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Compositions comprising pyridine carboxylate herbicides and 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitor herbicides

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(54) Title: COMPOSITIONS COMPRISING PYRIDINE CARBOXYLATE HERBICIDES AND 4-HYDROXYPHENYL-PYRUVATE DIOXYGENASE (HPPD) 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) an HPPD 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) an HPPD inhibitor herbicide or an agriculturally acceptable salt or ester thereof.

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COMPOSITIONS COMPRISING PYRIDINE CARBOXYLATE HERBICIDES AND 4-HYDROXYPHENYL-PYRUVATE DIOXYGENASE (HPPD) INHIBITOR HERBICIDES

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of priority of U.S. Provisional Application No. 62/756,827, 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 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitor herbicide or an agriculturally acceptable salt or ester thereof. The present disclosure also includes methods of controlling undesirable vegetation using the same.

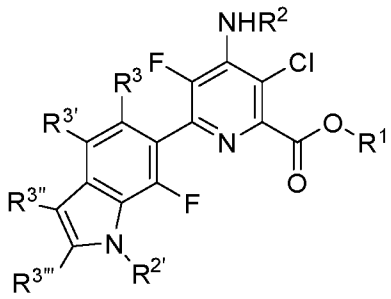
BACKGROUND

[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 contain (a) a pyridine carboxylate herbicide or agriculturally acceptable N-oxide, salt, or ester thereof and (b) a 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitor herbicide or an agriculturally acceptable salt or ester thereof. The weight ratio of (a) to (b) can be from 1:4500 to 300:1 (*e.g.*, from 1:2000 to 250:1, from 1:500 to 160:1, from 1:125 to 15:1, or from 1:30 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;

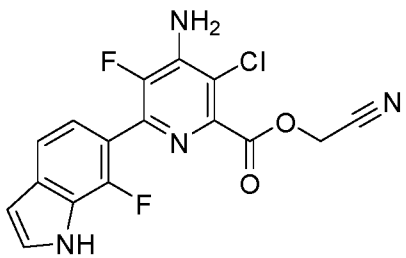
R^3, $R^{3'}$, $R^{3''}$, and $R^{3'''}$ are independently hydrogen, halogen, C_1-C_4 alkyl, C_1-C_4 haloalkyl, C_1-C_3 alkoxy, or C_1-C_3 haloalkoxy;

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

[0006] (b) a 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitor herbicide or an agriculturally acceptable salt or ester thereof.

[0007] 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:



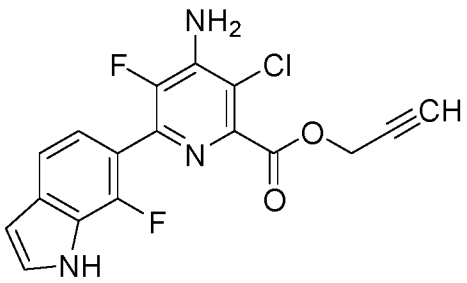
Compound A

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

(b) a 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitor herbicide or an agriculturally acceptable salt or ester thereof.

[0008] 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 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitor herbicide or an agriculturally acceptable salt or ester thereof.

[0009] In some aspects, (b) can comprise an HPPD inhibitor herbicide. In some aspects, (b) can include benzobicyclon, benzofenap, bicyclopyrone, fenquinotrione, isoxachlortole, isoxaflutole, mesotrione, pyrasulfotole, pyrazolynate, pyrazoxyfen, sulcotrione, tembotrione, tefuryltrione, topramezone, or an agriculturally acceptable salt thereof, or combinations thereof.

[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 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitor herbicide 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 0.5 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 HPPD inhibitor herbicide (b) can be applied in an amount of from 1 gram active ingredient per hectare (g ai/ha) to 4500 g ai/ha (*e.g.*, from 1 g ai/ha to 1000 g ai/ha). In some cases, (a) and (b) can be applied in a weight ratio of from 1:4500 to 300:1 (*e.g.*, from 1:2000 to 250:1, from 1:100 to 60:1, from 1:125 to 15:1, or from 1:30 to 5:1).

[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 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitor herbicide 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 or reduces the competitive capability of the weed with respect to a crop.

[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 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 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.

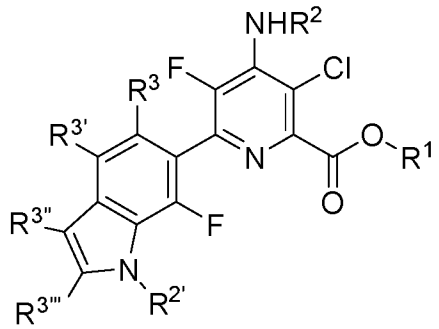
[0034] As used herein, agriculturally acceptable salts and esters may be understood to include salts and esters that exhibit herbicidal activity, or that are or can be converted in plants, water, or soil to the referenced herbicide. Exemplary agriculturally acceptable esters are those that are or can 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;

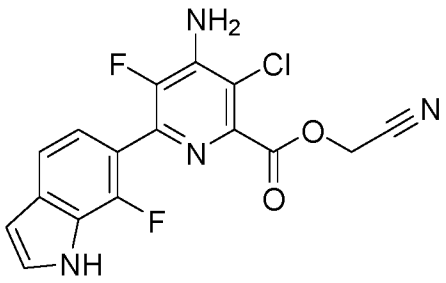
R^2 and $R^{2'}$ are independently hydrogen, C_1-C_6 alkyl, formyl, alkoxycarbonyl, or acyl;

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 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitor herbicide or an agriculturally acceptable salt or ester thereof.

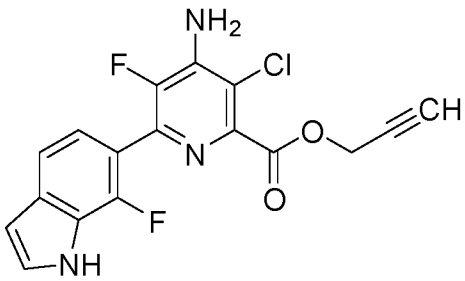
[0037] In some aspects, compositions and methods of the present disclosure include the composition comprising (a) the pyridine carboxylate herbicide cyanomethyl 4-amino-3-chloro-5-fluoro-6-(7-fluoro-1H-indol-6-yl)pyridine-2-carboxylate, Compound A:



Compound A

or an agriculturally acceptable N-oxide, salt, or ester thereof, and (b) a 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitor herbicide or an agriculturally acceptable salt or ester thereof.

[0038] In some aspects, compositions and methods of the present disclosure include the composition comprising (a) the pyridine carboxylate herbicide propargyl 4-amino-3-chloro-5-fluoro-6-(7-fluoro-1H-indol-6-yl)pyridine-2-carboxylate, Compound B:



Compound B

or an agriculturally acceptable N-oxide, salt, or ester thereof, and (b) a 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitor herbicide 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. HPPD Inhibitor Herbicides

[0043] In addition to the pyridine carboxylate herbicide of Formula (I), or agriculturally acceptable N-oxide, salt, or ester thereof, the compositions can include an inhibitor of 4-hydroxyphenylpyruvate dioxygenase (HPPD), an oxygenase enzyme involved in the creation of energy in plants and higher order eukaryotes. Examples of HPPD inhibitors include benzobicyclon, benzofenap, bicyclopyrone, fenquinotrione, isoxachlortole, isoxaflutole, lancotrione, mesotrione, pyrasulfotole, pyrazolynate, pyrazoxyfen, sulcotrione, tefuryltrione, tembotrione, tolpyralate, topramezone, or an agriculturally acceptable salt or esters thereof, and combinations thereof.

