ai/ha or less, 3750 g ai/ha or less, 3700 g ai/ha or less, 3600 g ai/ha or less, 3500 g ai/ha or less, 3400 g ai/ha or less, 3300 g ai/ha or less, 3250 g ai/ha or less, 3200 g ai/ha or less, 3100 g ai/ha or less, 3000 g ai/ha or less, 2900 g ai/ha or less, 2800 g ai/ha or less, 2750 g ai/ha or less, 2700 g ai/ha or less, 2600 g ai/ha or less, 2500 g ai/ha or less, 2450 g ai/ha or less, 2400 g ai/ha or less, 2350 g ai/ha or less, 2300 g ai/ha or less, 2250 g ai/ha or less, 2240 g ai/ha or less, 2200 g ai/ha or less, 2150 g ai/ha or less, 2100 g ai/ha or less, 2050 g ai/ha or less, 2000 g ai/ha or less, 1900 g ai/ha or less, 1800 g ai/ha or less, 1750 g ai/ha or less, 1700 g ai/ha or less, 1600 g ai/ha or less, 1500 g ai/ha or less, 1450 g ai/ha or less, 1400 g ai/ha or less, 1350 g ai/ha or less, 1300 g ai/ha or less, 1250 g ai/ha or less, 1240 g ai/ha or less, 1200 g ai/ha or less, 1150 g ai/ha or less, 1100 g ai/ha or less, 1050 g ai/ha or less, 1000 g ai/ha or less, 950 g ai/ha or less, 900 g ai/ha or less, 850 g ai/ha or less, 800 g ai/ha or less, 750 g ai/ha or less, 700 g ai/ha or less, 650 g ai/ha or less, 600 g ai/ha or less, 550 g ai/ha or less, 500 g ai/ha or less, 450 g ai/ha or less, 400 g ai/ha or less, 380 g ai/ha or less, 360 g ai/ha or less, 350 g ai/ha or less, 340 g ai/ha or less, 320 g ai/ha or less, 300 g ai/ha or less, 280 g ai/ha or less, 260 g ai/ha or less, 250 g ai/ha or less, 240 g ai/ha or less, 220 g ai/ha or less, 200 g ai/ha or less, 190 g ai/ha or less, 180 g ai/ha or less, 170 g ai/ha or less, 160 g ai/ha or less, 150 g ai/ha or less, 140 g ai/ha or less, 130 g ai/ha or less, 120 g ai/ha or less, 110 g ai/ha or less, 100 g ai/ha or less, 95 g ai/ha or less, 90 g ai/ha or less, 85 g ai/ha or less, 80 g ai/ha or less, 75 g ai/ha or less, 70 g ai/ha or less, 65 g ai/ha or less, 60 g ai/ha or less, 55 g ai/ha or less, 50 g ai/ha or less, 45 g ai/ha or less, 40 g ai/ha or less, 35 g ai/ha or less, 30 g ai/ha or less, 25 g ai/ha or less, 20 g ai/ha or less, or 15 g ai/ha or less; or in an amount ranging from any of the minimum values described above to any of the maximum values described above, such as 12.5–4500 g ai/ha, 15–2250 g ai/ha, 20-2500 g ai/ha, 25–3150 g ai/ha, 30–900 g ai/ha, 45–4200 g ai/ha, 50–1200 g ai/ha, 50–4100 g ai/ha, 60–750 g ai/ha, 75–2100 g ai/ha, 100–4000 g ai/ha, 200–3600 g ai/ha, 250–3000 g ai/ha, 250–1000 g ai/ha, 700–4250 g ai/ha, 800–1400 g ai/ha, or 1000–3700 g ai/ha.

[0046] In some aspects, the composition contains (a) a pyridine carboxylate herbicide or an agriculturally acceptable N-oxide, salt, or ester thereof, and (b) diflufenican, flurtamone, picolinafen, or mixtures thereof.

Beflubutamid

[0047] In some aspects, the PDS inhibitor herbicide can comprise beflubutamid or an agriculturally acceptable salt or ester thereof. Beflubutamid, shown below, is 2-[4-fluoro-3-(trifluoromethyl)phenoxy]-*N*-(phenylmethyl)butanamide. Its herbicidal activity is exemplified

in Tomlin, C. D. S., Ed. *The Pesticide Manual: A World Compendium*, 17th ed.; BCPC: Alton, 2016 (hereafter "*The Pesticide Manual*, Seventeenth Edition, 2016"). Exemplary uses of beflubutamid include its use alone, and in mixture with isoproturon, for pre- and early post-emergence control of broadleaf weeds, such as *Veronica persica*, *Lamium amplexicaule* and *Viola arvensis*, in wheat and barley.

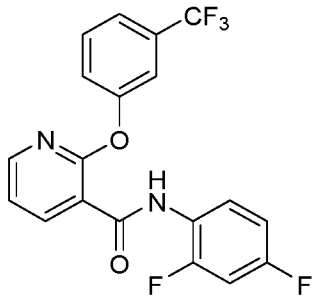


[0048] Beflubutamid can be applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount sufficient to induce a herbicidal effect. In some aspects, beflubutamid is applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount of 25 g ai/ha or more, such as 30 g ai/ha or more, 35 g ai/ha or more, 40 g ai/ha or more, 42.5 g ai/ha or more, 45 g ai/ha or more, 50 g ai/ha or more, 60 g ai/ha or more, 70 g ai/ha or more, 80 g ai/ha or more, 90 g ai/ha or more, 100 g ai/ha or more, 110 g ai/ha or more, 120 g ai/ha or more, 130 g ai/ha or more, 140 g ai/ha or more, 150 g ai/ha or more,160 g ai/ha or more, 170 g ai/ha or more, 180 g ai/ha or more, 190 g ai/ha or more, 200 g ai/ha or more, 220 g ai/ha or more, 240 g ai/ha or more, 250 g ai/ha or more, 255 g ai/ha or more, 260 g ai/ha or more, 270 g ai/ha or more, 275 g ai/ha or more, 280 g ai/ha or more, or 290 g ai/ha or more; in an amount of 300 g ai/ha or less, such as 290 g ai/ha or less, 280 g ai/ha or less, 275 g ai/ha or less, 270 g ai/ha or less, 260 g ai/ha or less, 255 g ai/ha or less, 250 g ai/ha or less, 240 g ai/ha or less, 220 g ai/ha or less, 200 g ai/ha or less, 190 g ai/ha or less, 180 g ai/ha or less, 170 g ai/ha or less, 160 g ai/ha or less, 150 g ai/ha or less, 140 g ai/ha or less, 130 g ai/ha or less, 120 g ai/ha or less, 110 g ai/ha or less, 100 g ai/ha or less, 90 g ai/ha or less, 80 g ai/ha or less, 70 g ai/ha or less, 60 g ai/ha or less, 50 g ai/ha or less, 45 g ai/ha or less, 42.5 g ai/ha or less, 40 g ai/ha or less, 35 g ai/ha or less, or 30 g ai/ha or less; or in an amount ranging from any of the minimum values described above to any of the maximum values described above, such as 25-300 g ai/ha, 45–250 g ai/ha, 60-275 g ai/ha, 120–255 g ai/ha, 90–200 g ai/ha, 130–260 g ai/ha, 150–275 g ai/ha, or 42.5–300 g ai/ha.

Diflufenican

[0049] In some aspects, the PDS inhibitor herbicide can comprise diflufenican or an agriculturally acceptable salt or ester thereof. Diflufenican, as well as methods of preparing

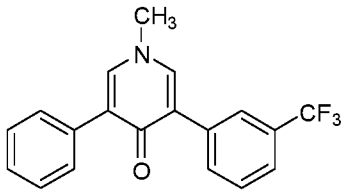
diflufenican, are known in the art. Diflufenican, shown below, is *N*-(2,4-difluorophenyl)-2-[3-(trifluoromethyl)phenoxy]-3-pyridinecarboxamide. Its herbicidal activity is exemplified in *The Pesticide Manual*, Seventeenth Edition, 2016. Exemplary uses of diflufenican include its use as a selective contact and residual herbicide that is used pre- and early post-emergence in autumn-sown wheat and barley to control grass and broadleaf weeds.



[0050] Diflufenican can be applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount sufficient to induce a herbicidal effect. In some aspects, diflufenican is applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount of 50 g ai/ha or more, such as 55 g ai/ha or more, 60 g ai/ha or more, 65 g ai/ha or more, 70 g ai/ha or more, 75 g ai/ha or more, 80 g ai/ha or more, 85 g ai/ha or more, 90 g ai/ha or more, 95 g ai/ha or more, 100 g ai/ha or more, 105 g ai/ha or more, 110 g ai/ha or more, 115 g ai/ha or more, 120 g ai/ha or more, 125 g ai/ha or more, 130 g ai/ha or more, 135 g ai/ha or more, 140 g ai/ha or more, 145 g ai/ha or more, 150 g ai/ha or more, 155 g ai/ha or more, 160 g ai/ha or more, 165 g ai/ha or more, 170 g ai/ha or more, 175 g ai/ha or more, 180 g ai/ha or more, or 185 g ai/ha or more; in an amount of 187.5 g ai/ha or less, such as 185 g ai/ha or less, 180 g ai/ha or less, 175 g ai/ha or less, 170 g ai/ha or less, 165 g ai/ha or less, 160 g ai/ha or less, 155 g ai/ha or less, 150 g ai/ha or less, 145 g ai/ha or less, 140 g ai/ha or less, 135 g ai/ha or less, 130 g ai/ha or less, 125 g ai/ha or less, 120 g ai/ha or less, 115 g ai/ha or less, 110 g ai/ha or less, 105 g ai/ha or less, 100 g ai/ha or less, 95 g ai/ha or less, 90 g ai/ha or less, 85 g ai/ha or less, 80 g ai/ha or less, 75 g ai/ha or less, 70 g ai/ha or less, 65 g ai/ha or less, 60 g ai/ha or less, or 55 g ai/ha or less; or in an amount ranging from any of the minimum values described above to any of the maximum values described above, such as 50–187.5 g ai/ha, 55–180 g ai/ha, 60–175 g ai/ha, 65–150 g ai/ha, 70–175 g ai/ha, 75–160 g ai/ha, 80–180 g ai/ha, 80–175 g ai/ha, 85–185 g ai/ha, 85–150 g ai/ha, 90–185 g ai/ha, 90–180 g ai/ha, 90–175 g ai/ha, or 90–170 g ai/ha.

Fluridone

[0051] In some aspects, the PDS inhibitor herbicide can comprise fluridone or an agriculturally acceptable salt or ester thereof. Fluridone, shown below, is 1-methyl-3-phenyl-5-[3-(trifluoromethyl)- phenyl]-4(1*H*)-pyridinone. Its herbicidal activity is exemplified in *The Pesticide Manual*, Seventeenth Edition, 2016. Exemplary uses of fluridone include its use as an aquatic herbicide for control of most submerged and emerged aquatic plants (including *Utricularia* spp., *Ceratophyllum demersum*, *Elodea canadensis*, *Myriophyllum* spp., *Najas guadalupensis*, *Potamogeton* spp., *Hydrilla verticillata* and *Panicum purpurascens*) in ponds, lakes, reservoirs, irrigation ditches.

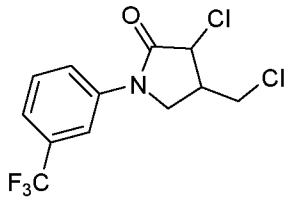


[0052] Fluridone can be applied to vegetation or an area adjacent the vegetation or applied to water to prevent the emergence or growth of vegetation in an amount sufficient to induce a herbicidal effect. In some aspects, fluridone can be applied to water to prevent the emergence or growth of vegetation in an amount of 200 g ai/ha or more, such as 220 g ai/ha or more, 240 g ai/ha or more, 250 g ai/ha or more, 260 g ai/ha or more, 280 g ai/ha or more, 300 g ai/ha or more, 320 g ai/ha or more, 340 g ai/ha or more, 350 g ai/ha or more, 360 g ai/ha or more, 380 g ai/ha or more, 400 g ai/ha or more, 450 g ai/ha or more, 500 g ai/ha or more, 550 g ai/ha or more, 600 g ai/ha or more, 650 g ai/ha or more, 700 g ai/ha or more, 750 g ai/ha or more, 800 g ai/ha or more, or 850 g ai/ha or more; in an amount of 900 g ai/ha or less, such as 850 g ai/ha or less, 800 g ai/ha or less, 750 g ai/ha or less, 700 g ai/ha or less, 650 g ai/ha or less, 600 g ai/ha or less, 550 g ai/ha or less, 500 g ai/ha or less, 450 g ai/ha or less, 400 g ai/ha or less, 380 g ai/ha or less, 360 g ai/ha or less, 350 g ai/ha or less, 340 g ai/ha or less, 320 g ai/ha or less, 300 g ai/ha or less, 280 g ai/ha or less, 260 g ai/ha or less, 250 g ai/ha or less, 240 g ai/ha or less, or 220 g ai/ha or less; or in an amount ranging from any of the minimum values described above to any of the maximum values described above, such as 200-900 g ai/ha, 280-750 g ai/ha, 250–800 g ai/ha, 450–600 g ai/ha, 350–700 g ai/ha, 250–650 g ai/ha, 400–700 g ai/ha, or 220–900 g ai/ha.

Flurochloridone

[0053] In some aspects, the PDS inhibitor herbicide can comprise flurochloridone or an agriculturally acceptable salt or ester thereof. Flurochloridone, shown below, is 3-chloro-4-

(chloromethyl)-1-[3-(trifluoromethyl)phenyl]-2-pyrrolidinone. Its herbicidal activity is exemplified in *The Pesticide Manual*, Seventeenth Edition, 2016. Exemplary uses of flurochloridone include its use for pre-emergence control of a wide range of broadleaf and grass weeds in sunflowers, carrots and other umbelliferous crops, winter wheat, winter rye, and potatoes.