[0044] The HPPD inhibitor or agriculturally acceptable salt or ester thereof can be applied to vegetation or an area adjacent to 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 HPPD inhibitor 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 1 grams active ingredient per hectare (g ai/ha) or more, such as 1.1 g ai/ha or more, 1.25 g ai/ha or more, 1.5 g ai/ha or more, 1.75 g ai/ha or more, 2 g ai/ha or more, 2.5 g ai/ha or more, 3 g ai/ha or more, 3.5 g ai/ha or more, 4 g ai/ha or more, 5 g ai/ha or more, 6 g ai/ha or more, 7 g ai/ha or more, 8 g ai/ha or more, 9 g ai/ha or more, 10 g ai/ha or more, 11 g ai/ha or more, 12 g ai/ha or more, 13 g ai/ha or more, 14 g ai/ha or more, 15 g ai/ha or more, 16 g ai/ha or more, 17 g ai/ha or more, 18 g ai/ha or more, 19 g ai/ha or more, 20 g ai/ha or more, 21 g ai/ha or more, 22 g ai/ha or more, 23 g ai/ha or more, 24 g ai/ha or more, 25 g ai/ha or more, 26 g ai/ha or more, 27 g ai/ha or more, 28 g ai/ha or more, 29 g ai/ha or more, 30 g ai/ha or more, 31 g ai/ha or more, 32 g ai/ha or more, 33 g ai/ha or more, 34 g ai/ha or more, 35 g ai/ha or more, 36 g ai/ha or more, 37 g ai/ha or more, 38 g ai/ha or more, 39 g ai/ha or more, 40 g ai/ha or more, 41 g ai/ha or more, 42 g ai/ha or more, 43 g ai/ha or more, 44 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

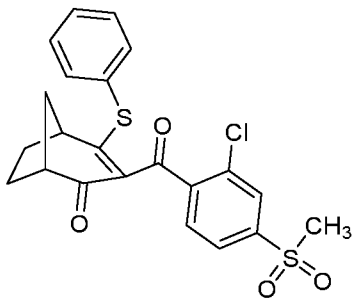
more, 3600 g ai/ha or more, 3700 g ai/ha or more, 3750 g ai/ha or more, 3800 g ai/ha or more, 3900 g ai/ha or more, 3950 g ai/ha or more, 4000 g ai/ha or more, 4100 g ai/ha or more, 4200 g ai/ha or more, 4250 g ai/ha or more, 4250 g ai/ha or more, 4300 g ai/ha or more, or 4350 g ai/ha or more, or 4400 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, 4350 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, 44 g ai/ha or less, 43 g ai/ha or less, 42 g ai/ha or less, 41 g ai/ha or less, 40 g ai/ha or less, 39 g ai/ha or less, 38 g ai/ha or less, 37 g ai/ha or less, 36 g ai/ha or less, 35 g ai/ha or less, 34 g ai/ha or less, 33 g ai/ha or less, 32 g ai/ha or less, 31 g ai/ha or less, 30 g ai/ha or less, 29 g ai/ha or less, 28 g ai/ha or less, 27 g ai/ha or less, 26 g ai/ha or less, 25 g ai/ha or less, 24 g ai/ha or less, 23 g ai/ha or less, 22 g ai/ha or less, 21 g ai/ha or less, 20 g ai/ha or less, 19 g ai/ha or less, 18 g ai/ha or less, 17 g ai/ha or less, 16 ai/ha or less, 15 g ai/ha or less, 14 g ai/ha or less, 13 g ai/ha or less, 12 g ai/ha or less, 11 g ai/ha or less, 10 g ai/ha or less, 9 g ai/ha or less, 8 g ai/ha or less, 7 g ai/ha or less, 6 g ai/ha or less, 5 g ai/ha or less, 4 g ai/ha or less, 3.5 g ai/ha or less, 3 g ai/ha or less, 2.5 g ai/ha or less, 2 g ai/ha or less, 1.75 g ai/ha or less, 1.5 g ai/ha or less, 1.25 g ai/ha or less, or 1.1 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 1–4500 g ai/ha, 4–3900 g ai/ha, 1.75-2500 g ai/ha, 75–3100 g ai/ha, 90–900 g ai/ha, 55–4200 g ai/ha, 50–2350 g ai/ha, 80–2900 g ai/ha, 120–4100 g ai/ha, 65–2700 g ai/ha, 300–4000 g ai/ha, 1200–3600 g ai/ha, 250–2000 g ai/ha, 1.75-250 g ai/ha, 700–4250 g ai/ha, 39–1100 g ai/ha, or 1.1–4450 g ai/ha.

[0045] In some aspects, the herbicidal composition contains a herbicidally effective amount of (a) a pyridine carboxylate herbicide or an agriculturally acceptable N-oxide, salt, or ester thereof, and (b) benzobicyclon, benzofenap, bicyclopyrone, fenquinotrione, isoxachlortole, isoxaflutole, lancotrione, mesotrione, pyrasulfotole, pyrazolynate, pyrazoxyfen, sulcotrione, tefuryltrione, tembotrione, tolpyralate, topramezone, agriculturally acceptable salts or esters, or combinations thereof.

Benzobicyclon

[0046] In some aspects, the HPPD inhibitor herbicide can comprise benzobicyclon or an agriculturally acceptable salt or ester thereof. Benzobicyclon, shown below, is 3-[2-chloro-4-(methylsulfonyl)benzoyl]-4-(phenylthio)bicyclo[3.2.1]oct-3-en-2-one. Its herbicidal activity is exemplified in *The Pesticide Manual*, Seventeenth Edition, 2016. Exemplary uses of benzobicyclon include its use for pre- to early post-emergence control of annual and perennial paddy weeds in direct-seeded and transplanted rice.

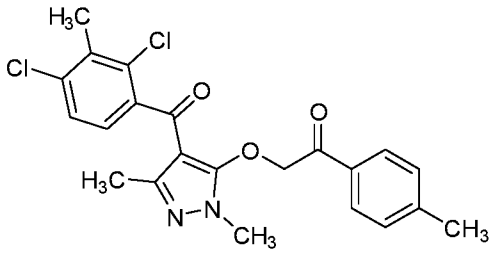


[0047] Benzobicyclon can be applied to vegetation or an area adjacent to the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount sufficient to induce a herbicidal effect. In some aspects, benzobicyclon is applied to vegetation or an area adjacent to the 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, 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, 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, 360 g ai/ha or more, 380 g ai/ha or more, or 400 g ai/ha or more; in an amount of 401 g ai/ha or less, such as 400 g ai/ha or less, 380 g ai/ha or less, 360 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, 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, 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, or 50 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 50–401 g ai/ha, 75–360 g ai/ha, 100–240 g ai/ha, 150–300 g ai/ha, 170–280 g ai/ha, 140–360 g ai/ha, 200–320 g ai/ha, 80–260 g ai/ha, or 55–400 g ai/ha.

Benzofenap

[0048] In some aspects, the HPPD inhibitor herbicide can comprise benzofenap or an agriculturally acceptable salt or ester thereof. Benzofenap, shown below, is 2-[[4-(2,4-dichloro-3-methylbenzoyl)-1,3-dimethyl-1*H*-pyrazol-5-yl]oxy]-1-(4-methylphenyl) ethanone. Its herbicidal activity is exemplified in *The Pesticide Manual*, Seventeenth Edition, 2016. Exemplary uses of benzofenap include its use for control of broadleaf weeds in rice.

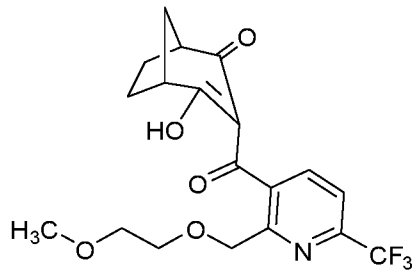


[0049] Benzofenap can be applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount sufficient to induce a herbicidal effect. In some aspects, benzofenap is applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount of 300 g ai/ha or more, such as 310 g ai/ha or more, 320 g ai/ha or more, 340 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, 625 g ai/ha or more, 650 g ai/ha or more, 675 g ai/ha or more, 700 g ai/ha or more, 725 g ai/ha or more, 750 g ai/ha or more, 775 g ai/ha or more, 800 g ai/ha or more, 825 g ai/ha or more, 850 g ai/ha or more, 875 g ai/ha or more, 900 g ai/ha or more, 925 g ai/ha or more, 950 g ai/ha or more, 975 g ai/ha or more, or 1000 g ai/ha or

more; in an amount of 1001 g ai/ha or less, such as 1000 g ai/ha or less, 975 g ai/ha or less, 950 g ai/ha or less, 925 g ai/ha or less, 900 g ai/ha or less, 875 g ai/ha or less, 850 g ai/ha or less, 825 g ai/ha or less, 800 g ai/ha or less, 775 g ai/ha or less, 750 g ai/ha or less, 725 g ai/ha or less, 700 g ai/ha or less, 675 g ai/ha or less, 650 g ai/ha or less, 625 g ai/ha or less, 600 g ai/ha or less, 575 g ai/ha or less, 550 g ai/ha or less, 525 g ai/ha or less, 500 g ai/ha or less, 475 g ai/ha or less, 450 g ai/ha or less, 425 g ai/ha or less, 400 g ai/ha or less, 380 g ai/ha or less, 360 g ai/ha or less, 340 g ai/ha or less, 320 g ai/ha or less, or 310 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 300–1001 g ai/ha, 450–1000 g ai/ha, 380–825 g ai/ha, 400–900 g ai/ha, 450–925 g ai/ha, 550–775 g ai/ha, 600–850 g ai/ha, 475–950 g ai/ha, 340–925 g ai/ha, 650–975 g ai/ha, 725–1000 g ai/ha, 450–850 g ai/ha, 800–950 g ai/ha, or 310–975 g ai/ha.

Bicyclopyrone

[0050] In some aspects, the HPPD inhibitor herbicide can comprise bicyclopyrone or an agriculturally acceptable salt or ester thereof. Bicyclopyrone, shown below, is 4-hydroxy-3-[[2-[(2-methoxyethoxy)methyl]-6-(trifluoromethyl)-3-pyridinyl]carbonyl] bicyclo[3.2.1]oct-3-en-2-one. Its herbicidal activity is exemplified in *The Pesticide Manual*, Seventeenth Edition, 2016. Exemplary uses of bicyclopyrone include its use for pre- and early post-emergence control of broadleaf and grass weeds in maize and cereals.

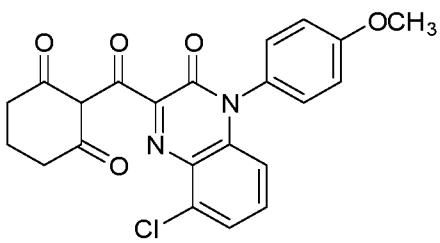


[0051] Bicyclopyrone can be applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount sufficient to induce a herbicidal effect. In some aspects, bicyclopyrone is applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount of 20 g ai/ha or more, such as 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, 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, 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, 360 g ai/ha or more, 380 g ai/ha or more, or 400 g ai/ha; in an amount of 401 g ai/ha or less, such as 400 g ai/ha or less, 380 g ai/ha or less, 360 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, 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, 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, or 20 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 20–401 g ai/ha, 30–260 g ai/ha, 40–380 g ai/ha, 55–300 g ai/ha, 60–340 g ai/ha, 45–320 g ai/ha, 25–300 g ai/ha, 100–190 g ai/ha, 200–380 g ai/ha, 50–200 g ai/ha, 30–300 g ai/ha, 85–220 g ai/ha, 30–65 g ai/ha, or 25–400 g ai/ha.

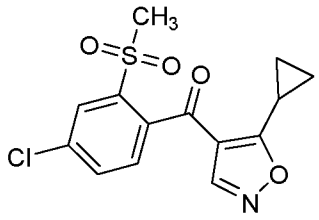
Fenquinotrione

[0052] In some aspects, the HPPD inhibitor herbicide can comprise fenquinotrione or an agriculturally acceptable salt or ester thereof. Fenquinotrione, shown below, is 2-[[8-chloro-3,4-dihydro-4-(4-methoxyphenyl)-3-oxo-2-quinoxalinyl]carbonyl]-1,3-cyclohexanedione.
According to the online edition of *The Pesticide Manual*, fenquinotrione is a herbicide under development for use on rice.



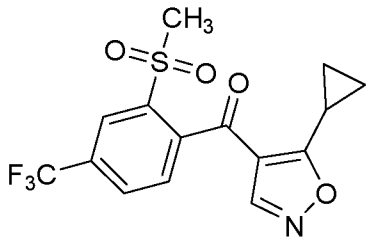
Isoxachlortole

[0053] In some aspects, the HPPD inhibitor herbicide can comprise isoxachlortole or an agriculturally acceptable salt or ester thereof. Isoxachlortole, shown below, is [4-chloro-2-(methylsulfonyl)phenyl](5-cyclopropyl-4-isoxazolyl) methanone. According to the online edition of *The Pesticide Manual*, isoxachlortole is a herbicide that was evaluated by Rhône-Poulenc.



Isoxaflutole

[0054] In some aspects, the HPPD inhibitor herbicide can comprise isoxaflutole or an agriculturally acceptable salt or ester thereof. Isoxaflutole, shown below, is (5-cyclopropyl-4-isoxazolyl)[2-(methylsulfonyl)-4-(trifluoromethyl)phenyl] methanone. Its herbicidal activity is exemplified in *The Pesticide Manual*. Exemplary uses of isoxaflutole include its use for pre-emergence or pre-plant control of grass and broadleaf weed in maize and sugar cane.

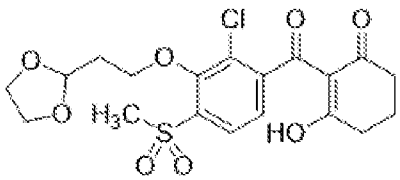


[0055] Isoxaflutole can be applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount sufficient to induce a herbicidal effect. In some aspects, isoxaflutole is applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount of 20 g ai/ha or more, such as 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, 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, 260 g ai/ha or more, 280 g ai/ha or more, or 300 g ai/ha or more; in an amount of 301 g ai/ha or less, such as 300 g ai/ha or less, 280 g ai/ha or less, 260 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, 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, or 25 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 20–301 g ai/ha, 30–300 g ai/ha, 40–170 g ai/ha, 25–260 g ai/ha, 60–120 g ai/ha, 70–190 g ai/ha, 75–240 g ai/ha, 35–200 g ai/ha, 65–220 g ai/ha, 85–140 g ai/ha, 100–300 g ai/ha, 150–280 g ai/ha, 200–301 g ai/ha, 130–200 g ai/ha, 25–100 g ai/ha, 70–90 g ai/ha, or 25–300 g ai/ha.

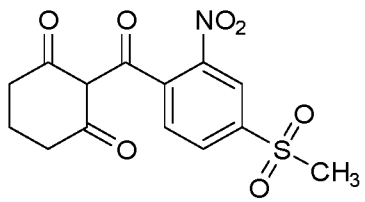
Lancotrione

[0056] In some aspects, the HPPD inhibitor herbicide can comprise lancotrione or an agriculturally acceptable salt or ester thereof. Lancotrione, shown below, is 2-[2-chloro-3-[2-(1,3-dioxolan-2-yl)ethoxy]-4-(methylsulfonyl)benzoyl]-3-hydroxy-2-cyclohexen-1-one. According to the online edition of *The Pesticide Manual*, lancotrione is a herbicide under development by Ishihara Sangyo Kaisha, Ltd.



Mesotrione

[0057] In some aspects, the HPPD inhibitor herbicide can comprise mesotrione or an agriculturally acceptable salt or ester thereof. Mesotrione, shown below, is 2-[4-(methylsulfonyl)-2-nitrobenzoyl]-1,3-cyclohexanedione. Its herbicidal activity is exemplified in *The Pesticide Manual*. Exemplary uses of mesotrione include its use for pre- and post-emergence control of broadleaf weeds and some grass weeds in maize.

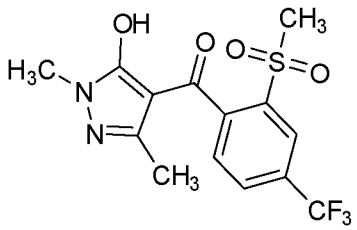


[0058] Mesotrione can be applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount sufficient to induce a herbicidal effect. In some aspects, mesotrione is applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount of 20 g ai/ha or more, such as 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, 100 g ai/ha or more, 110 g ai/ha or more, 120 g ai/ha or more, 125 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, 175 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, 225 g ai/ha or more, 240 g ai/ha or more, 250 g ai/ha or more, 260 g ai/ha or more, 275 g ai/ha or more, 280 g ai/ha or more, or 300 g ai/ha or more; in an amount of 301 g ai/ha or less, such as 300 g ai/ha or less, 280 g ai/ha or less, 275 g ai/ha or less, 260 g ai/ha or less, 250 g ai/ha or less, 240 g ai/ha or less, 225 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, 175 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, 125 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, 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, or 25 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 20–301 g ai/ha, 30–275 g ai/ha, 40–140 g ai/ha, 50–250 g ai/ha, 60–301 g ai/ha, 25–280 g ai/ha, 60–125 g ai/ha, 70–250 g ai/ha, 90–225 g ai/ha, 110–220 g ai/ha, 40–175 g ai/ha, 65–160 g ai/ha, 70–200 g ai/ha, 80–180 g ai/ha, 90–250 g ai/ha, 140–225 g ai/ha, 110–240 g ai/ha, 120–175 g ai/ha, 110–150 g ai/ha, 25-85 g ai/ha, or 25–300 g ai/ha.

Pyrasulfotole

[0059] In some aspects, the HPPD inhibitor herbicide can comprise pyrasulfotole or an agriculturally acceptable salt or ester thereof. Pyrasulfotole, shown below, is (5-hydroxy-1,3-dimethyl-1*H*-pyrazol-4-yl)[2-(methylsulfonyl)-4-(trifluoromethyl) phenyl]methanone. Its herbicidal activity is exemplified in *The Pesticide Manual*. Exemplary uses of pyrasulfotole include its use in mixture with mefenpyr-diethyl and bromoxynil or MCPA ester, for post-emergence control of broadleaf weeds in cereals.