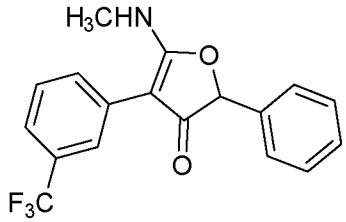


[0054] Flurochloridone can be applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount sufficient to induce a herbicidal effect. In some aspects, flurochloridone is applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount of 200 g ai/ha or more, such as 220 g ai/ha or more, 240 g ai/ha or more, 250 g ai/ha or more, 260 g ai/ha or more, 280 g ai/ha or more, 300 g ai/ha or more, 320 g ai/ha or more, 340 g ai/ha or more, 350 g ai/ha or more, 360 g ai/ha or more, 380 g ai/ha or more, 400 g ai/ha or more, 450 g ai/ha or more, 500 g ai/ha or more, 550 g ai/ha or more, 600 g ai/ha or more, 650 g ai/ha or more, 700 g ai/ha or more, 750 g ai/ha or more, 800 g ai/ha or more, or 850 g ai/ha or more; in an amount of 900 g ai/ha or less, such as 850 g ai/ha or less, 800 g ai/ha or less, 750 g ai/ha or less, 700 g ai/ha or less, 650 g ai/ha or less, 600 g ai/ha or less, 550 g ai/ha or less, 500 g ai/ha or less, 450 g ai/ha or less, 400 g ai/ha or less, 380 g ai/ha or less, 360 g ai/ha or less, 350 g ai/ha or less, 340 g ai/ha or less, 320 g ai/ha or less, 300 g ai/ha or less, 280 g ai/ha or less, 260 g ai/ha or less, 250 g ai/ha or less, 240 g ai/ha or less, or 220 g ai/ha or less; or in an amount ranging from any of the minimum values described above to any of the maximum values described above, such as 200-900 g ai/ha, 220-750 g ai/ha, 250–800 g ai/ha, 450–900 g ai/ha, 350–700 g ai/ha, 250–600 g ai/ha, 400–700 g ai/ha, or 500–900 g ai/ha.

Flurtamone

[0055] In some aspects, the PDS inhibitor herbicide can comprise flurtamone or an agriculturally acceptable salt or ester thereof. Flurtamone, shown below, is (±)-5-(methylamino)-2-phenyl-4-[3-(trifluoromethyl)phenyl]-3(2*H*)-furanone. Its herbicidal activity is exemplified in *The Pesticide Manual*, Seventeenth Edition, 2016. Exemplary uses of

flurtamone include its use for pre-plant incorporated, pre-emergence or post emergence control of broadleaf and some grass weeds in small grains, peanuts, cotton, peas and sunflowers.

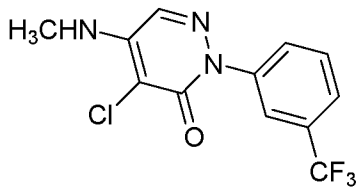


[0056] Flurtamone can be applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount sufficient to induce a herbicidal effect. In some aspects, flurtamone is applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount of 40 g ai/ha or more, such as 42.5 g ai/ha or more, 45 g ai/ha or more, 50 g ai/ha or more, 60 g ai/ha or more, 70 g ai/ha or more, 80 g ai/ha or more, 90 g ai/ha or more, 100 g ai/ha or more, 110 g ai/ha or more, 120 g ai/ha or more, 130 g ai/ha or more, 140 g ai/ha or more, 150 g ai/ha or more,160 g ai/ha or more, 170 g ai/ha or more, 180 g ai/ha or more, 190 g ai/ha or more, 200 g ai/ha or more, 220 g ai/ha or more, 240 g ai/ha or more, 250 g ai/ha or more, 255 g ai/ha or more, 260 g ai/ha or more, 265 g ai/ha or more, 270 g ai/ha or more, 275 g ai/ha or more, 280 g ai/ha or more, 285 g ai/ha or more, 290 g ai/ha or more, 295 g ai/ha or more, 300 g ai/ha or more, 305 g ai/ha or more, 310 g ai/ha or more, 315 g ai/ha or more, 320 g ai/ha or more, 325 g ai/ha or more, 330 g ai/ha or more, 335 g ai/ha or more, 340 g ai/ha or more, 345 g ai/ha or more, 350 g ai/ha or more, 355 g ai/ha or more, 360 g ai/ha or more, 365 g ai/ha or more, or 370 g ai/ha or more; in an amount of 375 g ai/ha or less, such as 370 g ai/ha or less, 365 g ai/ha or less, 360 g ai/ha or less, 355 g ai/ha or less, 350 g ai/ha or less, 345 g ai/ha or less, 340 g ai/ha or less, 335 g ai/ha or less, 330 g ai/ha or less, 325 g ai/ha or less, 320 g ai/ha or less, 315 g ai/ha or less, 310 g ai/ha or less, 305 g ai/ha or less, 300 g ai/ha or less, 295 g ai/ha or less, 290 g ai/ha or less, 285 g ai/ha or less, 280 g ai/ha or less, 275 g ai/ha or less, 270 g ai/ha or less, 265 g ai/ha or less, 260 g ai/ha or less, or 255 g ai/ha or less, 250 g ai/ha or less, 240 g ai/ha or less, 220 g ai/ha or less, 200 g ai/ha or less, 190 g ai/ha or less, 180 g ai/ha or less, 170 g ai/ha or less, 160 g ai/ha or less, 150 g ai/ha or less, 140 g ai/ha or less, 130 g ai/ha or less, 120 g ai/ha or less, 110 g ai/ha or less, 100 g ai/ha or less, 90 g ai/ha or less, 80 g ai/ha or less, 70 g ai/ha or less, 60 g ai/ha or less, 50 g ai/ha or less, 45 g ai/ha or less, or 42.5 g ai/ha or less; or in an amount ranging from any of the minimum values described above to any of the maximum values described above, such as 40–375 g ai/ha, 125–355 g ai/ha, 60–335 g ai/ha, 80–300 g ai/ha, 265–375 g ai/ha, 170–

325 g ai/ha, 45–300 g ai/ha, 190–375 g ai/ha, 120–295 g ai/ha, 180–355 g ai/ha, 220–335 g ai/ha, or 42.5–325 g ai/ha.

Norflurazon

[0057] In some aspects, the PDS inhibitor herbicide can comprise norflurazon or an agriculturally acceptable salt or ester thereof. Norflurazon, shown below, is 4-chloro-5-(methylamino)-2-[3-(trifluoromethyl)phenyl]-3(2*H*)-pyridazinone. Its herbicidal activity is exemplified in *The Pesticide Manual*, Seventeenth Edition, 2016. Exemplary uses of norflurazon include its use for pre-emergence control of grasses and sedges, including *Digitaria* spp. (crabgrasses), *Echinochloa* spp. (barnyard grasses), *Setaria* spp. (foxtails) and *Eleocharis acicularis* (spikerush), as well as broadleaf weeds, such as *Sida spinosa* (prickly sida), *Portulaca oleracea* (purslane), *Salsola* spp. (Russian thistle), and *Capsella bursa-pastoris* (shepherd's purse), in cotton, soybeans, peanuts, hops, orchards, ornamentals, and industrial areas.

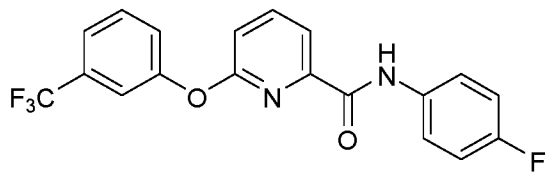


[0058] Norflurazon can be applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount sufficient to induce a herbicidal effect. In some aspects, norflurazon is applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount of 500 g ai/ha or more, such as 550 g ai/ha or more, 600 g ai/ha or more, 650 g ai/ha or more, 700 g ai/ha or more, 750 g ai/ha or more, 800 g ai/ha or more, 850 g ai/ha or more, 900 g ai/ha or more, 950 g ai/ha or more, 1000 g ai/ha or more, 1050 g ai/ha or more, 1100 g ai/ha or more, 1150 g ai/ha or more, 1200 g ai/ha or more, 1250 g ai/ha or more, 1300 g ai/ha or more, 1350 g ai/ha or more, 1400 g ai/ha or more, 1450 g ai/ha or more, 1500 g ai/ha or more, 1600 g ai/ha or more, 1700 g ai/ha or more, 1800 g ai/ha or more, 1900 g ai/ha or more, 2000 g ai/ha or more, 2050 g ai/ha or more, 2100 g ai/ha or more, 2150 g ai/ha or more, 2200 g ai/ha or more, 2240 g ai/ha or more, 2250 g ai/ha or more, 2300 g ai/ha or more, 2350 g ai/ha or more, 2400 g ai/ha or more, 2450 g ai/ha or more, 2500 g ai/ha or more, 2600 g ai/ha or more, 2700 g ai/ha or more, 2750 g ai/ha or more, 2800 g ai/ha or more, 2900 g ai/ha or more, 3000 g ai/ha or more, 3100 g ai/ha or more, 3200 g ai/ha or more, 3250 g ai/ha or more, 3300 g ai/ha or more, 3400 g ai/ha or more, 3500 g ai/ha or more, 3600 g ai/ha or more, 3700 g ai/ha or more, 3750 g ai/ha or more, 3800 g ai/ha or more, 3900 g ai/ha or more, or 3950 g ai/ha or more; in an

amount of 4000 g ai/ha or less, such as 3950 g ai/ha or less, 3900 g ai/ha or less, 3800 g ai/ha or less, 3750 g ai/ha or less, 3700 g ai/ha or less, 3600 g ai/ha or less, 3500 g ai/ha or less, 3400 g ai/ha or less, 3300 g ai/ha or less, 3250 g ai/ha or less, 3200 g ai/ha or less, 3100 g ai/ha or less, 3000 g ai/ha or less, 2900 g ai/ha or less, 2800 g ai/ha or less, 2750 g ai/ha or less, 2700 g ai/ha or less, 2600 g ai/ha or less, 2500 g ai/ha or less, 2450 g ai/ha or less, 2400 g ai/ha or less, 2350 g ai/ha or less, 2300 g ai/ha or less, 2250 g ai/ha or less, 2240 g ai/ha or less, 2200 g ai/ha or less, 2150 g ai/ha or less, 2100 g ai/ha or less, 2050 g ai/ha or less, 2000 g ai/ha or less, 1900 g ai/ha or less, 1800 g ai/ha or less, 1750 g ai/ha or less, 1700 g ai/ha or less, 1600 g ai/ha or less, 1500 g ai/ha or less, 1450 g ai/ha or less, 1400 g ai/ha or less, 1350 g ai/ha or less, 1300 g ai/ha or less, 1250 g ai/ha or less, 1240 g ai/ha or less, 1200 g ai/ha or less, 1150 g ai/ha or less, 1100 g ai/ha or less, 1050 g ai/ha or less, 1000 g ai/ha or less, 950 g ai/ha or less, 900 g ai/ha or less, 850 g ai/ha or less, 800 g ai/ha or less, 750 g ai/ha or less, 700 g ai/ha or less, 650 g ai/ha or less, 600 g ai/ha or less, or 550 g ai/ha or less; or in an amount ranging from any of the minimum values described above to any of the maximum values described above, such as 500–4000 g ai/ha, 600–3600 g ai/ha, 1250–3000 g ai/ha, 2000–4000 g ai/ha, 1700–3250 g ai/ha, 2800–3950 g ai/ha, or 1000–3700 g ai/ha.

Picolinafen

[0059] In some aspects, the PDS inhibitor herbicide can comprise picolinafen or an agriculturally acceptable salt or ester thereof. Picolinafen, shown below, is *N*-(4-fluorophenyl)-6-[3-(trifluoromethyl)phenoxy]-2-pyridinecarboxamide. Its herbicidal activity is exemplified in *The Pesticide Manual*, Seventeenth Edition, 2016. Exemplary uses of picolinafen include its use as a post-emergence herbicide either alone or in mixtures for broad-spectrum weed control in cereals.



[0060] Picolinafen can be applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount sufficient to induce a herbicidal effect. In some aspects, picolinafen is applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount of 12.5 g ai/ha or more, such as 15 g ai/ha or more, 17.5 g ai/ha or more, 20 g ai/ha or more, 22.5 g ai/ha or more, 25 g ai/ha or more, 27.5 g ai/ha or more, 30 g ai/ha or

more, 32.5 g ai/ha or more, 35 g ai/ha or more, 37.5 g ai/ha or more, 40 g ai/ha or more, 42.5 g ai/ha or more, 45 g ai/ha or more, 47.5 g ai/ha or more, 50 g ai/ha or more, 52.5 g ai/ha or more, 55 g ai/ha or more, 57.5 g ai/ha or more, 60 g ai/ha or more, 62.5 g ai/ha or more, 65 g ai/ha or more, 67.5 g ai/ha or more, 70 g ai/ha or more, 72.5 g ai/ha or more, 75 g ai/ha or more, 77.5 g ai/ha or more, 80 g ai/ha or more, 82.5 g ai/ha or more, 85 g ai/ha or more, 87.5 g ai/ha or more, 90 g ai/ha or more, 92.5 g ai/ha or more, 95 g ai/ha or more, or 97.5 g ai/ha or more; in an amount of 100 g ai/ha or less, such as 95 g ai/ha or less, 92.5 g ai/ha or less, 90 g ai/ha or less, 87.5 g ai/ha or less, 85 g ai/ha or less, 82.5 g ai/ha or less, 80 g ai/ha or less, 77.5 g ai/ha or less, 75 g ai/ha or less, 72.5 g ai/ha or less, 70 g ai/ha or less, 67.5 g ai/ha or less, 65 g ai/ha or less, 62.5 g ai/ha or less, 60 g ai/ha or less, 57.5 g ai/ha or less, 55 g ai/ha or less, 52.5 g ai/ha or less, 50 g ai/ha or less, 47.5 g ai/ha or less, 45 g ai/ha or less, 42.5 g ai/ha or less, 40 g ai/ha or less, 37.5 g ai/ha or less, 35 g ai/ha or less, 32.5 g ai/ha or less, 30 g ai/ha or less, 27.5 g ai/ha or less, 25 g ai/ha or less, 22.5 g ai/ha or less, 20 g ai/ha or less, 17.5 g ai/ha or less; or in an amount ranging from any of the minimum values described above to any of the maximum values described above, such as 12.5–100 g ai/ha, 15–90 g ai/ha, 20–80 g ai/ha, 25–75 g ai/ha, 25–95 g ai/ha, 25–80 g ai/ha, 30–75 g ai/ha, 35–90 g ai/ha, 40–95 g ai/ha, 40–75 g ai/ha, 45–95 g ai/ha, 45–90 g ai/ha, 50–80 g ai/ha, or 50–75 g ai/ha.

IV. Compositions

[0061] A composition comprising (a) a pyridine carboxylate herbicide or an agriculturally acceptable N-oxide, salt, or ester thereof may be mixed with or applied in combination with (b) a phytoene desaturase (PDS) inhibitor or an agriculturally acceptable salt or ester thereof.

[0062] In some aspects, (a) and (b) are used in an amount sufficient to induce an unexpectedly enhanced herbicidal effect (*e.g.*, increased damage or injury to undesirable vegetation) while still showing good crop compatibility (*e.g.*, no increased damage to crops or minimal increased damage or injury to crops) when compared to the individual application of the herbicidal compounds (a) and (b). In some aspects, the damage or injury to undesirable vegetation caused by the compositions and methods disclosed herein is evaluated using a scale from 0% to 100%, when compared with the untreated control vegetation, wherein 0% indicates no damage to the undesirable vegetation and 100% indicates complete destruction of the undesirable vegetation.

[0063] In some aspects, the joint action of (a) the pyridine carboxylate herbicide or an agriculturally acceptable N-oxide, salt, or ester thereof and (b) the PDS inhibitor or an agriculturally acceptable salt or ester thereof results in unexpectedly enhanced herbicidal effect

against undesirable vegetation, even at application rates below those typically used for the herbicide to have a herbicidal effect on its own. In some aspects, the compositions and methods disclosed herein can, based on the individual components, be used at lower application rates to achieve a herbicidal effect comparable to the effect produced by the individual components at normal application rates.

[0064] In some aspects, the weight ratio of (a) the pyridine carboxylate herbicide or an agriculturally acceptable N-oxide, salt, or ester thereof (in g ae/ha) to (b) the PDS inhibitor herbicide or an agriculturally acceptable salt or ester thereof (in g ai/ha) can be 1:9000 or more, such as 1:8000 or more, 1:7500 or more, 1:7000 or more, 1:6500 or more, 1:6000 or more, 1:5500 or more, 1:5000 or more, 1:4500 or more, 1:4000 or more, 1:3800 or more, 1:3600 or more, 1:3400 or more, 1:3200 or more, 1:3000 or more, 1:2800 or more, 1:2600 or more, 1:2400 or more, 1:2200 or more, 1:2000 or more, 1:1800 or more, 1:1600 or more, 1:1400 or more, 1:1200 or more, 1:1000 or more, 1: 900 or more, 1:800 or more, 1:700 or more, 1:600 or more, 1:500 or more, 1:400 or more, 1:300 or more, 1:200 or more, 1:100 or more, 1:90 or more, 1:80 or more, 1:70 or more, 1:60 or more, 1:50 or more, 1:40 or more, 1:30 or more, 1:24 or more, 1:20 or more, 1:18 or more, 1:16 or more, 1:14 or more, 1:13 or more, 1:10 or more, 1:9 or more, 1:8 or more, 1:7 or more, 1:6 or more, 1:5 or more, 1:4 or more, 1:3 or more, 1:2 or more, 1:1.9 or more, 1:1.8 or more, 1:1.7 or more, 1:1.6 or more, 1:1.5 or more, 1:1.4 or more, 1:1.3 or more, 1:1.2 or more, 1:1.1 or more, 1:1 or more, 1.1:1 or more, 1.2:1 or more, 1.3:1 or more, 1.4:1 or more, 1.5:1 or more, 1.6:1 or more, 1.7:1 or more, 1.8:1 or more, 1.9:1 or more, 2:1 or more, 3:1 or more, 4:1 or more, 5:1 or more, 6:1 or more, 7:1 or more, 8:1 or more, 9:1 or more, 10:1 or more, 12:1 or more, 14:1 or more, 15:1 or more, 16:1 or more, 18:1 or more, 20:1 or more, 22:1 or more, or 23:1 or more; the weight ratio of (a) to (b) can be 24:1 or less, such as 23:1 or less, 22:1 or less, 20:1 or less, 18:1 or less, 16:1 or less, 15:1 or less, 14:1 or less, 12:1 or less, 20:1 or less, 10:1 or less, 9:1 or less, 8:1 or less, 7:1 or less, 6:1 or less, 5:1 or less, 4:1 or less, 3:1 or less, 2:1 or less, 1.9:1 or less, 1.8:1 or less, 1.7:1 or less, 1.6:1 or less, 1.5:1 or less, 1.4:1 or less, 1.3:1 or less, 1.2:1 or less, 1.1:1 or less, 1:1 or less, 1:1.1 or less, 1:1.2 or less, 1:1.3 or less, 1:1.4 or less, 1:1.5 or less, 1:1.6 or less, 1:1.7 or less, 1:1.8 or less, 1:1.9 or less, 1:2 or less, 1:3 or less, 1:4 or less, 1:5 or less, 1:6 or less, 1:7 or less, 1:8 or less, 1:9 or less, 1:10 or less, 1:12 or less, 1:14 or less, 1:15 or less, 1:16 or less, 1:18 or less, 1:20 or less, 1:24 or less, 1:30 or less, 1:40 or less, 1:50 or less, 1:60 or less, 1:70 or less, 1:80 or less, 1:90 or less, 1:100 or less, 1:200 or less, 1:300 or less, 1:400 or less, 1:500 or less, 1:600 or less, 1:700 or less, 1:800 or less, 1:900 or less, 1:1000 or less, 1:1200 or less, 1:1400 or less, 1:1600 or less, 1:1800 or less, 1:2000 or less, 1:2200 or less, 1:2400 or less, 1:2600 or less, 1:2800 or less, 1:3000 or less, 1:3200 or less,

1:3400 or less, 1:3600 or less, 1:3800 or less, 1:4000 or less, 1:4500 or less, 1:5000 or less, 1:5500 or less, 1:6000 or less, 1:6500 or less, 1:7000 or less, or 1:7500 or less; or the weight ratio of (a) to (b) can range from any of the minimum ratios to any of the maximum ratios provided above, such as from 1:8000 to 24:1, from 1:6500 to 10:1, from 1:1500 to 12:1, from 1:100 to 16:1, from 1:24 to 1:18, from 1:16 to 1:12, or from 1:5 to 5:1.

[0065] In some aspects, the active ingredients in the compositions disclosed herein consist of (a) a pyridine carboxylate herbicide or an agriculturally acceptable N-oxide, salt, or ester thereof and (b) a PDS inhibitor herbicide or an agriculturally acceptable salt or ester thereof. In some aspects, the composition may include other components, such as safeners or adjuvants, but does not include a herbicidal active ingredient in addition to (a) and (b). In some aspects, the compositions may exclude one or more herbicidal active ingredients specified above. In some aspects, the compositions may include one or more herbicidal active ingredients in addition to (a) and (b), but may exclude one or more herbicidal ingredients specified above.

[0066] In some aspects, (a) and (b), independently, can be employed in a purity of from 90% to 100% (*e.g.*, from 95% to 100%) according to nuclear magnetic resonance (NMR) spectroscopy.

V. Formulations

[0067] The present disclosure also includes formulations of the compositions and methods disclosed herein.

A. Additives

[0068] The compositions and methods disclosed herein can also be mixed with or applied with an additive. In some aspects, the additive is added sequentially. In some aspects, the additive is added simultaneously. In some aspects, the additive is premixed with the pyridine carboxylate herbicide or agriculturally acceptable N-oxide, salt, or ester thereof.

1. Other Pesticides

[0069] Some aspects of the described herbicidal compositions includes adding one or more additional pesticide active ingredients to the herbicidal compositions. These pesticide active ingredients may include one or more of an herbicide, an insecticide, a fungicide, a nematocide, a miticide, a arthropodicide, a bactericide, a plant growth regulator, or combinations thereof that are compatible with the compositions of the present disclosure.

[0070] In some aspects, the additive is an additional herbicide. For example, the compositions described herein can be applied in conjunction with one or more additional herbicides to control undesirable vegetation. The composition can be formulated with the one or more additional herbicides, tank mixed with the one or more additional herbicides, or applied sequentially with the one or more additional herbicides. Exemplary additional herbicides include, but are not limited to: 4-CPA; 4-CPB; 4-CPP; 2;4-D; 2;4-D choline salt; 2,4-D salts, esters and amines; 2,4-DB; 3,4-DA; 3,4-DB; 2,4-DEB; 2,4-DEP; 2,4-DP; 3,4-DP; 2,3,6-TBA; 2,4,5-T; 2,4,5-TB; acetochlor; acifluorfen; aclonifen; acrolein; alachlor; allidochlor; alloxydim; allyl alcohol; alorac; ametridione; ametryne; amibuzin; amicarbazone; amidosulfuron; aminocyclopyrachlor; 4-aminopicolinic acid based herbicides, such as halauxifen, halauxifen-methyl, florpyrauxifen, and those described in U.S. Patent Nos. 7,314,849 and 7,432,227 to Balko, et al.; aminopyralid; amiprofos-methyl; amitrole; ammonium sulfamate; anilofos; anisuron; asulam; atraton; atrazine; azafenidin; azimsulfuron; aziprotryne; barban; BCPC; beflubutamid; benazolin; bencarbazone; benfluralin; benfuresate; bensulide; bensulfuron; benthiocarb; bentazone; benzadox; benzfendizone; benzipram; benzobicyclon; benzofenap; benzofluor; benzoylprop; benzthiazuron; bialaphos; bicyclopyrone; bifenox; bilanafos; bispyribac; borax; bromacil; bromobonil; bromobutide; bromofenoxim; bromoxynil; brompyrazon; butachlor; butafenacil; butamifos; butenachlor; buthidazole; buthiuron; butralin; butroxydim; buturon; butylate; cacodylic acid; cafenstrole; calcium chlorate; calcium cyanamide; cambendichlor; carbasulam; carbetamide; carboxazole; chlorprocarb; carfentrazone-ethyl; CDEA; CEPC; chlomethoxyfen; chloramben; chloranocryl; chlorazifop; chlorazine; chlorobromuron; chlorbufam; chloreturon; chlorfenac; chlorfenprop; chlorflurazole; chlorflurenol; chloridazon; chlorimuron; chlornitrofen; chloropon; chlorotoluron; chloroxuron; chloroxynil; chlorpropham; chlorsulfuron; chlorthal; chlorthiamid; cinidon-ethyl; cinmethylin; cinosulfuron; cisanilide; clacyfos; clethodim; cliodinate; clodinafop-propargyl; clofop; clomazone; clomeprop; cloprop; cloproxydim; clopyralid; cloransulam-methyl; CMA; copper sulfate; CPMF; CPPC; credazine; cresol; cumyluron; cyanatryn; cyanazine; cycloate; cyclopyrimorate; cyclosulfamuron; cycloxydim; cycluron; cyhalofop-butyl; cyperquat; cyprazine; cyprazole; cypromid; daimuron; dalapon; dazomet; delachlor; desmedipham; desmetryn; di-allate; dicamba; dichlobenil; dichloralurea; dichlormate; dichlorprop; dichlorprop-P; diclofop-methyl; diclosulam; diethamquat; diethatyl; difenopenten; difenoxuron; difenzoquat; diflufenican; diflufenzopyr; dimefuron; dimepiperate; dimethachlor; dimethametryn; dimethenamid; dimethenamid-P; dimexano; dimidazon; dinitramine; dinofenate; dinoprop; dinosam; dinoseb; dinoterb; diphenamid; dipropetryn; diquat; disul; dithiopyr; diuron; DMPA;

DNOC; DSMA; EBEP; eglinazine; endothal; epronaz; EPTC; erbon; esprocarb; ethalfluralin; ethametsulfuron; ethbenzamide; ethametsulfuron; ethidimuron; ethiolate; ethobenzamid; ethofumesate; ethoxyfen; ethoxysulfuron; etinofen; etnipromid; etobenzanid; EXD; fenasulam; fenoprop; fenoxaprop; fenoxaprop-P-ethyl; fenoxaprop-P-ethyl + isoxadifen-ethyl; fenoxasulfone; fenquinotrione; fenteracol; fenthiaprop; fentrazamide; fenuron; ferrous sulfate; flamprop; flamprop-M; flazasulfuron; florasulam; fluazifop; fluazifop-P-butyl; fluazolate; flucarbazone; flucetosulfuron; fluchloralin; flufenacet; flufenican; flufenpyr-ethyl; flumetsulam; flumezin; flumiclorac-pentyl; flumioxazin; flumipropyn; fluometuron; fluorodifen; fluoroglycofen; fluoromidine; fluoronitrofen; fluothiuron; flupoxam; flupropacil; flupropanate; flupyrsulfuron; fluridone; flurochloridone; fluroxypyr; fluroxypyr-meptyl; flurtamone; fluthiacet; fomesafen; foramsulfuron; fosamine; fumiclorac; furyloxyfen; glufosinate; glufosinate-ammonium; glufosinate-P-ammonium; glyphosate salts and esters; halosafen; halosulfuron; haloxydine; haloxyfop; 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; lactofen; lenacil; linuron; MAA; MAMA; MCPA esters and amines; MCPA-thioethyl; MCPB; mecoprop; mecoprop-P; medinoterb; mefenacet; mefluidide; mesoprazine; mesosulfuron; mesotrione; metam; metamifop; metamitron; metazachlor; metflurazon; methabenzthiazuron; methalpropalin; methazole; methiobencarb; methiozolin; methiuron; methometon; methoprotryne; methyl bromide; methyl isothiocyanate; methyldymron; metobenzuron; metobromuron; metolachlor; metosulam; metoxuron; metribuzin; metsulfuron; molinate; monalide; monisouron; monochloroacetic acid; monolinuron; monuron; morfamquat; MSMA; naproanilide; napropamide; napropamide-M; naptalam; neburon; nicosulfuron; nipyraclofen; nitralin; nitrofen; nitrofluorfen; norflurazon; noruron; OCH; orbencarb; *ortho*-dichlorobenzene; orthosulfamuron; oryzalin; oxadiargyl; oxadiazon; oxapyrazon; oxasulfuron; oxaziclomefone; oxyfluorfen; paraflufen-ethyl; parafluron; paraquat; pebulate; pelargonic acid; pendimethalin; penoxsulam; pentachlorophenol; pentanochlor; pentoxazone; perfluidone; pethoxamid; phenisopham; phenmedipham; phenmedipham-ethyl; phenobenzuron; phenylmercury acetate; picloram; picolinafen; pinoxaden; piperophos; potassium arsenite; potassium azide; potassium cyanate; pretilachlor; primisulfuron; procyazine; prodiamine; profluazol; profluralin; profoxydim; proglinazine; prohexadione-calcium; prometon; prometryne; pronamide; propachlor; propanil; propaquizafop;

propazine; propham; propisochlor; propoxycarbazone; propyrisulfuron; propyzamide; prosulfalin; prosulfocarb; prosulfuron; proxan; prynachlor; pydanon; pyraclonil; pyraflufen; pyrasulfotole; pyrazogyl; pyrazone; pyrazolynate; pyrazosulfuron; pyrazoxyfen; pyribenzoxim; pyributicarb; pyriclor; pyridafol; pyridate; pyriftalid; pyriminobac; pyrimisulfan; pyrithiobac-sodium; pyroxasulfone; pyroxsulam; quinclorac; quinmerac; quinoclamine; quinonamid; quizalofop; quizalofop-P-ethyl; quizalofop-P-tefuryl; rhodethanil; rimsulfuron; saflufenacil; S-metolachlor; sebuthylazine; secbumeton; sethoxydim; siduron; simazine; simeton; simetryn; SMA; sodium arsenite; sodium azide; sodium chlorate; sulcotrione; sulfallate; sulfentrazone; sulfometuron; sulfosate; sulfosulfuron; sulfuric acid; sulglycapin; swep; TCA; tebutam; tebuthiuron; tefuryltrione; tembotrione; tepraloxydim; terbacil; terbucarb; terbuchlor; terbumeton; terbuthylazine; terbutryne; tetrafluron; thenylchlor; thiameturon; thiazafluron; thiazopyr; thidiazimin; thidiazuron; thiencarbazone; thifensulfuron; thiobencarb; tiafenacil; tiocarbazil; tioclorim; tolpyralate; topramezone; tralkoxydim; tri-allate; triafamone; triasulfuron; triaziflam; tribenuron; tribenuron; tricamba; triclopyr choline salt; triclopyr esters and amines; tridiphane; trietazine; trifloxysulfuron; trifludimoxazin; trifluralin; triflusulfuron; trifop; trifopsime; trihydroxytriazine; trimeturon; tripropindan; tritac; tritosulfuron; vernolate; xylachlor; and salts, esters, optically active isomers, and mixtures thereof. In some aspects, the additional pesticide is selected from halauxifen, florpyrauxifen, flufenacet, iodosulfuron, mesosulfuron, an agriculturally acceptable salt or ester thereof, or combinations thereof