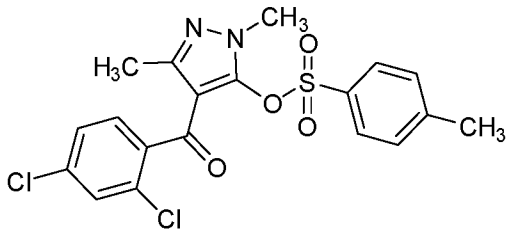
[0060] Pyrasulfotole can be applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount sufficient to induce a herbicidal effect. In some aspects, pyrasulfotole is applied to vegetation or an area adjacent the

vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount of 1 g ai/ha or more, such as 1.1 g ai/ha or more, 1.25 g ai/ha or more, 1.4 g ai/ha or more, 1.5 g ai/ha or more, 1.6 g ai/ha or more, 1.75 g ai/ha or more, 1.9 g ai/ha or more, 2 g ai/ha or more, 2.25 g ai/ha or more, 2.5 g ai/ha or more, 2.75 g ai/ha or more, 3 g ai/ha or more, 3.25 g ai/ha or more, 3.5 g ai/ha or more, 3.75 g ai/ha or more, 4 g ai/ha or more, 4.5 g ai/ha or more, 5 g ai/ha or more, 6 g ai/ha or more, 7 g ai/ha or more, 8 g ai/ha or more, 9 g ai/ha or more, 9.5 g ai/ha or more, 10 g ai/ha or more, 10.5 g ai/ha or more, 11 g ai/ha or more, 11.5 g ai/ha or more, 12 g ai/ha or more, 12.5 g ai/ha or more, 13 g ai/ha or more, 13.5 g ai/ha or more, 14 g ai/ha or more, 14.5 g ai/ha or more, 15 g ai/ha or more, 15.5 g ai/ha or more, 16 g ai/ha or more, 16.5 g ai/ha or more, 17 g ai/ha or more, 17.5 g ai/ha or more, 18 g ai/ha or more, 18.5 g ai/ha or more, 20 g ai/ha or more, 21 g ai/ha or more, 22 g ai/ha or more, 23 g ai/ha or more, 24 g ai/ha or more, 25 g ai/ha or more, 26 g ai/ha or more, 27 g ai/ha or more, 28 g ai/ha or more, 29 g ai/ha or more, 30 g ai/ha or more, 31 g ai/ha or more, 32 g ai/ha or more, 33 g ai/ha or more, 34 g ai/ha or more, 35 g ai/ha or more, 36 g ai/ha or more, 37 g ai/ha or more, 38 g ai/ha or more, 39 g ai/ha or more, 40 g ai/ha or more, 41 g ai/ha or more, 42 g ai/ha or more, 43 g ai/ha or more, 44 g ai/ha or more, 45 g ai/ha or more, or 47 g ai/ha or more; in an amount of 50 g ai/ha or less, such as 47 g ai/ha or less, 45 g ai/ha or less, 44 g ai/ha or less, 43 g ai/ha or less, 42 g ai/ha or less, 41 g ai/ha or less, 40 g ai/ha or less, 39 g ai/ha or less, 38 g ai/ha or less, 37 g ai/ha or less, 36 g ai/ha or less, 35 g ai/ha or less, 34 g ai/ha or less, 33 g ai/ha or less, 32 g ai/ha or less, 31 g ai/ha or less, 30 g ai/ha or less, 29 g ai/ha or less, 28 g ai/ha or less, 27 g ai/ha or less, 26 g ai/ha or less, 25 g ai/ha or less, 24 g ai/ha or less, 23 g ai/ha or less, 22 g ai/ha or less, 21 g ai/ha or less, 20 g ai/ha or less, 19 g ai/ha or less, 18.5 g ai/ha or less, 18 g ai/ha or less, 17.5 g ai/ha or less, 17 g ai/ha or less, 16.5 g ai/ha or less, 16 g ai/ha or less, 15.5 g ai/ha or less, 15 g ai/ha or less, 14.5 g ai/ha or less, 14 g ai/ha or less, 13.5 g ai/ha or less, 13 g ai/ha or less, 12.5 g ai/ha or less, 12 g ai/ha or less, 11.5 g ai/ha or less, 11 g ai/ha or less, 10.5 g ai/ha or less, 10 g ai/ha or less, 9.5 g ai/ha or less, 9 g ai/ha or less, 8.5 g ai/ha or less,8 g ai/ha or less, 7.5 g ai/ha or less, 7 g ai/ha or less, 6.5 g ai/ha or less, 6 g ai/ha or less, 5.5 g ai/ha or less, 5 g ai/ha or less, 4.5 g ai/ha or less, 4 g ai/ha or less, 3.75 g ai/ha or less, 3.5 g ai/ha or less, 3.25 g ai/ha or less, 3 g ai/ha or less, 2.75 g ai/ha or less, 2.5 g ai/ha or less, 2.25 g ai/ha or less, 2 g ai/ha or less, 1.9 g ai/ha or less, 1.75 g ai/ha or less, 1.6 g ai/ha or less, 1.5 g ai/ha or less, 1.4 g ai/ha or less, 1.25 g ai/ha or less, or 1.1 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 1–50 g ai/ha, 1.4–45 g ai/ha, 1.2–42 g ai/ha, 2.5–35 g ai/ha, 4–30 g ai/ha, 6.5–29 g ai/ha, 1.25–24 g ai/ha, 3.75–18.5 g ai/ha, 2.5–38 g ai/ha, 11–17 g ai/ha, 8–16 g ai/ha, 2.75–19 g ai/ha, 3–25 g ai/ha,

7–23 g ai/ha, 3.5–16 g ai/ha, 10–41 g ai/ha, 25–50 g ai/ha, 14–44 g ai/ha, 35–45 g ai/ha, 40–51 g ai/ha, or 1.1–47 g ai/ha.

Pyrazolynate

[0061] In some aspects, the HPPD inhibitor herbicide can comprise pyrazolynate or an agriculturally acceptable salt or ester thereof. Pyrazolynate, shown below, is (2,4-dichlorophenyl)[1,3-dimethyl-5-[[(4-methylphenyl) sulfonyl]oxy]-1*H*-pyrazol-4-yl]methanone. Its herbicidal activity is exemplified in *The Pesticide Manual*. Exemplary uses of pyrazolynate include its use to control grasses, sedges, *Potamogeton distinctus*, *Sagittaria pygmaea*, *Sagittaria trifolia* and *Alisma canaliculatum* in paddy rice.

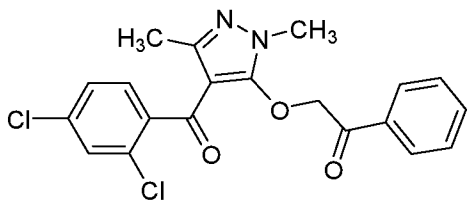


[0062] Pyrazolynate can be applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount sufficient to induce a herbicidal effect. In some aspects, pyrazolynate is applied to vegetation or an area adjacent the vegetation 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 225 g ai/ha or more, 250 g ai/ha or more, 275 g ai/ha or more, 300 g ai/ha or more, 350 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, 1200 g ai/ha or more, 1400 g ai/ha or more, 1600 g ai/ha or more, 1800 g ai/ha or more, 2000 g ai/ha or more, 2200 g ai/ha or more, 2400 g ai/ha or more, 2500 g ai/ha or more, 2600 g ai/ha or more, 2800 g ai/ha or more, 3000 g ai/ha or more, 3200 g ai/ha or more, 3400 g ai/ha or more, 3500 g ai/ha or more, 3600 g ai/ha or more, 3800 g ai/ha or more, 4000 g ai/ha or more, 4200 g ai/ha or more, or 4400 g ai/ha or more; in an amount of 4500 g ai/ha or less, such as 4400 g ai/ha or less, 4200 g ai/ha or less, 4000 g ai/ha or less, 3800 g ai/ha or less, 3600 g ai/ha or less, 3500 g ai/ha or less, 3400 g ai/ha or less, 3200 g ai/ha or less, 3000 g ai/ha or less, 2800 g ai/ha or less, 2600 g ai/ha or less, 2500 g ai/ha or less, 2400 g ai/ha or less, 2200 g ai/ha or less, 2000 g ai/ha or less, 1800 g ai/ha or less, 1600 g ai/ha or less, 1400 g ai/ha or less, 1200 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, 350 g ai/ha or less, 300 g ai/ha or less, 275 g ai/ha or less, 250 g ai/ha or less, or 225 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 200-4500 g ai/ha, 2000–4000 g ai/ha, 400–1600 g ai/ha, 1600–3800 g ai/ha, 750–3000 g ai/ha, 500–2200 g ai/ha, 1600–2500 g ai/ha, 250–800 g ai/ha, 2500–3400 g ai/ha, 1200–3500 g ai/ha, 350–1000 g ai/ha, or 225–4400 g ai/ha.