[0071] The additional pesticide or agriculturally acceptable salt or ester thereof can be applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount sufficient to induce a herbicidal effect. In some aspects, the additional pesticide or agriculturally acceptable salt or ester thereof is applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount of 12.5 gram active ingredient per hectare (g ai/ha) or more such as 15 g ai/ha or more, 20 g ai/ha or more, 25 g ai/ha or more, 30 g ai/ha or more, 35 g ai/ha or more, 40 g ai/ha or more, 45 g ai/ha or more, 50 g ai/ha or more, 55 g ai/ha or more, 60 g ai/ha or more, 65 g ai/ha or more, 70 g ai/ha or more, 75 g ai/ha or more, 80 g ai/ha or more, 85 g ai/ha or more, 90 g ai/ha or more, 95 g ai/ha or more, 100 g ai/ha or more, 110 g ai/ha or more, 120 g ai/ha or more, 130 g ai/ha or more, 140 g ai/ha or more, 150 g ai/ha or more, 160 g ai/ha or more, 170 g ai/ha or more, 180 g ai/ha or more, 190 g ai/ha or more, 200 g ai/ha or more, 220 g ai/ha or more, 240 g ai/ha or more, 250 g ai/ha or more, 260 g ai/ha or more, 280 g ai/ha or more, 300 g ai/ha or more, 320 g ai/ha or more, 340 g ai/ha or more, 350 g ai/ha or more, 360 g ai/ha or more, 380 g ai/ha or more, 400 g ai/ha or more, 450 g ai/ha or more, 500 g ai/ha or more, 550 g

ai/ha or more, 600 g ai/ha or more, 650 g ai/ha or more, 700 g ai/ha or more, 750 g ai/ha or more, 800 g ai/ha or more, 850 g ai/ha or more, 900 g ai/ha or more, 950 g ai/ha or more, 1000 g ai/ha or more, 1050 g ai/ha or more, 1100 g ai/ha or more, 1150 g ai/ha or more, 1200 g ai/ha or more, 1250 g ai/ha or more, 1300 g ai/ha or more, 1350 g ai/ha or more, 1400 g ai/ha or more, 1450 g ai/ha or more, 1500 g ai/ha or more, 1600 g ai/ha or more, 1700 g ai/ha or more, 1800 g ai/ha or more, 1900 g ai/ha or more, 2000 g ai/ha or more, 2050 g ai/ha or more, 2100 g ai/ha or more, 2150 g ai/ha or more, 2200 g ai/ha or more, 2240 g ai/ha or more, 2250 g ai/ha or more, 2300 g ai/ha or more, 2350 g ai/ha or more, 2400 g ai/ha or more, 2450 g ai/ha or more, 2500 g ai/ha or more, 2600 g ai/ha or more, 2700 g ai/ha or more, 2750 g ai/ha or more, 2800 g ai/ha or more, 2900 g ai/ha or more, 3000 g ai/ha or more, 3100 g ai/ha or more, 3200 g ai/ha or more, 3250 g ai/ha or more, 3300 g ai/ha or more, 3400 g ai/ha or more, 3500 g ai/ha or more, 3600 g ai/ha or more, 3700 g ai/ha or more, 3750 g ai/ha or more, 3800 g ai/ha or more, 3900 g ai/ha or more, 3950 g ai/ha or more, 4000 g ai/ha or more, 4100 g ai/ha or more, 4200 g ai/ha or more, 4250 g ai/ha or more, 4300 g ai/ha or more, 4400 g ai/ha or more, or 4450 g ai/ha or more).

[0072] In some aspects, the additional pesticide or agriculturally acceptable salt or ester thereof is applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount of 4500 g ai/ha or less such as 4450 g ai/ha or less, 4400 g ai/ha or less, 4300 g ai/ha or less, 4250 g ai/ha or less, 4100 g ai/ha or less, 4000 g ai/ha or less, 3950 g ai/ha or less, 3900 g ai/ha or less, 3800 g ai/ha or less, 3750 g ai/ha or less, 3700 g ai/ha or less, 3600 g ai/ha or less, 3500 g ai/ha or less, 3400 g ai/ha or less, 3300 g ai/ha or less, 3250 g ai/ha or less, 3200 g ai/ha or less, 3100 g ai/ha or less, 3000 g ai/ha or less, 2900 g ai/ha or less, 2800 g ai/ha or less, 2750 g ai/ha or less, 2700 g ai/ha or less, 2600 g ai/ha or less, 2500 g ai/ha or less, 2450 g ai/ha or less, 2400 g ai/ha or less, 2350 g ai/ha or less, 2300 g ai/ha or less, 2250 g ai/ha or less, 2240 g ai/ha or less, 2200 g ai/ha or less, 2150 g ai/ha or less, 2100 g ai/ha or less, 2050 g ai/ha or less, 2000 g ai/ha or less, 1900 g ai/ha or less, 1800 g ai/ha or less, 1750 g ai/ha or less, 1700 g ai/ha or less, 1600 g ai/ha or less, 1500 g ai/ha or less, 1450 g ai/ha or less, 1400 g ai/ha or less, 1350 g ai/ha or less, 1300 g ai/ha or less, 1250 g ai/ha or less, 1240 g ai/ha or less, 1200 g ai/ha or less, 1150 g ai/ha or less, 1100 g ai/ha or less, 1050 g ai/ha or less, 1000 g ai/ha or less, 950 g ai/ha or less, 900 g ai/ha or less, 850 g ai/ha or less, 800 g ai/ha or less, 750 g ai/ha or less, 700 g ai/ha or less, 650 g ai/ha or less, 600 g ai/ha or less, 550 g ai/ha or less, 500 g ai/ha or less, 450 g ai/ha or less, 400 g ai/ha or less, 380 g ai/ha or less, 360 g ai/ha or less, 350 g ai/ha or less, 340 g ai/ha or less, 320 g ai/ha or less, 300 g ai/ha or less, 280 g ai/ha or less, 260 g ai/ha or less, 250 g ai/ha or less, 240 g ai/ha or less, 220 g ai/ha or less, 200 g ai/ha or less, 190 g ai/ha or less, 180 g ai/ha or less, 170 g ai/ha or less, 160 g ai/ha or less, 150

g ai/ha or less, 140 g ai/ha or less, 130 g ai/ha or less, 120 g ai/ha or less, 110 g ai/ha or less, 100 g ai/ha or less, 95 g ai/ha or less, 90 g ai/ha or less, 85 g ai/ha or less, 80 g ai/ha or less, 75 g ai/ha or less, 70 g ai/ha or less, 65 g ai/ha or less, 60 g ai/ha or less, 55 g ai/ha or less, 50 g ai/ha or less, 45 g ai/ha or less, 40 g ai/ha or less, 35 g ai/ha or less, 30 g ai/ha or less, 25 g ai/ha or less, 20 g ai/ha or less, or 15 g ai/ha or less).

[0073] The additional pesticide or an agriculturally acceptable salt or ester thereof can be applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount ranging from any of the minimum values described above to any of the maximum values described above, *e.g.*, 12.5–4500 g ai/ha, 15–2250 g ai/ha, 20-2500 g ai/ha, 25–3150 g ai/ha, 30–900 g ai/ha, 45–4200 g ai/ha, 50–1200 g ai/ha, 50–4100 g ai/ha, 60–750 g ai/ha, 75–2100 g ai/ha, 100–4000 g ai/ha, 200–3600 g ai/ha, 250–3000 g ai/ha, 250–1000 g ai/ha, 700–4250 g ai/ha, 800–1400 g ai/ha, or 1000–3700 g ai/ha.

[0074] In some aspects, the additional pesticide or an agriculturally acceptable salt or ester thereof is provided in a premixed formulation with (a) and (b), or combinations thereof. In some aspects, the pyridine carboxylate herbicide or an agriculturally acceptable N-oxide, salt, or ester thereof is provided in a premixed formulation with the additional pesticide. In some aspects, the PDS inhibitor herbicide or an agriculturally acceptable salt or ester thereof is provided in a premixed formulation with an additional pesticide.

[0075] In some aspects, the compositions may include one or more herbicidal active ingredients in addition to (a) and (b). In some aspects, the compositions do not include an herbicidal active ingredient in addition to (a) and (b). In some aspects, the composition may include other components, such as safeners or adjuvants, but does not include a herbicidal active ingredient in addition to (a) and (b). In some aspects, the compositions may exclude one or more herbicidal active ingredients specified above. In some aspects, the compositions may include one or more herbicidal active ingredients in addition to (a) and (b), but may exclude one or more herbicidal ingredients specified above.

2. Adjuvants

[0076] In some aspects, the additive includes an agriculturally acceptable adjuvant. Exemplary agriculturally acceptable adjuvants include, but are not limited to, antifreeze agents, antifoam agents, compatibilizing agents, sequestering agents, neutralizing agents and buffers, corrosion inhibitors, colorants, odorants, penetration aids, wetting agents, spreading agents, dispersing agents, thickening agents, freeze point depressants, antimicrobial agents, crop oil,

adhesives (for instance, for use in seed formulations), surfactants, protective colloids, emulsifiers, tackifiers, and mixtures thereof.

[0077] Exemplary agriculturally acceptable adjuvants include, but are not limited to, crop oil concentrates (*e.g.*, 85% mineral oil + 15% emulsifiers); nonylphenol ethoxylates; benzylcocoalkyldimethyl quaternary ammonium salts; blends of petroleum hydrocarbon, alkyl esters, organic acids, and anionic surfactants; C_9-C_{11} alkylpolyglycoside; phosphate alcohol ethoxylates; natural primary alcohol (C_{12}-C_{16}) ethoxylate; di-*sec*-butylphenol EO-PO block copolymers; polysiloxane-methyl cap; nonylphenol ethoxylate+urea ammonium nitrates; emulsified methylated seed oils; tridecyl alcohol (synthetic) ethoxylates (*e.g.*, 8 EO); tallow amine ethoxylates (*e.g.*, 15 EO); and PEG(400) dioleate-99.

[0078] Exemplary surfactants (*e.g.*, wetting agents, tackifiers, dispersants, emulsifiers) include, but are not limited to: the alkali metal salts, alkaline earth metal salts and ammonium salts of fatty acids or of aromatic sulfonic acids (*e.g.*, lignosulfonic acids, phenolsulfonic acids, naphthalenesulfonic acids, and dibutylnaphthalenesulfonic acid); alkyl- and alkylarylsulfonates; alkyl sulfates, lauryl ether sulfates and fatty alcohol sulfates; salts of sulfated hexa-, hepta- and octadecanols; salts of fatty alcohol glycol ethers; condensates of sulfonated naphthalene and its derivatives with formaldehyde; condensates of naphthalene or of the naphthalene sulfonic acids with phenol and formaldehyde; polyoxyethylene octylphenol ether; ethoxylated isooctyl-, octyl- or nonylphenol, alkylphenyl or tributylphenyl polyglycol ether; alkyl aryl polyether alcohols; isotridecyl alcohol; fatty alcohol/ethylene oxide condensates; ethoxylated castor oil; polyoxyethylene alkyl ethers or polyoxypropylene alkyl ethers; lauryl alcohol polyglycol ether acetate; sorbitol esters; lignosulfite waste liquors and proteins; denatured proteins, polysaccharides (*e.g.*, methylcellulose); hydrophobically modified starches; and polyvinyl alcohol, polycarboxylates, polyalkoxylates, polyvinyl amine, polyethyleneimine, polyvinylpyrrolidone, and copolymers thereof.

[0079] Exemplary thickeners include, but are not limited to, polysaccharides (*e.g.*, xanthan gum), organic and inorganic sheet minerals, and mixtures thereof.

[0080] Exemplary antifoam agents include, but are not limited to, silicone emulsions, long-chain alcohols, fatty acids, fatty acid salts, organofluorine compounds, and mixtures thereof.

[0081] Exemplary antimicrobial agents include, but are not limited to: bactericides based on dichlorophen and benzyl alcohol hemiformal; isothiazolinone derivatives, such as alkylisothiazolinones and benzisothiazolinones; and mixtures thereof.

[0082] Exemplary antifreeze agents, include, but are not limited to ethylene glycol, propylene glycol, urea, glycerol, and mixtures thereof.

[0083] Exemplary colorants include, but are not limited to, the dyes known under the names Rhodamine B, pigment blue 15:4, pigment blue 15:3, pigment blue 15:2, pigment blue 15:1, pigment blue 80, pigment yellow 1, pigment yellow 13, pigment red 112, pigment red 48:2, pigment red 48:1, pigment red 57:1, pigment red 53:1, pigment orange 43, pigment orange 34, pigment orange 5, pigment green 36, pigment green 7, pigment white 6, pigment brown 25, basic violet 10, basic violet 49, acid red 51, acid red 52, acid red 14, acid blue 9, acid yellow 23, basic red 10, basic red 108, and mixtures thereof.

[0084] Exemplary adhesives include, but are not limited to, polyvinylpyrrolidone, polyvinyl acetate, polyvinyl alcohol, tylose, and mixtures thereof.

3. Safeners

[0085] In some aspects, the additive is a safener. Safeners are compounds leading to better crop plant compatibility when applied with a herbicide. In some aspects, the safener itself is herbicidally active. In some aspects, the safener acts as an antidote or antagonist in the crop plants and can protect the crop plants from damage that might otherwise occur from an applied herbicide. Exemplary safeners include, but are not limited to, AD-67 (MON 4660), benoxacor, benthiocarb, brassinolide, cloquintocet, cloquintocet-mexyl, cyometrinil, cyprosulfamide, daimuron, dichlormid, dicyclonon, dietholate, dimepiperate, disulfoton, fenchlorazole, fenchlorazole-ethyl, fenclorim, flurazole, fluxofenim, furilazole, harpin proteins, isoxadifen-ethyl, jiecaowan, jiecaoxi, mefenpyr, mefenpyr-diethyl, mephenate, naphthalic anhydride, 2,2,5-trimethyl-3-(dichloroacetyl)-1,3-oxazolidine, 4-(dichloroacetyl)-1-oxa-4-azaspiro [4.5]decane, oxabetrinil, R29148, and *N*-phenyl-sulfonylbenzoic acid amides, as well as thereof agriculturally acceptable salts and, provided they have a carboxyl group, their agriculturally acceptable derivatives. In some aspects, the safener can be cloquintocet or an ester or salt thereof, such as cloquintocet-mexyl. In some aspects, the safener can be mefenpyr or an ester or salt thereof, such as mefenpyr-diethyl. In some aspects, the safener is employed in rice, cereal, or maize. For example, mefenpyr or cloquintocet can be used to antagonize harmful effects of the compositions on rice, row crops, and cereals.

4. Carriers

[0086] In some aspects, the additive includes a carrier. In some aspects, the additive includes a liquid or solid carrier. In some aspects, the additive includes an organic or inorganic carrier.

Exemplary liquid carriers include, but are not limited to: water; 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; 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; glycerin; *N*-methyl-2-pyrrolidinone; *N;N*-dimethyl alkylamides; dimethyl sulfoxide; and liquid fertilizers, as well as mixtures thereof. Exemplary solid carriers include, but are not limited to: silicas, silica gels, silicates, talc, kaolin, limestone, lime, chalk, bole, loess, clay, dolomite, diatomaceous earth, calcium sulfate, magnesium sulfate, magnesium oxide, ground synthetic materials, pyrophyllite clay, attapulgus clay, kieselguhr, calcium carbonate, bentonite clay, Fuller's earth, cottonseed hulls, wheat flour, soybean flour, pumice, wood flour, walnut shell flour, lignin, ammonium sulfate, ammonium phosphate, ammonium nitrate, ureas, cereal meal, tree bark meal, wood meal and nutshell meal, cellulose powders, and mixtures thereof.

B. Physical States

[0087] In some aspects, the formulation of (a) the pyridine carboxylate herbicide or an agriculturally acceptable N-oxide, salt, or ester thereof and (b) the PDS inhibitor herbicide or an agriculturally acceptable salt or ester thereof may present in suspended, emulsified, dissolved, or solid form. Exemplary formulations include, but are not limited to, aqueous solutions, aqueous suspensions, aqueous dispersions, aqueous emulsions, aqueous microemulsions, aqueous suspo-emulsions, oil solutions, oil suspensions, oil dispersions, oil emulsions, oil microemulsions, oil suspo-emulsions, self-emulsifying formulations, pastes, powders, dusts, granules, and materials for spreading.

[0088] In some aspects, (a) and (b) are aqueous solutions that can be diluted before use. In various aspects, (a) and (b) may be provided as a high-strength formulation such as a concentrate. In some aspects, the concentrate is stable and retains potency during storage and shipping. In various aspects, the concentrate is a clear, homogeneous liquid that is stable at temperatures of

54 °C or greater. In some aspects, the concentrate does not exhibit any precipitation of solids at temperatures of -10 °C or higher. In some aspects, the concentrate does not exhibit separation, precipitation, or crystallization of any components at low temperatures. For example, the concentrate remains a clear solution at temperatures below 0 °C (*e.g.*, below -5 °C, below -10 °C, below -15 °C). In some aspects, the concentrate exhibits a viscosity of less than 50 centipoise (50 megapascals), even at temperatures as low as 5 °C. In some aspects, the concentrate does not exhibit separation, precipitation, or crystallization of any components during storage for a period of 2 weeks or greater (*e.g.*, 4 weeks, 6 weeks, 8 weeks, 3 months, 6 months, 9 months, or 12 months or greater).

[0089] In some aspects, emulsions, pastes, or oil dispersions can be prepared by homogenizing (a) and (b) in water with a wetting agent, tackifier, dispersant, or emulsifier. In some aspects, concentrates suitable for dilution with water can be prepared, comprising (a), (b), a wetting agent, a tackifier, and a dispersant or emulsifier.

[0090] In some aspects, powders, materials for spreading, or dusts can be prepared by mixing or concomitant grinding of (a) and (b) and optionally other additives with a solid carrier.

[0091] In some aspects, granules (*e.g.*, coated granules, impregnated granules and homogeneous granules) can be prepared by binding the (a) and (b) to solid carriers.

[0092] In some aspects, the formulations comprise, by total weight of (a) and (b), from 1% to 99% of (a) and 1% to 99% of (b) (*e.g.*, 95% of (a) and 5% of (b); 70% of (a) and 30% of (b); or 40% of (a) and 60% of (b)). In formulations designed to be employed as concentrates, the total amount of (a) and (b) can be present in a concentration of from about 0.1 to about 98 weight percent (wt. %), based on the total weight of the formulation. For example, the total amount of (a) and (b) can be present in a concentration as little as about 1 wt. %, about 2.5 wt. %, about 5 wt. %, about 7.5 wt. %, about 10 wt. %, about 15wt. %, about 20 wt. %, about 25 wt. %, about 30 wt. %, about 35 wt. %, about 40 wt. %, about 45 wt. %, as high as about 50 wt. %, about 55 wt. %, about 60 wt. %, about 65 wt. %, about 70 wt. %, about 75 wt. %, about 80 wt. %, about 85 wt. %, about 90 wt. %, about 95 wt. %, about 97 wt. %, or within any range defined between any two of the forgoing values, such as between about 1 wt. % to about 97 wt. %, between about 10 wt. % to about 90 wt. %, between about 20 wt. % to about 45 wt. %, and about 25 wt. % to about 50 wt. % based on the total weight of the formulation. Concentrates can be diluted with an inert carrier, such as water, prior to application. The diluted formulations applied to undesirable vegetation or the locus of undesirable vegetation can contain from 0.0006 to 8.0 wt.

% of the total amount of (a) and (b) (*e.g.*, from 0.001 to 5.0 wt. %), based on the total weight of the diluted formulation.

C. Packaging

[0093] In some aspects, the formulation can be in the form of a single package formulation including (a) the pyridine carboxylate herbicide or an agriculturally acceptable N-oxide, salt, or ester thereof, and (b) the PDS inhibitor herbicide or an agriculturally acceptable salt or ester thereof. In some aspects, the formulation can be in the form of a single package formulation including (a) or (b), and further including at least one additive. In some aspects, the formulation can be in the form of a multi-package formulation, such as a two-package formulation, wherein one package contains (a) and optionally at least one additive while the other package contains (b) and optionally at least one additive. In some aspects of the two-package formulation, the formulation including (a) and optionally at least one additive and the formulation including (b) and optionally at least one additive are mixed before application and then applied simultaneously. In some aspects, the mixing is performed as a tank mix (*e.g.*, the formulations are mixed immediately before or upon dilution with water). In some aspects, the formulation including (a) and the formulation including (b) are not mixed but are applied sequentially (in succession), for example, immediately or within 1 hour, within 2 hours, within 4 hours, within 8 hours, within 16 hours, within 24 hours, within 2 days, or within 3 days, of each other.

VI. Methods of Use

[0094] The compositions disclosed herein can be applied in any known technique for applying herbicides. Exemplary application techniques include, but are not limited to, spraying, atomizing, dusting, spreading, or direct application into water. The method of application can vary depending on the intended purpose. In some aspects, the method of application can be chosen to ensure the finest possible distribution of the compositions disclosed herein.

[0095] In some aspects, a method of controlling undesirable vegetation which comprises contacting the vegetation or the locus thereof with or applying to the soil or water to prevent the emergence or growth of vegetation any of the compositions is disclosed herein.

[0096] The compositions disclosed herein can be applied pre-emergence (before the emergence of undesirable vegetation) or post-emergence (*e.g.*, during and/or after emergence of the undesirable vegetation). In some aspects, the composition is applied post-emergence to the undesirable vegetation. In some aspects, the pyridine carboxylate herbicide and the PDS inhibitor herbicide are applied simultaneously. In some aspects, the pyridine carboxylate

herbicide and PDS inhibitor herbicide, are applied sequentially, for example, immediately or with minimal delay, within about 10 minutes, within about 20 minutes, within about 30 minutes, within about 40 minutes, within about 1 hour, within about 2 hours, within about 4 hours, within about 8 hours, within about 16 hours, within about 24 hours, within about 2 days, or within about 3 days, of each other.

[0097] When the compositions are used in crops, the compositions can be applied after seeding and before or after the emergence of the crop plants. In some aspects, the compositions disclosed herein show good crop tolerance even when the crop has already emerged and can be applied during or after the emergence of the crop plants. In some aspects, when the compositions are used in crops, the compositions can be applied before seeding of the crop plants.

[0098] In some aspects, the compositions disclosed herein are applied to vegetation or an area adjacent the vegetation or applying to soil or water to prevent the emergence or growth of vegetation by spraying (*e.g.*, foliar spraying). In some aspects, the spraying techniques use, for example, water as carrier and spray volume rates of from 2 liters per hectare (L/ha) to 2000 L/ha (*e.g.*, from 10–1000 L/ha or from 50–500 L/ha). In some aspects, the compositions disclosed herein are applied by the low-volume or the ultra-low-volume method, wherein the application is in the form of micro granules. In some aspects, wherein the compositions disclosed herein are less well tolerated by certain crop plants, the compositions can be applied with the aid of the spray apparatus in such a way that they come into little contact, if any, with the leaves of the sensitive crop plants while reaching the leaves of undesirable vegetation that grows underneath or on the bare soil (*e.g.*, post-directed or lay-by). In some aspects, the compositions disclosed herein can be applied as dry formulations (*e.g.*, granules, powders, or dusts).

[0099] In some aspects, wherein the undesirable vegetation is treated post-emergence, the compositions disclosed herein are applied by foliar application. In some aspects, herbicidal activity is exhibited by the compounds of the mixture when they are applied directly to the plant or to the locus of the plant at any stage of growth or before planting or emergence. The effect observed can depend upon the type of undesirable vegetation to be controlled, the stage of growth of the undesirable vegetation, 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. In some aspects, these and other factors can be adjusted to promote non-selective or selective herbicidal action.

[0100] The compositions and methods disclosed herein can be used to control undesirable vegetation in a variety of applications. The compositions and methods disclosed herein can be used for controlling undesirable vegetation in areas including, but not limited to, farmland, turfgrass, pastures, grasslands, rangelands, fallow land, rights-of-way, aquatic settings, tree and vine, wildlife management areas, or rangeland. In some aspects, the undesirable vegetation is controlled in a row crop. Exemplary crops include, but are not limited to, wheat, barley, triticale, rye, teff, oats, maize, cotton, soy, sorghum, rice, millet, sugarcane and range land (*e.g.*, pasture grasses). In some aspects, the compositions and methods disclosed herein can be used for controlling undesirable vegetation in maize, wheat, barley, rice, sorghum, millet, oats, or combinations thereof. In some aspects, the compositions and methods disclosed herein can be used for controlling undesirable vegetation in broadleaf crops. In some aspects, the compositions and methods disclosed herein can be used for controlling undesirable vegetation in canola, flax, sunflower, soy, or cotton. In some aspects, the compositions and methods disclosed herein can be used in industrial vegetation management (IVM) or for utility, pipeline, roadside, and railroad rights−of−way applications. In some aspects, the compositions and methods disclosed herein can also be used in forestry (*e.g.*, for site preparation or for combating undesirable vegetation in plantation forests). In some aspects, the compositions and methods disclosed herein can be used to control undesirable vegetation in conservation reserve program lands (CRP), trees, vines, grasslands, and grasses grown for seeds. In some aspects, the compositions and methods disclosed herein can be used on lawns (*e.g.*, residential, industrial, and institutional), golf courses, parks, cemeteries, athletic fields, and sod farms.

[0101] The compositions and methods disclosed herein can also be used in crop plants that are resistant to, for instance, herbicides, pathogens, and/or insects. In some aspects, the compositions and methods disclosed herein can be used in crop plants that are resistant to one or more herbicides because of genetic engineering or breeding. In some aspects, the compositions and methods disclosed herein can be used in crop plants that are resistant to one or more pathogens such as plant pathogenic fungi owing to genetic engineering or breeding. In some aspects, the compositions and methods disclosed herein can be used in crop plants that are resistant to attack by insects owing to genetic engineering or breeding. Exemplary resistant crops include, but are not limited to, crops that are resistant to photosystem II inhibitors, or crop plants that, owing to introduction of the gene for *Bacillus thuringiensis* (or *Bt*) toxin by genetic modification, are resistant to attack by certain insects. In some aspects, the compositions and methods described herein can be used in conjunction with glyphosate, glufosinate, dicamba, phenoxy auxins, pyridyloxy auxins, aryloxyphenoxypropionates, acetyl CoA carboxylase

(ACCase) inhibitors, imidazolinones, acetolactate synthase (ALS) inhibitors, 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitors, protoporphyrinogen oxidase (PPO) inhibitors, triazines, and bromoxynil to control vegetation in crops tolerant to glyphosate, glufosinate, dicamba, phenoxy auxins, pyridyloxy auxins, aryloxyphenoxypropionates, ACCase inhibitors, imidazolinones, synthetic auxin herbicide, HPPD inhibitors, PPO inhibitors, triazines, bromoxynil, or combinations thereof. In some aspects, the undesirable vegetation is controlled in glyphosate, glufosinate, dicamba, phenoxy auxins, pyridyloxy auxins, aryloxyphenoxypropionates, ACCase inhibitors, synthetic auxin herbicide, HPPD inhibitors, PPO inhibitors, triazines, and bromoxynil tolerant crops possessing single, multiple or stacked traits conferring tolerance to single or multiple chemistries and/or multiple modes of action. In some aspects, the undesirable vegetation can be controlled in a crop that is ACCase-tolerant, ALS-tolerant, or a combination thereof. The combination of (a), (b), and optionally (c) can be used in combination with one or more herbicides that are selective for the crop being treated and which complement the spectrum of weeds controlled by these compounds at the application rate employed. In some aspects, the compositions described herein and other complementary herbicides are applied at the same time, either as a combination formulation or as a tank mix, or as sequential applications. The compositions and methods may be used in controlling undesirable vegetation in crops possessing agronomic stress tolerance (including but not limited to drought, cold, heat, salt, water, nutrient, fertility, pH), pest tolerance (including but not limited to insects, fungi and pathogens), and crop improvement traits (including but not limited to yield; protein, carbohydrate, or oil content; protein, carbohydrate, or oil composition; plant stature and plant architecture).