Pyrazoxyfen

[0063] In some aspects, the HPPD inhibitor herbicide can comprise pyrazoxyfen or an agriculturally acceptable salt or ester thereof. Pyrazoxyfen, shown below, is 2-[[4-(2,4-dichlorobenzoyl)-1,3-dimethyl-1*H*-pyrazol-5-yl]oxy]-1-phenylethanone. Its herbicidal activity is exemplified in *The Pesticide Manual*. Exemplary uses of pyrazoxyfen include pre- or post-emergence control of annual and perennial weeds in transplanted or direct-seeded paddy rice.

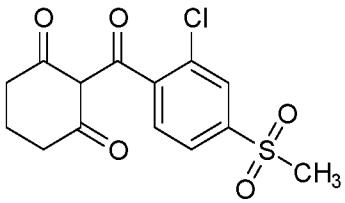


[0064] Pyrazoxyfen can be applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount sufficient to induce a herbicidal effect. In some aspects, pyrazoxyfen is applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount of 1000 g ai/ha or more, such as 1100 g ai/ha or more, 1200 g ai/ha or more, 1400 g ai/ha or more, 1600 g ai/ha or more, 1800 g ai/ha or more, 2000 g ai/ha or more, 2200 g ai/ha or more, 2400 g ai/ha or more, 2500 g ai/ha or more, 2600 g ai/ha or more, 2800 g ai/ha or more, 3000 g ai/ha or more, 3200 g ai/ha or more, 3400 g ai/ha or more, 3500 g ai/ha or more, 3600 g ai/ha or more, 3800 g ai/ha or more, 4000 g ai/ha or more, 4200 g ai/ha or more, or 4400 g ai/ha or more; in an amount of 4500 g ai/ha or less, such as 4400 g ai/ha or less, 4200 g ai/ha or less, 4000 g ai/ha or less, 3800 g ai/ha or less, 3600 g ai/ha or less, 3500 g ai/ha or less, 3400 g ai/ha or less, 3200 g ai/ha or less, 3000 g ai/ha or less, 2800 g ai/ha or less, 2600 g ai/ha or less, 2500 g ai/ha or less, 2400 g ai/ha or less, 2200 g ai/ha or less, 2000 g ai/ha or less, 1800 g ai/ha or less, 1600 g ai/ha or less, 1400 g ai/ha or less, 1200 g ai/ha or less, or 1100 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 1000-4500 g ai/ha, 1100–4000 g ai/ha, 1400–3600 g ai/ha, 1200–1800 g ai/ha, 1800–4000 g ai/ha, 2200–4500 g ai/ha, 1500–3200 g ai/ha, 2000–3500 g ai/ha, 2500–3400 g ai/ha, or 1100–4400 g ai/ha.

Sulcotrione

[0065] In some aspects, the HPPD inhibitor herbicide can comprise sulcotrione or an agriculturally acceptable salt or ester thereof. Sulcotrione, shown below, is 2-[2-chloro-4-(methylsulfonyl)benzoyl]-1,3-cyclohexanedione. Its herbicidal activity is exemplified in The Pesticide *Manual*. Exemplary uses of sulcotrione include its use to control broadleaf weeds and grasses post-emergence in maize and sugar cane.

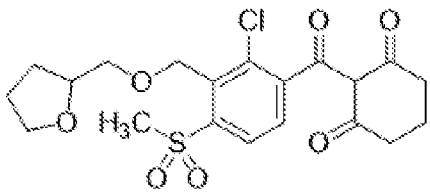


[0066] Sulcotrione can be applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount sufficient to induce a herbicidal effect. In some aspects, sulcotrione is applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount of 20 g ai/ha or more, such as 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, 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, 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, 360 g ai/ha or more, 380 g ai/ha or more, 400 g ai/ha or more, 420 g ai/ha or more, 440 g ai/ha or more, 460 g ai/ha or more, 480 g ai/ha or more, 500 g ai/ha or more, 520 g ai/ha or more, 540 g ai/ha or more, 560 g ai/ha or more, or 580 g ai/ha or more; in an amount of 600 g ai/ha or less, such as 580 g ai/ha or less, 560 g ai/ha or less, 540 g ai/ha or less, 520 g ai/ha or less, 500 g ai/ha or less, 480 g ai/ha or less, 460 g ai/ha or less, 440 g ai/ha or less, 420 g ai/ha or less, 400 g ai/ha or less, 380 g ai/ha or less, 360 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, 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, 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, or 25 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 20–600 g ai/ha, 40–400 g ai/ha, 65–420 g ai/ha, 120–240 g ai/ha, 300–460 g ai/ha, 400–580 g ai/ha, 30–500 g ai/ha, 250–560 g ai/ha, 250–440 g ai/ha, 75–520 g ai/ha, 35–300 g ai/ha, 90–540 g ai/ha, 150–400 g ai/ha, 400–560 g ai/ha, 50–300 g ai/ha, 110–480 g ai/ha, 75–420 g ai/ha, 65–360 g ai/ha, 170–300 g ai/ha, 200–300 g ai/ha, 220–600 g ai/ha, or 25–580 g ai/ha.

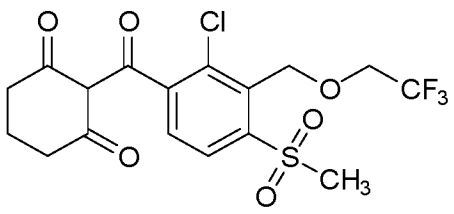
Tefuryltrione

[0067] In some aspects, the HPPD inhibitor herbicide can comprise tefuryltrione or an agriculturally acceptable salt or ester thereof. Tefuryltrione, shown below, is 2-[2-chloro-4-(methylsulfonyl)-3- [[(tetrahydro-2-furanyl)-methoxy]-methyl]-benzoyl]- 1,3-cyclohexandione. According to the online edition of *The Pesticide Manual*, tefuryltrione is a herbicide jointly developed by Bayer CropScience, Hokko Chemical, and Zen-Noh for pre-and post-emergence control of annual and perennial broadleaf weeds in rice and cereals.



Tembotrione

[0068] In some aspects, the HPPD inhibitor herbicide can comprise tembotrione or an agriculturally acceptable salt or ester thereof. Tembotrione, shown below, is 2-[2-chloro-4-(methylsulfonyl)-3-[(2,2,2-trifluoroethoxy) methyl]benzoyl]-1,3-cyclohexanedione. Its herbicidal activity is exemplified in *The Pesticide Manual*. Exemplary uses of tembotrione include its use for post-emergence control of grass and broadleaf weed species in maize.



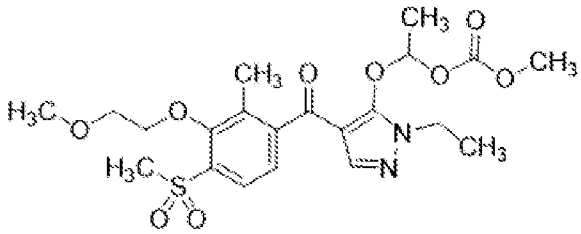
[0069] Tembotrione can be applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount sufficient to induce a herbicidal effect. In some aspects, tembotrione is applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount of 1 g ai/ha or more, such as 1.1 g ai/ha or more, 1.25 g ai/ha or more, 1.4 g ai/ha or more, 1.5 g ai/ha or more, 1.6 g ai/ha or more, 1.75 g ai/ha or more, 1.9 g ai/ha or more, 2 g ai/ha or more, 2.25 g ai/ha or more, 2.5 g ai/ha or more, 2.75 g ai/ha or more, 3 g ai/ha or more, 3.25 g ai/ha or more, 3.5 g ai/ha or more, 3.75 g ai/ha or more, 4 g ai/ha or more, 4.5 g ai/ha or more, 5 g ai/ha or more, 6 g ai/ha or more, 7 g ai/ha or more, 8 g ai/ha or more, 9 g ai/ha or more, 9.5 g ai/ha or more, 10 g ai/ha or more, 10.5 g ai/ha or more, 11 g ai/ha or more, 11.5 g ai/ha or more, 12 g ai/ha or more, 12.5 g ai/ha or more, 13 g ai/ha or more, 13.5 g ai/ha or more, 14 g ai/ha or more, 14.5 g ai/ha or more, 15 g ai/ha or more, 15.5 g ai/ha or more, 16 g ai/ha or more, 16.5 g ai/ha or more, 17 g ai/ha or more, 17.5 g ai/ha or more, 18 g ai/ha or more, 18.5 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, or 200 g ai/ha or more; in an amount of 200 g ai/ha or less, such as 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, 19 g ai/ha or less, 18.5 g ai/ha or less, 18 g ai/ha or less, 17.5 g ai/ha or less, 17 g ai/ha or less, 16.5 g ai/ha or less, 16 g ai/ha or less, 15.5 g ai/ha or less, 15 g ai/ha or less, 14.5 g ai/ha or less, 14 g ai/ha or less, 13.5 g ai/ha or less, 13 g ai/ha or less, 12.5 g ai/ha or less, 12 g ai/ha or less, 11.5 g ai/ha or less, 11 g ai/ha or less, 10.5 g ai/ha or less, 10 g ai/ha or less, 9.5 g ai/ha or less, 9 g ai/ha or less, 8.5 g ai/ha or less,8 g ai/ha or less, 7.5 g ai/ha or less, 7 g ai/ha or less, 6.5 g ai/ha or less, 6 g ai/ha or less, 5.5 g ai/ha or less, 5 g ai/ha or less, 4.5 g ai/ha or less, 4 g ai/ha or less, 3.75 g ai/ha or less, 3.5 g ai/ha or less, 3.25 g ai/ha or less, 3 g ai/ha or less, 2.75 g ai/ha or less, 2.5 g ai/ha or less, 2.25 g ai/ha or less, 2 g ai/ha or less, 1.9 g ai/ha or less, 1.75 g ai/ha or less, 1.6 g ai/ha or less, 1.5 g ai/ha or less, 1.4 g ai/ha or less, 1.25 g ai/ha or less, or 1.1 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 1–200 g ai/ha, 1.4–75 g ai/ha, 3.5–150 g ai/ha, 10–140 g ai/ha, 6–75 g ai/ha, 8–180 g ai/ha, 1.5–25 g ai/ha, 2.5–15 g ai/ha, 2.25–10 g ai/ha, 25–120 g ai/ha, 1.9–130 g ai/ha, 20–40 g ai/ha, 30–180 g ai/ha, 45–190 g ai/ha, 3.5–70 g ai/ha, 6–130 g ai/ha, 70–90 g ai/ha, 15–110 g ai/ha, 120–140 g ai/ha, or 1.1–190 g ai/ha.