[0102] In some aspects, the compositions disclosed herein can be used for controlling undesirable vegetation including grasses, broadleaf weeds, sedge weeds, and combinations thereof. In some aspects, the compositions disclosed herein can be used for controlling undesirable vegetation including, but not limited to, *Polygonum* species, *Amaranthus* species, *Chenopodium* species, *Sida* species, *Ambrosia* species, *Cyperus* species, *Setaria* species, *Sorghum* species, *Acanthospermum* species, *Anthemis* species, *Atriplex* species, *Brassica* species, *Cirsium* species, *Convolvulus* species, *Conyza* species, *Cassia* species, *Commelina* species, *Datura* species, *Euphorbia* species, *Geranium* species, *Galinsoga* species, *Ipomea* species, *Lamium* species, *Lolium* species, *Malva* species, *Matricaria* species, *Prosopis* species, *Rumex* species, *Sisymbrium* species, *Solanum* species, *Trifolium* species, *Xanthium* species, *Veronica* species, and *Viola* species. In some aspects, the undesired vegetation includes common chickweed (*Stellaria media*), velvetleaf (*Abutilon theophrasti*), hemp sesbania (*Sesbania*

exaltata Cory), *Anoda cristata, Bidens pilosa, Brassica kaber,* shepherd's purse (*Capsella bursa-pastoris*), cornflower (*Centaurea cyanus* or *Cyanus segetum*), hempnettle *(Galeopsis tetrahit),* cleavers (*Galium aparine*), common sunflower (*Helianthus annuus*), *Desmodium tortuosum,* Italian ryegrass (*Lolium multiflorum*), kochia (*Kochia scoparia*), *Medicago arabica, Mercurialis annua, Myosotis arvensis,* common poppy (*Papaver rhoeas*), *Raphanus raphanistrum,* broad-leaf dock (*Rumex obtusifolius*), Russian thistle (*Salsola kali*), wild mustard (*Sinapis arvensis*), *Sonchus arvensis, Thlaspi arvense, Tagetes minuta, Richardia brasiliensis, Plantago major, Plantago lanceolata,* bird's-eye speedwell (*Veronica persica*), pigweed (*Amaranthus retroflexus*), winter rape (*Brassica napus*), lambsquarters (*Chenopodium album*), Canada thistle (*Cirsium arvense*), nutsedge (*Cyperus esculentus*), poinsettia (*Euphorbiaheterophylla*), prickly lettuce (*Lactuca serriola*), purple deadnettle (*Lamium purpureum*), wild chamomile (*Matricaria chamomilla*), false chamomile (*Matricaria inodora*), field chamomile (*Anthemis arvensis*), common buckwheat (*Fagopyrum esculentum*), wild buckwheat (*Polygonum convulvus*), giant foxtail (*Setaria faberi*), green foxtail (*Setaria viridis*), common sorghum (*Sorghum vulgare*), wild pansy (*Viola tricolor*), or combinations thereof.

[0103] The compositions described herein can be used to control herbicide resistant or tolerant weeds. The methods employing the compositions described herein may also be employed to control herbicide resistant or tolerant weeds. Exemplary resistant or tolerant weeds include, but are not limited to, biotypes resistant or tolerant to acetolactate synthase (ALS) or acetohydroxy acid synthase (AHAS) inhibitors (*e.g.*, imidazolinones, sulfonylureas, pyrimidinylthiobenzoates, triazolopyrimidines, sulfonylaminocarbonyltriazolinones), photosystem II inhibitors (*e.g.*, phenylcarbamates, pyridazinones, triazines, triazinones, uracils, amides, ureas, benzothiadiazinones, nitriles, phenylpyridazines), acetyl CoA carboxylase (ACCase) inhibitors (*e.g.*, aryloxyphenoxypropionates, cyclohexanediones, phenylpyrazolines), synthetic auxins (*e.g.*, benzoic acids, phenoxycarboxylic acids, pyridine carboxylates, quinoline carboxylic acids), auxin transport inhibitors (*e.g.*, phthalamates, semicarbazones), photosystem I inhibitors (*e.g.*, bipyridyliums), 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase inhibitors (*e.g.*, glyphosate), glutamine synthetase inhibitors (*e.g.*, glufosinate, bialaphos), microtubule assembly inhibitors (*e.g.*, benzamides, benzoic acids, dinitroanilines, phosphoramidates, pyridines), mitosis inhibitors (*e.g.*, carbamates), very long chain fatty acid (VLCFA) inhibitors (*e.g.*, acetamides, chloroacetamides, oxyacetamides, tetrazolinones), fatty acid and lipid synthesis inhibitors (*e.g.*, phosphorodithioates, thiocarbamates, benzofuranes, chlorocarbonic acids), protoporphyrinogen oxidase (PPO) inhibitors (*e.g.*, diphenylethers, *N*-phenylphthalimides, oxadiazoles, oxazolidinediones, phenylpyrazoles, pyrimidindiones,

thiadiazoles, triazolinones), carotenoid biosynthesis inhibitors (*e.g.*, clomazone, amitrole, aclonifen), phytoene desaturase (PDS) inhibitors (*e.g.*, amides, anilidex, furanones, phenoxybutan-amides, pyridiazinones, pyridines), 4-hydroxyphenyl-pyruvate-dioxygenase (HPPD) inhibitors (*e.g.*, callistemones, isoxazoles, pyrazoles, triketones), cellulose biosynthesis inhibitors (*e.g.*, nitriles, benzamides, quinclorac, triazolocarboxamides), herbicides with multiple modes of action such as quinclorac, and unclassified herbicides such as arylaminopropionic acids, difenzoquat, endothall, and organoarsenicals. Exemplary resistant or tolerant weeds include, but are not limited to, biotypes with resistance or tolerance to multiple herbicides, biotypes with resistance or tolerance to multiple chemical classes, biotypes with resistance or tolerance to multiple herbicide modes of action, and biotypes with multiple resistance or tolerance mechanisms (*e.g.*, target site resistance or metabolic resistance).

[0104] By way of non-limiting illustration, examples of some aspects of the present disclosure are given below. Parts and percentages are on a per weight basis unless otherwise indicated.

Examples

Greenhouse Trial Methodology - Evaluation of Postemergence Herbicidal Effect

[0105] Seeds of the desired test plant species were planted in a 90:10 % v/v (volume/volume) mixture of PRO-MIX® BX (Premier Tech Horticulture, Quakertown, PA, USA) and PROFILE® GREENS GRADE™ (Profile Products LLC, Buffalo Grove, IL, USA) planting mixture, which typically has a pH of 5.2 to 6.2 and an organic matter content of at least 50 percent, in plastic pots with a surface area of 103.2 square centimeters (cm^2). In some aspects, to ensure good germination and healthy plants, a fungicide treatment and/or other chemical or physical treatment was applied. The plants were grown for 7–36 days (d) in a greenhouse with an approximate 14-hour (h) photoperiod which was maintained at about 23 °C during the day and 22 °C during the night. Nutrients and water were added on a regular basis and supplemental lighting was provided with overhead metal halide 1000-Watt lamps as necessary. The plants were employed for testing when they reached the second or third true leaf stage.

[0106] Emulsifiable concentrates of each of each pyridine carboxylate herbicide (Compound A or Compound B) were prepared at 100 grams acid equivalent per liter (g ae/L). The emulsifiable concentrates also included a safener, cloquintocet-mexyl, at 120 grams active ingredient per liter (g ai/L). An aliquot of each emulsifiable concentrate was placed in a 25 mL glass vial and diluted with an aqueous mixture of 1.25% (v/v) ACTIROB® B esterified rapeseed

oil (Bayer Crop Science, Research Triangle Park, NC, USA) or MSO® Concentrate with LECI-TECH® methylated soybean oil (Loveland Products, Loveland, CO, USA) to obtain concentrated stock solutions at the highest application rate for each herbicide, based upon a 12 milliliter (mL) application volume at a rate of 187 liters per hectare (L/ha). The concentrated stock solutions were further diluted with an aqueous mixture of 1.25% v/v ACTIROB® B or MSO® Concentrate with LECI-TECH® to obtain stock solutions at reduced application rates for each herbicide. Spray solutions of the herbicide combinations (Compound A or Compound B plus PDS inhibitor herbicide) were prepared by adding weighed amounts or aliquots of the PDS inhibitor herbicide to the stock solutions of Compound A or Compound B to form 12-mL spray solutions in two- or three-way combinations.

[0107] The spray solutions were applied to the plant material with an overhead Mandel track sprayer equipped with 8002E nozzles calibrated to deliver 187 L/ha over an application area of 0.503 square meters (m^2) at a spray height of 18 inches (43 centimeters (cm)) above the average plant canopy. Control plants were sprayed in the same manner with the solvent blank. All pyridine carboxylate herbicide (component a) application rates are given as "g ae/ha" and all PDS inhibitor herbicide (component b) application rates are given as "g ai/ha."

[0108] The treated plants and control plants were placed in a greenhouse as described above and watered by sub-irrigation to prevent wash-off of the test compounds. After 20-22 d, the condition of the test plants as compared with that of the control plants was determined visually and scored on a scale of 0 to 100 percent where 0 corresponds to no injury and 100 corresponds to complete kill.

[0109] The details of the compositions and the crops tested are specified in the following Examples.

Example 1

[0110] Compositions comprising Compound A and diflufenican were tested on undesirable vegetation species, including winter rape (BRSNW, *Brassica napus*), wild buckwheat (POLCO, *Polygonum convolvulus)*, wild mustard (SINAR, *Sinapis arvensis*), Russian thistle (SASKR, *Salsola kali*), kochia (KCHSC, *Kochia scoparia*), common lambsquarters (CHEAL, *Chenopodium album* L.), pigweed (AMARE, *Amaranthus retroflexus*), wild chamomile (MATCH, *Matricaria chamomilla*), and Canada thistle (CIRAR, *Cirsium arvense*), to determine the efficacy of the compositions on these undesirable vegetation species. The compositions were also tested on spring wheat (TRZAS) and spring barley (HORVS), and the phytotoxicity of the compositions on each crop was measured.

[0111] The results are summarized in Table 1 below.

Table 1. Herbicidal Effects (% visual injury) of Compound A and Diflufenican on weed and grain crops.

Application rate (g/ha)	Compound A	7.5	10	0	7.5	10
	Diflufenican	0	0	60	60	60
BRSNW		35	43	18	90	88
POLCO		78	93	10	95	97
SINAR		88	90	23	100	100
SASKR		60	63	18	68	73
KCHSC		63	63	13	65	68
CHEAL		88	93	13	90	98
AMARE		78	73	20	88	93
MATCH		20	30	0	15	45
CIRAR		30	40	5	75	78
TRZAS		0	0	0	0	0
HORVS		0	0	13	0	0

g/ha = grams per hectare

BRSNW = *Brassica napus* (winter rape)
POLCO = *Polygonum convolvulus* (wild buckwheat)
SINAR = *Sinapis arvensis* (wild mustard)
SASKR = *Salsola kali* (Russian thistle)
KCHSC = *Kochia scoparia* (kochia)
CHEAL = *Chenopodium album* L. (common lambsquarters)
AMARE = *Amaranthus retroflexus* (pigweed)
MATCH = *Matricaria chamomilla* (wild chamomile)
CIRAR = *Cirsium arvense* (Canada thistle)
TRZAS = *Triticum aestivum* (spring wheat)
HORVS = *Hordeum vulgare* (spring barley)

Example 2

[0112] Compositions comprising Compound A and beflubutamid were tested on undesirable vegetation species, including spring rape (BRSNN, *Brassica napus*), wild buckwheat (POLCO, *Polygonum convolvulus)*, wild mustard (SINAR, *Sinapis arvensis*), Russian thistle (SASKR, *Salsola kali*), kochia (KCHSC, *Kochia scoparia*), common lambsquarters (CHEAL, *Chenopodium album* L.), and wild chamomile (MATCH, *Matricaria chamomilla)*, to determine the efficacy of the compositions on these undesirable vegetation species. The compositions were also tested on spring wheat (TRZAS) and spring barley (HORVS), and the phytotoxicity of the compositions on each crop was measured.

[0113] The results are summarized in Table 2 below.

Table 2. Herbicidal Effects (% visual injury) of Compound A and Beflubutamid on weed and grain crops.

Application rate (g/ha)	Compound A	7.5	10	0	7.5	10
	Beflubutamid	0	0	42.5	42.5	42.5
BRSNN	Obs	55	60	25	75	88
	Exp	--	--	--	66	70
	△				9	18
POLCO	Obs	70	78	0	94	98
	Exp	--	--	--	70	78
	△				24	20
SINAR	Obs	88	92	5	99	100
	Exp	--	--	--	88	92
	△				10	8
SASKR	Obs	45	60	0	60	68
	Exp	--	--	--	45	60
	△				15	8
KCHSC	Obs	50	58	0	68	85
	Exp	--	--	--	50	58
	△				18	28
CHEAL	Obs	70	83	0	83	92
	Exp	--	--	--	70	83
	△				13	9
MATCH	Obs	13	15	0	20	50
	Exp	--	--	--	13	15
	△				8	35
TRZAS	Obs	0	0	0	0	0
	Exp	--	--	--	0	0
	△				0	0
HORVS	Obs	8	0	18	8	8
	Exp	--	--	--	24	18
	△				-16	-10

g/ha = grams per hectare

BRSNN = *Brassica napus* (spring rape)
POLCO = *Polygonum convolvulus* (wild buckwheat)

SINAR = *Sinapis arvensis* (wild mustard)
SASKR = *Salsola kali* (Russian thistle)
KCHSC = *Kochia scoparia* (kochia)
CHEAL = *Chenopodium album* L. (common lambsquarters)
MATCH = *Matricaria chamomilla* (wild chamomile)
TRZAS = *Triticum aestivum* (spring wheat)
HORVS = *Hordeum vulgare* (spring barley)

Example 3

[0114] Compositions comprising Compound A and fluridone were tested on undesirable vegetation species, including spring rape (BRSNN, *Brassica napus*), wild buckwheat (POLCO, *Polygonum convolvulus)*, wild mustard (SINAR, *Sinapis arvensis*), Russian thistle (SASKR, *Salsola kali*), pigweed (AMARE, *Amaranthus retroflexus*), common lambsquarters (CHEAL, *Chenopodium album* L.), wild chamomile (MATCH, *Matricaria chamomilla*), and Canada thistle (CIRAR, *Cirsium arvense*), to determine the efficacy of the compositions on these undesirable vegetation species. The compositions were also tested on spring wheat (TRZAS) and spring barley (HORVS), and the phytotoxicity of the compositions on each crop was measured.