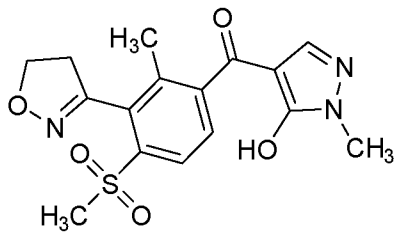
Tolpyralate

[0070] In some aspects, the HPPD inhibitor herbicide can comprise tolpyralate or an agriculturally acceptable salt or ester thereof. Tolpyralate, shown below, is 1-[[1-ethyl-4-[3-(2-methoxyethoxy)-2-methyl-4-(methylsulfonyl)benzoyl]-1*H*-pyrazol-5-yl]oxy]ethyl methyl carbonate. According to the online edition of *The Pesticide Manual*, tefuryltrione is a herbicide developed by Ishihara Sangyo Kaisha Ltd. for pre-and post-emergence control of broadleaf and grass weeds, including Palmer amaranth, water hemp, giant ragweed, and giant foxtail in maize.

Topramezone



[0071] In some aspects, the HPPD inhibitor herbicide can comprise topramezone or an agriculturally acceptable salt or ester thereof. Topramezone, shown below, is [3-(4,5-dihydro-3-isoxazolyl)-2-methyl-4-(methylsulfonyl) phenyl] (5-hydroxy-1-methyl- 1*H*-pyrazol-4-yl) methanone. Its herbicidal activity is exemplified in *The Pesticide Manual*. Exemplary uses of topramezone include its use for post-emergence weed control in maize.



[0072] Topramezone 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, topramezone 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 1 g ai/ha or more, such as 1.1 g ai/ha or more, 1.25 g ai/ha or more, 1.4 g ai/ha or more, 1.5 g ai/ha or more, 1.6 g ai/ha or more, 1.75 g ai/ha or more, 1.9 g ai/ha or more, 2 g ai/ha or

more, 2.25 g ai/ha or more, 2.5 g ai/ha or more, 2.75 g ai/ha or more, 3 g ai/ha or more, 3.25 g ai/ha or more, 3.5 g ai/ha or more, 3.75 g ai/ha or more, 4 g ai/ha or more, 4.5 g ai/ha or more, 5 g ai/ha or more, 6 g ai/ha or more, 7 g ai/ha or more, 8 g ai/ha or more, 9 g ai/ha or more, 9.5 g ai/ha or more, 10 g ai/ha or more, 10.5 g ai/ha or more, 11 g ai/ha or more, 11.5 g ai/ha or more, 12 g ai/ha or more, 12.5 g ai/ha or more, 13 g ai/ha or more, 13.5 g ai/ha or more, 14 g ai/ha or more, 14.5 g ai/ha or more, 15 g ai/ha or more, 15.5 g ai/ha or more, 16 g ai/ha or more, 16.5 g ai/ha or more, 17 g ai/ha or more, 17.5 g ai/ha or more, 18 g ai/ha or more, 18.5 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, or 100 g ai/ha or more; in an amount of 100 g ai/ha or less, such as 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, 19 g ai/ha or less, 18.5 g ai/ha or less, 18 g ai/ha or less, 17.5 g ai/ha or less, 17 g ai/ha or less, 16.5 g ai/ha or less, 16 g ai/ha or less, 15.5 g ai/ha or less, 15 g ai/ha or less, 14.5 g ai/ha or less, 14 g ai/ha or less, 13.5 g ai/ha or less, 13 g ai/ha or less, 12.5 g ai/ha or less, 12 g ai/ha or less, 11.5 g ai/ha or less, 11 g ai/ha or less, 10.5 g ai/ha or less, 10 g ai/ha or less, 9.5 g ai/ha or less, 9 g ai/ha or less, 8.5 g ai/ha or less,8 g ai/ha or less, 7.5 g ai/ha or less, 7 g ai/ha or less, 6.5 g ai/ha or less, 6 g ai/ha or less, 5.5 g ai/ha or less, 5 g ai/ha or less, 4.5 g ai/ha or less, 4 g ai/ha or less, 3.75 g ai/ha or less, 3.5 g ai/ha or less, 3.25 g ai/ha or less, 3 g ai/ha or less, 2.75 g ai/ha or less, 2.5 g ai/ha or less, 2.25 g ai/ha or less, 2 g ai/ha or less, 1.9 g ai/ha or less, 1.75 g ai/ha or less, 1.6 g ai/ha or less, 1.5 g ai/ha or less, 1.4 g ai/ha or less, 1.25 g ai/ha or less, or 1.1 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 1–100 g ai/ha, 2–90 g ai/ha, 4–80 g ai/ha, 2.5–75 g ai/ha, 9–60 g ai/ha, 10–55 g ai/ha, 3–25 g ai/ha, 8–15 g ai/ha, 1.5–10 g ai/ha, 5–80 g ai/ha, 6.5–45 g ai/ha, 15–85 g ai/ha, 20–90 g ai/ha, 2.5–40 g ai/ha, 3–30 g ai/ha, 9–85 g ai/ha, or 1.5–95 g ai/ha.

IV. Compositions

[0073] 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) an HPPD inhibitor herbicide or an agriculturally acceptable salt or ester thereof.

[0074] 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) or (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.

[0075] 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 HPPD inhibitor herbicide 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.

[0076] 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 HPPD inhibitor herbicide or an agriculturally acceptable salt or ester thereof (in g ai/ha) can be 1:4500 or more, such as 1:4000 or more, 1:3500 or more, 1:3000 or more, 1:2500 or more, 1:2000 or more, 1:1500 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, 1:15 or more, 1:12 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, 15:1 or more, 20:1 or more, 22:1 or more, 24:1 or more, 25:1 or more, 26:1 or more, 28:1 or more, 30:1 or more, 35:1 or more, 40:1 or more, 45:1 or more, 50:1 or more, or 55:1 or more; the weight ratio of (a) to (b) can be 300:1 or less, such as 250:1 or less, 200:1 or less, 150:1 or less, 125:1 or less, 100:1 or less, 90:1 or less, 80:1 or less, 70:1 or less, 60:1 or less, 50:1 or less, 40:1 or less, 30:1 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, 1:20 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, 1:1000 or less, 1:1500 or less, 1:2000 or less, 1:2500 or less, 1:3000 or less, 1:3500 or less, or 1:4000 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 1:4500 to 300:1, from 1:700 to 6:1, from 1:40 to 90:1, from 1:10 to 16:1, from 1:14 to 10:1, from 1:8 to 1:6, or from 1:5 to 5:1.

[0077] 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) an HPPD 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).

[0078] 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

[0079] The present disclosure also includes formulations of the compositions and methods disclosed herein.

A. Additives

[0080] 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

[0081] 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.

[0082] 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.