[0115] The results are summarized in Table 3 below.

Table 3. Herbicidal Effects (% visual injury) of Compound A and Fluridone on weed and grain crops.

Application rate (g/ha)	Compound A	7.5	10	0	7.5	10
	Fluridone	0	0	280	280	280
BRSNN	Obs	55	70	18	100	89
	Exp	--	--	--	63	75
	△				37	13
POLCO	Obs	88	96	13	98	95
	Exp	--	--	--	89	97
	△				8	-2
SINAR	Obs	85	90	45	100	100
	Exp	--	--	--	92	95
	△				8	6
SASKR	Obs	38	63	0	83	88
	Exp	--	--	--	38	63
	△				45	25
AMARE	Obs	70	98	23	98	100
	Exp	--	--	--	77	98
	△				21	2
CHEAL	Obs	60	90	13	98	100
	Exp	--	--	--	65	91

	△				33	9
MATCH	Obs	0	33	5	93	95
	Exp	--	--	--	5	36
	△				88	59
CIRAR	Obs	10	23	18	80	85
	Exp	--	--	--	26	36
	△				54	49
TRZAS	Obs	0	0	0	0	0
	Exp	--	--	--	0	0
	△				0	0
HORVS	Obs	0	0	0	0	0
	Exp	--	--	--	0	0
	△				0	0

g/ha = grams per hectare

BRSNN = *Brassica napus* (spring rape)
POLCO = *Polygonum convolvulus* (wild buckwheat)
SINAR = *Sinapis arvensis* (wild mustard)
SASKR = *Salsola kali* (Russian thistle)
AMARE = *Amaranthus retroflexus* (pigweed)
CHEAL = *Chenopodium album* L. (common lambsquarters)
MATCH = *Matricaria chamomilla* (wild chamomile)
CIRAR = *Cirsium arvense* (Canada thistle)
TRZAS = *Triticum aestivum* (spring wheat)
HORVS = *Hordeum vulgare* (spring barley)

Example 4

[0116] Compositions comprising Compound A and picolinafen were tested on undesirable vegetation species, including wild pansy (VIOTR, *Viola tricolor*), common lambsquarters (CHEAL, *Chenopodium album* L.), Italian ryegrass (LOLMU, *Lolium multiflorum.*), common rice (ORYSA, *Oryza sativa*), barnyardgrass (ECHCG, *Echinochloa crus-galli*), large crabgrass (DIGSA, *Digitaria sanguinalis*), velvetleaf (ABUTH, *Abutilon theophrasti*), Canada thistle (CIRAR, *Cirsium arvense*), spring rape (BRSNN, *Brassica napus*), giant foxtail (SETFA, *Setaria faberi*), broad-leaf dock (RUMOB, *Rumex obtusifolius*), soybean (GLXMA = *Glycine max*), and ivyleaf morningglory (IPOHE, *Ipomoea hederacea*), to determine the efficacy of the compositions on these undesirable vegetation species.

[0117] The results are summarized in Table 4 below.

Table 4. Herbicidal Effects (% visual injury) of Compound A and Picolinafen on weeds.

Application rate (g/ha)	Compound A	7.5	10	0	7.5	10
	Picolinafen	0	0	12.5	12.5	12.5
VIOTR	Obs	10	18	0	45	53
	Exp	-	-	-	10	18

	△				35	35
CHEAL	Obs	97	93	20	100	100
	Exp	-	-	-	97	94
	△				3	6
LOLMU	Obs	0	0	0	10	18
	Exp	-	-	-	0	0
	△				10	18
ORYSA	Obs	13	10	5	35	45
	Exp	-	-	-	17	15
	△				18	31
ECHCG	Obs	73	78	0	84	92
	Exp	-	-	-	73	78
	△				12	14
DIGSA	Obs	45	25	50	75	80
	Exp	-	-	-	73	63
	△				3	18
ABUTH	Obs	68	78	15	82	78
	Exp	-	-	-	72	81
	△				9	-3
CIRAR	Obs	23	20	5	65	70
	Exp	-	-	-	26	24
	△				39	46
BRSNN	Obs	73	83	28	85	90
	Exp	-	-	-	80	87
	△				5	3
SETFA	Obs	70	70	0	93	95
	Exp	-	-	-	70	70
	△				23	25
RUMOB	Obs	8	10	0	20	23
	Exp	-	-	-	8	10
	△				13	13
GLXMA	Obs	93	95	20	100	100
	Exp	-	-	-	94	96
	△				6	4
IPOHE	Obs	3	8	5	40	40
	Exp	-	-	-	7	12
	△				33	28

g/ha = grams per hectare

VIOTR = *Viola tricolor* (wild pansy)
CHEAL = *Chenopodium album* L. (common lambsquarters)
LOLMU = *Lolium multiflorum* (Italian ryegrass)
ORYSA = *Oryza sativa* (common rice)
ECHCG = *Echinochloa crus-galli* (barnyardgrass)
DIGSA = *Digitaria sanguinalis* (large crabgrass)
ABUTH = *Abutilon theophrasti* (velvetleaf)

CIRAR = *Cirsium arvense* (Canada thistle)
BRSNN = *Brassica napus* (spring rape)
SETFA = *Setaria faberi* (giant foxtail)
RUMOB = *Rumex obtusifolius* (broad-leaf dock)
GLXMA = *Glycine max* (soybean)
IPOHE = *Ipomoea hederacea* (ivyleaf morningglory)

Example 5

[0118] Compositions comprising Compound A, diflufenican and flurtamone were tested on undesirable vegetation species, including wild pansy (VIOTR, *Viola tricolor*), velvetleaf (ABUTH, *Abutilon theophrasti*), wild buckwheat (POLCO, *Polygonum convolvulus)*, poinsettia (EPHHL, *Euphorbia heterophylla*), Canada thistle (CIRAR, *Cirsium arvense*), ivyleaf morningglory (IPOHE, *Ipomoea hederacea*), pigweed (AMARE, *Amaranthus retroflexus*), common sunflower (HELAN, *Helianthus annuus*), and kochia (KCHSC, *Kochia scoparia*), to determine the efficacy of the compositions on these undesirable vegetation species. The compositions were also tested on spring wheat (TRZAS), and the phytotoxicity of the compositions on the crop was measured.

[0119] The results are summarized in Table 5 below.

Table 5. Herbicidal Effects (% visual injury) of Compound A, Diflufenican, and Flurtamone on weeds and grain crops.

Application rate (g/ha)	Compound A	7.5	10	0	7.5	10
	Diflufenican	0	0	51.5	51.5	51.5
	Flurtamone	0	0	128.5	128.5	128.5
VIOTR	Obs	3	3	5	30	28
	Exp	-	-	-	7	7
	△				23	20
ABUTH	Obs	40	48	15	83	75
	Exp	-	-	-	49	55
	△				34	20
POLCO	Obs	68	70	0	83	89
	Exp	-	-	-	68	70
	△				15	19
EPHHL	Obs	91	83	20	91	85
	Exp	-	-	-	93	86
	△				-2	-1
CIRAR	Obs	25	20	18	63	83
	Exp	-	-	-	38	34
	△				24	49
IPOHE	Obs	5	0	0	60	40
	Exp	-	-	-	5	0
	△				55	40

AMARE	Obs	80	85	5	94	94
	Exp	-	-	-	81	86
	△				13	8
HELAN	Obs	83	88	5	93	92
	Exp	-	-	-	83	88
	△				9	3
KCHSC	Obs	63	65	40	73	78
	Exp	-	-	-	78	79
	△				-5	-2
TRZAS	Obs	0	0	0	0	0
	Exp	-	-	-	0	0
	△				0	0

g/ha = grams per hectare

VIOTR = *Viola tricolor* (wild pansy)
ABUTH = *Abutilon theophrasti* (velvetleaf)
POLCO = *Polygonum convolvulus* (wild buckwheat)
EPHHL = *Euphorbia heterophylla* (poinsettia)
CIRAR = *Cirsium arvense* (Canada thistle)
IPOHE = *Ipomoea hederacea* (ivyleaf morningglory)
AMARE = *Amaranthus retroflexus* (pigweed)
HELAN = *Helianthus annuus* (common sunflower)
KCHSC = *Kochia scoparia* (kochia)
TRZAS = *Triticum aestivum* (spring wheat)

Example 6

[0120] Compositions comprising Compound A, with the PDS inhibitor herbicides diflufenican and flurtamone and the VLCFA synthesis inhibitor flufenacet, were tested on undesirable vegetation species, including wild pansy (VIOTR, *Viola tricolor*), velvetleaf (ABUTH, *Abutilon theophrasti*), wild buckwheat (POLCO, *Polygonum convolvulus)*, poinsettia (EPHHL, *Euphorbia heterophylla*), Canada thistle (CIRAR, *Cirsium arvense*), ivyleaf morningglory (IPOHE, *Ipomoea hederacea*), pigweed (AMARE, *Amaranthus retroflexus*), common sunflower (HELAN, *Helianthus annuus*), and kochia (KCHSC, *Kochia scoparia*), to determine the efficacy of the compositions on these undesirable vegetation species. The compositions were also tested on spring wheat (TRZAS), and the phytotoxicity of the compositions on the crop was measured.

[0121] The results are summarized in Table 6 below.

Table 6. Herbicidal Effects (% visual injury) of Compound A, Diflufenican, Flurtamone, and Flufenacet on weeds and grain crops.

Application rate (g/ha)	Compound A	7.5	10	0	7.5	10
	Diflufenican	0	0	58.3	58.3	58.3
	Flurtamone	0	0	58.3	58.3	58.3

	Flufenacet	0	0	58.3	58.3	58.3
VIOTR	Obs	3	3	20	25	28
	Exp	-	-	-	22	22
	△				3	6
ABUTH	Obs	40	48	0	68	53
	Exp	-	-	-	40	48
	△				28	5
POLCO	Obs	68	70	10	73	78
	Exp	-	-	-	71	73
	△				2	5
EPHHL	Obs	91	83	20	90	93
	Exp	-	-	-	93	86
	△				-3	7
CIRAR	Obs	25	20	23	75	83
	Exp	-	-	-	42	38
	△				33	45
IPOHE	Obs	5	0	10	20	15
	Exp	-	-	-	15	10
	△				6	5
AMARE	Obs	80	85	5	90	90
	Exp	-	-	-	81	86
	△				9	4
HELAN	Obs	83	88	5	92	98
	Exp	-	-	-	83	88
	△				8	9
KCHSC	Obs	63	65	48	78	79
	Exp	-	-	-	80	82
	△				-3	-3
TRZAS	Obs	0	0	15	20	0
	Exp	-	-	-	15	15
	△				5	-15

g/ha = grams per hectare

VIOTR = *Viola tricolor* (wild pansy)
ABUTH = *Abutilon theophrasti* (velvetleaf)
POLCO = *Polygonum convolvulus* (wild buckwheat)
EPHHL = *Euphorbia heterophylla* (poinsettia)
CIRAR = *Cirsium arvense* (Canada thistle)
IPOHE = *Ipomoea hederacea* (ivyleaf morningglory)
AMARE = *Amaranthus retroflexus* (pigweed)
HELAN = *Helianthus annuus* (common sunflower)
KCHSC = *Kochia scoparia* (kochia)
TRZAS = *Triticum aestivum* (spring wheat)

Example 7

[0122] Compositions comprising Compound A, the PDS inhibitor herbicide diflufenican, and the ALS inhibitor herbicides iodosulfuron and mesosulfuron were tested on undesirable vegetation species, including pigweed (AMARE, *Amaranthus retroflexus*), winter rape (BRSNW, *Brassica napus*), common lambsquarters (CHEAL, *Chenopodium album* L.), Canada thistle (CIRAR, *Cirsium arvense*), kochia (KCHSC, *Kochia scoparia*), wild chamomile (MATCH, *Matricaria chamomilla*), wild buckwheat (POLCO, *Polygonum convolvulus)*, and wild mustard (SINAR, *Sinapis arvensis*), to determine the efficacy of the compositions on these undesirable vegetation species. The compositions were also tested on spring wheat (TRZAS) and spring barley (HORVS), and the phytotoxicity of the compositions on each crop was measured.

[0123] The results are summarized in Table 7 below. In the table, an application rate of "X+Y+Z" indicates that the application rate of diflufenican is "X," iodosulfuron is "Y," and mesosulfuron is "Z."

Table 7. Herbicidal Effects (% visual injury) of Compound A and Diflufenican + Iodosulfuron + Mesosulfuron on weeds and grain crops.

Application rate (g/ha)	Compound A	7.5	10	0	7.5	10
	Diflufenican + Iodosulfuron + Mesosulfuron	0	0	150 + 2 + 10	150 + 2 + 10	150 + 2 + 10
AMARE	Obs	70	90	98	100	100
	Exp	-	-	-	99	100
	△				1	0
BRSNW	Obs	63	68	95	98	99
	Exp	-	-	-	98	98
	△				-1	0
CHEAL	Obs	70	78	93	90	96
	Exp	-	-	-	98	98
	△				-8	-2
CIRAR	Obs	18	30	30	78	85
	Exp	-	-	-	42	51
	△				35	34
KCHSC	Obs	65	70	25	73	80
	Exp	-	-	-	74	78
	△				-1	3

MATCH	Obs	18	30	80	88	88
	Exp	-	-	-	84	86
	△				4	2
POLCO	Obs	60	70	80	90	93
	Exp	-	-	-	92	94
	△				-2	-2
SINAR	Obs	85	88	98	100	100
	Exp	-	-	-	100	100
	△				0	0
HORVS	Obs	0	0	35	43	50
	Exp	-	-	-	35	35
	△				8	15
TRZAS	Obs	0	0	0	0	0
	Exp	-	-	-	0	0
	△				0	0

g/ha = grams per hectare

AMARE = *Amaranthus retroflexus* (pigweed)
BRSNW = *Brassica napus* (winter rape)
CHEAL = *Chenopodium album* L. (common lambsquarters)
CIRAR = *Cirsium arvense* (Canada thistle)
KCHSC = *Kochia scoparia* (kochia)
MATCH = *Matricaria chamomilla* (wild chamomile)
POLCO = *Polygonum convolvulus* (wild buckwheat)
SINAR = *Sinapis arvensis* (wild mustard)
HORVS = *Hordeum vulgare* (spring barley)
TRZAS = *Triticum aestivum* (spring wheat)

Example 8

[0124] Compositions comprising Compound A, the PDS inhibitor herbicide diflufenican, and the ALS inhibitor herbicides iodosulfuron and mesosulfuron were tested on undesirable vegetation species, including pigweed (AMARE, *Amaranthus retroflexus*), winter rape (BRSNW, *Brassica napus*), common lambsquarters (CHEAL, *Chenopodium album* L.), kochia (KCHSC, *Kochia scoparia*), wild chamomile (MATCH, *Matricaria chamomilla*), wild buckwheat (POLCO, *Polygonum convolvulus)*, and Russian thistle (SASKR, *Salsola kali*), to determine the efficacy of the compositions on these undesirable vegetation species. The compositions were also tested on spring wheat (TRZAS) and spring barley (HORVS), and the phytotoxicity of the compositions on each crop was measured.

[0125] The results are summarized in Table 8 below. In the table, an application rate of "X+Y+Z" indicates that the application rate of diflufenican is "X," iodosulfuron is "Y," and mesosulfuron is "Z."

Table 8. Herbicidal Effects (% visual injury) of Compound A and Diflufenican + Iodosulfuron + Mesosulfuron on weeds and grain crops.

Application rate (g/ha)	Compound A	7.5	10	15	0	0	7.5	10	15	7.5	10	15
	Diflufenican + Iodosulfuron + Mesosulfuron	0	0	0	37.5 + 1.875 + 5.625	75 + 3.75 + 11.25	37.5 + 1.875 + 5.625	37.5 + 1.875 + 5.625	37.5 + 1.875 + 5.625	75 + 3.75 + 11.25	75 + 3.75 + 11.25	75 + 3.75 + 11.25
AMARE	Obs	78	78	83	38	60	70	80	75	73	70	73
	Exp	-	-	-	-	-	86	86	89	91	91	93
	△						-16	-6	-14	-19	-21	-21
BRSNW	Obs	60	60	75	99	100	99	99	99	99	99	100
	Exp	-	-	-	-	-	99	99	100	100	100	100
	△						-1	-1	-1	-1	-1	0
CHEAL	Obs	70	78	83	45	70	85	85	75	78	83	83
	Exp	-	-	-	-	-	84	88	90	91	93	95
	△						2	-3	-15	-14	-11	-12
KCHSC	Obs	70	70	70	15	30	80	85	83	73	80	78
	Exp	-	-	-	-	-	75	75	75	79	79	79
	△						6	11	8	-7	1	-2
MATCH	Obs	8	15	10	45	83	68	75	73	70	75	80
	Exp	-	-	-	-	-	49	53	51	84	85	84
	△						18	22	22	-14	-10	-4
POLCO	Obs	63	60	63	43	73	73	70	73	73	70	68
	Exp	-	-	-	-	-	78	77	78	90	89	90

	△						-6	-7	-6	-17	-19	-22
SASKR	Obs	55	58	65	68	75	73	83	75	83	90	94
	Exp	-	-	-	-	-	85	86	89	89	89	91
	△						-13	-4	-14	-6	1	2
HORVS	Obs	8	5	3	18	35	23	25	28	25	38	30
	Exp	-	-	-	-	-	24	22	20	40	38	37
	△						-1	3	8	-15	-1	-7
TRZAS	Obs	3	3	0	5	3	5	5	5	3	5	5
	Exp	-	-	-	-	-	7	7	5	5	5	3
	△						-2	-2	0	-2	0	3

g/ha = grams per hectare

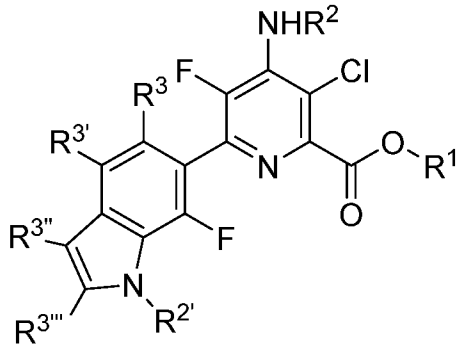
AMARE = *Amaranthus retroflexus* (pigweed)
BRSNW = *Brassica napus* (winter rape)
CHEAL = *Chenopodium album* L. (common lambsquarters)
KCHSC = *Kochia scoparia* (kochia)
MATCH = *Matricaria chamomilla* (wild chamomile)
POLCO = *Polygonum convolvulus* (wild buckwheat)
SASKR = *Salsola kali* (Russian thistle)
HORVS = *Hordeum vulgare* (spring barley)
TRZAS = *Triticum aestivum* (spring wheat)

[0126] The compositions and methods of the appended claims are not limited in scope by the specific compositions and methods described herein, which are intended as illustrations of a few aspects of the claims and any compositions and methods that are functionally equivalent are intended to fall within the scope of the claims. Various modifications of the compositions and methods in addition to those shown and described herein are intended to fall within the scope of the appended claims. Further, while only certain representative compositions and method steps disclosed herein are specifically described, other combinations of the compositions and method steps also are intended to fall within the scope of the appended claims, even if not specifically recited. Thus, a combination of steps, elements, components, or constituents may be explicitly mentioned herein; however, other combinations of steps, elements, components, and constituents are included, even though not explicitly stated. The term "comprising" and variations thereof as used herein is used synonymously with the term "including" and variations thereof and are open, non-limiting terms. Although the terms "comprising" and "including" have been used herein to describe various aspects, the terms "consisting essentially of" and "consisting of" can be used in place of "comprising" and "including" to provide for more specific aspects and are also disclosed. Other than in the examples, or where otherwise noted, all numbers expressing quantities of ingredients, reaction conditions, and so forth used in the specification and claims are to be understood to be construed in light of the number of significant digits and ordinary rounding approaches, and not as an attempt to limit the application of the doctrine of equivalents to the scope of the claims.

WHAT IS CLAIMED IS:

1. A composition, comprising:

(a) a pyridine carboxylate herbicide defined by Formula (I):



Formula (I)

wherein:

R^1 is cyanomethyl or propargyl;

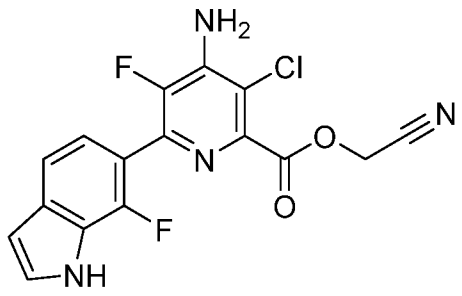
R^2 and $R^{2'}$ are independently hydrogen, C_1-C_6 alkyl, formyl, alkoxycarbonyl, or acyl;

R^3, $R^{3'}$, $R^{3''}$, and $R^{3'''}$ are independently hydrogen, halogen, C_1-C_4 alkyl, C_1-C_4 haloalkyl, C_1-C_3 alkoxy, or C_1-C_3 haloalkoxy;

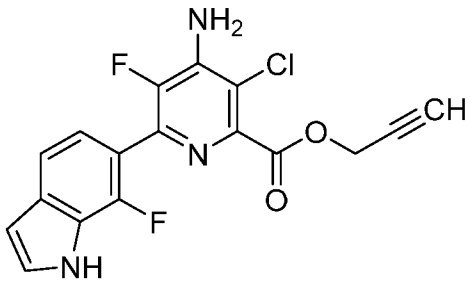
or an agriculturally acceptable N-oxide, salt, or ester thereof; and

(b) a PDS inhibitor herbicide or an agriculturally acceptable salt or ester thereof.

2. The composition of claim 1, wherein the pyridine carboxylate herbicide compound is cyanomethyl 4-amino-3-chloro-5-fluoro-6-(7-fluoro-1H-indol-6-yl)pyridine-2-carboxylate:



3. The composition of claim 1, wherein the pyridine carboxylate herbicide compound is propargyl 4-amino-3-chloro-5-fluoro-6-(7-fluoro-1H-indol-6-yl)pyridine-2-carboxylate:



4. The composition of any one of claims 1-3, wherein the PDS inhibitor herbicide is selected from the group consisting of beflubutamid, diflufenican, fluridone, flurochloridone, flurtamone, norflurazon, picolinafen, an agriculturally acceptable salt or ester thereof, and combinations thereof.

5. The composition of any one of claims 1-4, wherein the weight ratio of the pyridine carboxylate herbicide (in g ae/ha) to the PDS inhibitor herbicide (in g ai/ha) is from 1:9000 to 24:1.

6. The composition of any one of claims 1-5, further comprising a safener.

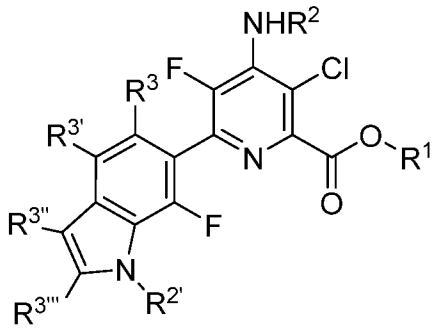
7. The composition of any one of claims 1-6, further comprising an additional pesticide.

8. The composition of claim 7, wherein the additional herbicide is selected from the group consisting of halauxifen, florpyrauxifen, flufenacet, iodosulfuron, mesosulfuron, an agriculturally acceptable salt or ester thereof, and combinations thereof.

9. The composition of any one of claims 1-7, wherein the composition does not include a herbicidal active ingredient in addition to (a) and (b).

10. A method of controlling undesirable vegetation, comprising applying to vegetation or an area adjacent the vegetation or applying to soil or water to limit the emergence or growth of vegetation a composition, comprising:

(a) a pyridine carboxylate herbicide defined by Formula (I):



Formula (I)

wherein

R^1 is cyanomethyl or propargyl;

R^2 and $R^{2'}$ are independently hydrogen, C_1-C_6 alkyl, formyl, alkoxycarbonyl, or acyl;

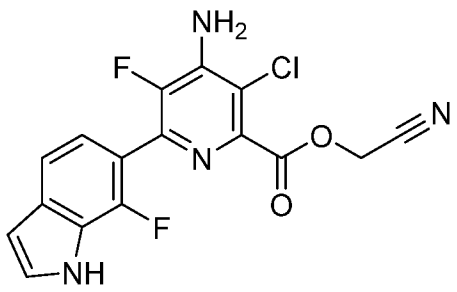
R^3, $R^{3'}$, $R^{3''}$, and $R^{3'''}$ are independently hydrogen, halogen, C_1-C_4 alkyl, C_1-C_4 haloalkyl, C_1-C_3 alkoxy, or C_1-C_3 haloalkoxy;

or an agriculturally acceptable N-oxide, salt, or ester thereof, and

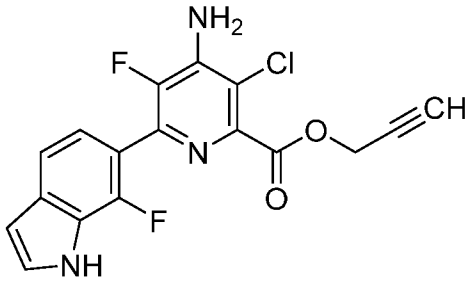
(b) a PDS inhibitor herbicide or an agriculturally acceptable salt or ester thereof,

wherein the pyridine carboxylate herbicide is applied in an amount of at least 0.1 g ae/ha; and wherein the PDS inhibitor herbicide is applied in an amount of at least 12.5 g ai/ha.

11. The method of claim 10, wherein the pyridine carboxylate herbicide compound is cyanomethyl 4-amino-3-chloro-5-fluoro-6-(7-fluoro-1H-indol-6-yl)pyridine-2-carboxylate:



12. The method of claim 10, wherein the pyridine carboxylate herbicide compound is propargyl 4-amino-3-chloro-5-fluoro-6-(7-fluoro-1H-indol-6-yl)pyridine-2-carboxylate:



13. The method of any one of claims 10-12, wherein the PDS inhibitor herbicide is selected from the group consisting of beflubutamid, diflufenican, fluridone, flurochloridone, flurtamone, norflurazon, picolinafen, agriculturally acceptable salts and esters thereof, and combinations thereof.

14. The method of any one of claims 10-13, wherein weight ratio of the pyridine carboxylate herbicide (in g ae/ha) to the PDS inhibitor herbicide (in g ai/ha) is from about 1:9000 to 24:1.

15. The method any one of claims 10-14, wherein the pyridine carboxylate herbicide and the PDS inhibitor herbicide are applied simultaneously.

16. The method of any one of claims 10-15, wherein the composition further comprises a safener.

17. The method of any one of claims 10-16 wherein the composition further comprises an additional pesticide.

18. The method of claim 17, wherein the additional herbicide is selected from the group consisting of halauxifen, florpyrauxifen, flufenacet, iodosulfuron, mesosulfuron, an agriculturally acceptable salt or ester thereof, and combinations thereof.

19. The method of any one of claims 10-17, wherein the composition does not include a herbicidal active ingredient in addition to (a) and (b).

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2019/059605

A. CLASSIFICATION OF SUBJECT MATTER
INV. A01N43/40 A01P13/02 A01N43/58 A01N39/02 A01N43/36
A01N43/08 A01N47/36
ADD.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A01N A01P

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2013/014165 A1 (BAYER IP GMBH [DE]; HOFFMANN MICHAEL GERHARD [DE] ET AL.) 31 January 2013 (2013-01-31) Formula (I); A15; page 118, line 20 - page 122, line 15; claims 1, 6-10; tables 16-17 -----	1-19
X	WO 2014/151005 A1 (DOW AGROSCIENCES LLC [US]) 25 September 2014 (2014-09-25) Formula (I); A15; paragraph [0135]; page 142, entry 1.15; page 152, entry 1.15; page 163 entry 1.15; claims 1, 11-14; tables 15-17; compound 1.15 ----- -/--	1-19

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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

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"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

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
6 March 2020	19/03/2020

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1

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2019/059605

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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