[0083] In some aspects, the additional pesticide or an agriculturally acceptable salt or ester thereof is provided in a premixed formulation with (a), (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 an additional pesticide. In some aspects, the HPPD inhibitor herbicide or an agriculturally acceptable salt or ester thereof is provided in a premixed formulation with an additional pesticide.

[0084] 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 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), but may exclude one or more herbicidal ingredients specified above.

2. Adjuvants

[0085] 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.

[0086] 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.

[0087] 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.

[0088] Exemplary thickeners include, but are not limited to, polysaccharides (*e.g.*, xanthan gum), organic and inorganic sheet minerals, and mixtures thereof.

[0089] Exemplary antifoam agents include, but are not limited to, silicone emulsions, long-chain alcohols, fatty acids, fatty acid salts, organofluorine compounds, and mixtures thereof.

[0090] 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.

[0091] Exemplary antifreeze agents, include, but are not limited to ethylene glycol, propylene glycol, urea, glycerol, and mixtures thereof.

[0092] 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.

[0093] Exemplary adhesives include, but are not limited to, polyvinylpyrrolidone, polyvinyl acetate, polyvinyl alcohol, tylose, and mixtures thereof.

3. Safeners

[0094] 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

[0095] 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; glycerine; *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

[0096] In some aspects, the formulation of (a) the pyridine carboxylate herbicide or an agriculturally acceptable N-oxide, salt, or ester thereof and (b) the HPPD inhibitor herbicide or an agriculturally acceptable salt or ester thereof may be 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.

[0097] In some aspects, (a) and (b) are in an aqueous solution 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).

[0098] 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.

[0099] 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.

[0100] 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.

[0101] 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

[0102] In some aspects, the formulation can be in the form of a single package formulation including both: (a) the pyridine carboxylate herbicide or an agriculturally acceptable N-oxide, salt, or ester thereof; and (b) the HPPD 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 both (a) and (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

[0103] 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.

[0104] 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.

[0105] 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 HPPD inhibitor herbicide are applied simultaneously. In some aspects, the pyridine carboxylate herbicide and HPPD 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.

[0106] 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.

[0107] 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).

[0108] 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.

[0109] 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.

[0110] 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 combinations thereof. The combination of (a) and (b) 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).

[0111] 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*), Canadian 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.

[0112] 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, sulfonylaminocarbonyl-triazolinones), 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, bilanafos), 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).

[0113] 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

[0114] 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 help 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.

[0115] 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 HPPD inhibitor herbicide) were prepared by adding weighed amounts or aliquots of the HPPD inhibitor herbicides to the stock solutions of Compound A or Compound B to form 12-mL spray solutions in two-way combinations.

[0116] 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 HPPD inhibitor herbicide (component b) application rates are given as "g ai/ha."

[0117] 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.

[0118] The details of the compositions and the crops tested are specified in the following Examples.

Example 1

[0119] Compositions comprising Compound A and benzobicyclon were tested on undesirable vegetation species, including chickweed (STEME, *Stellaria media*), spring rape (BRSNN, *Brassica napus*), giant foxtail (SETFA, *Setaria faberi*), kochia (KCHSC, *Kochia scoparia*), Italian ryegrass (LOLMU, *Lolium multiflorum*), barnyard grass (ECHCG, *Echinochloa crus-galli*), and

large crabgrass (DIGSA, *Digitaria sanguinalis*), to determine the efficacy of the compositions on these undesirable vegetation species.

[0120] The results are summarized in Table 1 below.

Table 1. Herbicidal Effects (% visual injury) of Compound A and Benzobicyclon on weeds.

Application rate (g/ha)	Compound A	7.5	10	0	7.5	10
	Benzobicyclon	0	0	50	50	50
STEME	Obs	90	85	28	83	85
	Exp	--	--	--	93	89
	△				-10	-4
BRSNN	Obs	23	45	8	43	40
	Exp	--	--	--	28	49
	△				14	-9
SETFA	Obs	60	78	0	70	78
	Exp	--	--	--	60	78
	△				10	0
KCHSC	Obs	63	70	0	60	70
	Exp	--	--	--	63	70
	△				-3	0
LOLMU	Obs	8	3	0	10	15
	Exp	--	--	--	8	3
	△				3	13
ECHCG	Obs	80	88	0	68	75
	Exp	--	--	--	80	88
	△				-13	-13
DIGSA	Obs	13	25	10	33	35
	Exp	--	--	--	21	33
	△				11	3

g/ha = grams per hectare
STEME = *Stellaria media* (chickweed)
BRSNN = *Brassica napus* (spring rape)
SETFA = *Setaria faberi* (giant foxtail)
KCHSC = *Kochia scoparia* (kochia)
LOLMU = *Lolium multiflorum* (Italian ryegrass)
ECHCG = *Echinochloa crus-galli* (barnyard grass)
DIGSA = *Digitaria sanguinalis* (large crabgrass)

Example 2

[0121] Compositions comprising Compound A and isoxaflutole were tested to determine the efficacy of the compositions on undesirable vegetation species, including velvetleaf (ABUTH, *Abutilon theophrasti*), wild buckwheat (POLCO, *Polygonum convolvulus)*, Canadian thistle (CIRAR, *Cirsium arvense*), ivyleaf morningglory (IPOHE, *Ipomoea hederacea*), pigweed (AMARE, *Amaranthus retroflexus*), sunflower (HELAN, *Helianthus annuus*), and kochia (KCHSC, *Kochia scoparia*).

[0122] The results are summarized in Table 2 below.

Table 2. Herbicidal Effects (% visual injury) of Compound A and Isoxaflutole on weeds.

Application rate (g/ha)	Compound A	7.5	10	0	7.5	10
	Isoxaflutole	0	0	60	60	60
VIOTR	Obs	3	3	25	48	60
	Exp	--	--	--	27	27
	△				21	33
ABUTH	Obs	40	48	58	99	99
	Exp	--	--	--	75	78
	△				24	21
POLCO	Obs	68	70	0	90	88
	Exp	--	--	--	68	70
	△				23	18
CIRAR	Obs	25	20	70	83	84
	Exp	--	--	--	78	76
	△				5	8
IPOHE	Obs	5	0	38	30	25
	Exp	--	--	--	41	38
	△				-11	-13
AMARE	Obs	80	85	53	98	97
	Exp	--	--	--	91	93
	△				7	4
HELAN	Obs	83	88	85	99	100

	Exp	--	--	--	97	98
	△				1	2
KCHSC	Obs	63	65	38	70	75
	Exp	--	--	--	77	78
	△				-7	-3

g/ha = grams per hectare
VIOTR = *Viola tricolor* (wild pansy)
ABUTH = *Abutilon theophrasti* (velvetleaf)
POLCO = *Polygonum convolvulus* (wild buckwheat)
CIRAR = *Cirsium arvense* (Canadian thistle)
IPOHE = *Ipomoea hederacea* (ivyleaf morningglory)
AMARE = *Amaranthus retroflexus* (pigweed)
HELAN = *Helianthus annuus* (common sunflower)
KCHSC = *Kochia scoparia* (kochia)

Example 3

[0123] Compositions comprising Compound A and mesotrione were tested to determine the efficacy of the compositions on undesirable vegetation species, including wild pansy (VIOTR, *Viola tricolor*), velvetleaf (ABUTH, *Abutilon theophrasti*), wild buckwheat (POLCO, *Polygonum convolvulus)*, poinsettia (EPHHL, *Euphorbia heterophylla*), Canadian thistle (CIRAR, *Cirsium arvense*), pigweed (AMARE, *Amaranthus retroflexus*), sunflower (HELAN, *Helianthus annuus*), and kochia (KCHSC, *Kochia scoparia*).

[0124] The results are summarized in Table 3 below.

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

Application rate (g/ha)	Compound A	7.5	10	0	7.5	10
	Mesotrione	0	0	35	35	35
VIOTR	Obs	3	3	75	85	90
	Exp	--	--	--	76	76
	△				9	14
ABUTH	Obs	40	48	99	100	100
	Exp	--	--	--	99	99
	△				1	1
POLCO	Obs	68	70	75	80	86
	Exp	--	--	--	92	93

	△				-12	-7
EPHHL	Obs	91	83	100	99	98
	Exp	--	--	--	100	100
	△				-2	-3
CIRAR	Obs	25	20	84	85	88
	Exp	--	--	--	88	87
	△				-3	1
AMARE	Obs	80	85	90	100	90
	Exp	--	--	--	2	-9
	△				7	4
HELAN	Obs	83	88	90	99	100
	Exp	--	--	--	98	99
	△				0	1
KCHSC	Obs	63	65	35	68	75
	Exp	--	--	--	76	77
	△				-8	-2

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* (Canadian thistle)
AMARE = *Amaranthus retroflexus* (pigweed)
HELAN = *Helianthus annuus* (common sunflower)
KCHSC = *Kochia scoparia* (kochia)

Example 4

[0125] Compositions comprising Compound A and sulcotrione were tested to determine the efficacy of the compositions on undesirable vegetation species, including spring rape (BRSNN, *Brassica napus*), 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 spring barley (HORVS), and the phytotoxicity of the compositions on each crop was measured.

[0126] The results are summarized in Table 4 below.

Table 4. Herbicidal Effects (% visual injury) of Compound A and Sulcotrione on weed and grain crops.

Application rate (g/ha)	Compound A	7.5	10	0	7.5	10
	Sulcotrione	0	0	75	75	75
BRSNN	Obs	55	60	75	99	100
	Exp	-	-	-	89	90
	△				10	10
KCHSC	Obs	50	58	30	73	78
	Exp	-	-	-	65	70
	△				8	7
TRZAS	Obs	0	0	0	0	0
	Exp	-	-	-	0	0
	△				0	0
HORVS	Obs	8	0	8	10	15
	Exp	-	-	-	14	8
	△				-4	8

g/ha = grams per hectare
BRSNN = *Brassica napus* (spring rape)
KCHSC = *Kochia scoparia* (kochia)
TRZAS = *Triticum aestivum* (spring wheat)
HORVS = *Hordeum vulgare* (spring barley)

Example 5

[0127] Herbicidal compositions comprising Compound A and pyrazolynate were tested on undesirable vegetation species, including pigweed (AMARE, *Amaranthus retroflexus*), winter rape (BRSNW, *Brassica napus*), common lambsquarters (CHEAL, *Chenopodium album* L.), Canadian thistle (CIRAR, *Cirsium arvense*), kochia (KCHSC, *Kochia scoparia*), wild chamomile (MATCH, *Matricaria chamomilla)*, wild buckwheat (POLCO, *Polygonum convolvulus)*, Russian thistle (SASKR, *Salsola kali*), and wild mustard (SINAR, *Sinapis arvensis*), to determine the efficacy of the herbicidal compositions on these undesirable vegetation species. The herbicidal compositions were also tested on spring wheat (TRZAS) and spring barley (HORVS), and the phytotoxicity of the herbicidal compositions on each crop was measured.

[0128] The results are summarized in Table 5 below.

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

Application rate (g/ha)	Compound A	7.5	10	0	7.5	10
	Pyrazolynate	0	0	225	225	225
AMARE	Obs	90	85	10	100	93
	Exp	-	-	-	91	87
	△				9	6
BRSNW	Obs	35	40	0	35	45
	Exp	-	-	-	35	40
	△				0	5
CHEAL	Obs	75	80	5	85	85
	Exp	-	-	-	76	81
	△				9	4
CIRAR	Obs	40	55	0	60	63
	Exp	-	-	-	40	55
	△				20	8
KCHSC	Obs	70	70	0	70	78
	Exp	-	-	-	70	70
	△				0	8
MATCH	Obs	10	20	0	48	50
	Exp	-	-	-	10	20
	△				38	30
POLCO	Obs	30	43	5	60	65
	Exp	-	-	-	34	45
	△				27	20
SASKR	Obs	60	63	0	68	70
	Exp	-	-	-	60	63
	△				8	8
SINAR	Obs	83	88	5	93	94
	Exp	-	-	-	83	88
	△				9	6
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

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

Example 6

[0129] Herbicidal compositions comprising Compound A and tembotrione were tested on undesirable vegetation species, including pigweed (AMARE, *Amaranthus retroflexus*), winter rape (BRSNW, *Brassica napus*), common lambsquarters (CHEAL, *Chenopodium album* L.), Canadian thistle (CIRAR, *Cirsium arvense*), kochia (KCHSC, *Kochia scoparia*), wild chamomile (MATCH, *Matricaria chamomilla)*, wild buckwheat (POLCO, *Polygonum convolvulus)*, Russian thistle (SASKR, *Salsola kali*), and wild mustard (SINAR, *Sinapis arvensis*), to determine the efficacy of the herbicidal compositions on these undesirable vegetation species. The herbicidal compositions were also tested on spring wheat (TRZAS) and spring barley (HORVS), and the phytotoxicity of the herbicidal compositions on each crop was measured.

[0130] The results are summarized in Table 6 below.

Table 6. Herbicidal Effects (% visual injury) of Compound A and Tembotrione on weeds and grain crops.

Application rate (g/ha)	Compound A	7.5	10	0	7.5	10
	Tembotrione	0	0	25	25	25
AMARE	Obs	90	85	100	100	100
	Exp	-	-	-	100	100
	△				0	0

BRSNW	Obs	35	40	88	95	94
	Exp	-	-	-	92	93
	△				3	1
CHEAL	Obs	75	80	100	100	100
	Exp	-	-	-	100	100
	△				0	0
CIRAR	Obs	40	55	75	73	83
	Exp	-	-	-	85	89
	△				-13	-6
KCHSC	Obs	70	70	48	80	83
	Exp	-	-	-	84	84
	△				-4	-2
MATCH	Obs	10	20	73	85	88
	Exp	-	-	-	75	78
	△				10	10
POLCO	Obs	30	43	25	70	83
	Exp	-	-	-	48	57
	△				23	26
SASKR	Obs	60	63	78	85	88
	Exp	-	-	-	91	92
	△				-6	-4
SINAR	Obs	83	88	95	99	99
	Exp	-	-	-	99	99
	△				-1	-1
TRZAS	Obs	0	0	20	15	15
	Exp	-	-	-	20	20
	△				-5	-5
HORVS	Obs	0	0	10	10	10
	Exp	-	-	-	10	10
	△				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* (Canadian thistle)
KCHSC = *Kochia scoparia* (kochia)
MATCH = *Matricaria chamomilla* (wild chamomile)
POLCO = *Polygonum convolvulus* (wild buckwheat)
SASKR = *Salsola kali* (Russian thistle)
SINAR = *Sinapis arvensis* (wild mustard)
TRZAS = *Triticum aestivum* (spring wheat)
HORVS = *Hordeum vulgare* (spring barley)

Example 7

[0131] Herbicidal compositions comprising Compound A and topramezone were tested on undesirable vegetation species, including pigweed (AMARE, *Amaranthus retroflexus*), winter rape (BRSNW, *Brassica napus*), common lambsquarters (CHEAL, *Chenopodium album* L.), Canadian 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 herbicidal compositions on these undesirable vegetation species. The herbicidal compositions were also tested on spring wheat (TRZAS) and spring barley (HORVS), and the phytotoxicity of the herbicidal compositions on each crop was measured.

[0132] The results are summarized in Table 7 below.

Table 7. Herbicidal Effects (% visual injury) of Compound A and Topramezone on weeds and grain crops.

Application rate (g/ha)	Compound A	7.5	10	0	7.5	10
	Topramezone	0	0	40	40	40
AMARE	Obs	70	90	100	98	100
	Exp	-	-	-	100	100
	△				-3	0
BRSNW	Obs	63	68	98	99	99
	Exp	-	-	-	99	99
	△				-1	-1
CHEAL	Obs	70	78	100	96	98
	Exp	-	-	-	100	100
	△				-4	-3
CIRAR	Obs	18	30	20	78	85
	Exp	-	-	-	34	44

	△				44	41
KCHSC	Obs	65	70	35	75	83
	Exp	-	-	-	77	81
	△				-2	2
MATCH	Obs	18	30	30	53	55
	Exp	-	-	-	42	51
	△				10	4
POLCO	Obs	60	70	43	88	88
	Exp	-	-	-	77	83
	△				11	5
SINAR	Obs	85	88	100	100	98
	Exp	-	-	-	100	100
	△				0	-3
TRZAS	Obs	0	0	33	33	18
	Exp	-	-	-	33	33
	△				0	-15
HORVS	Obs	0	0	38	45	33
	Exp	-	-	-	38	38
	△				8	-5

g/ha = grams per hectare

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

Example 8

[0133] Compositions comprising Compound B and mesotrione were tested on undesirable vegetation species, including velvetleaf (ABUTH, *Abutilon theophrasti*), Canadian thistle (CIRAR, *Cirsium arvense*), and wild pansy (VIOTR, *Viola tricolor*), to determine the efficacy of the compositions on these undesirable vegetation species.

[0134] The results are summarized in Table 8 below.

Table 8. Herbicidal Effects (% visual injury) of Compound B and Mesotrione on weeds.

Application rate (g/ha)	Compound B	7.5	10	0	7.5	10
	Mesotrione	0	0	35	35	35
ABUTH	Obs	68	68	85	99	100
	Exp	-	-	-	95	95
	△				3	5
CIRAR	Obs	45	45	73	92	93
	Exp	-	-	-	85	85
	△				7	8
VIOTR	Obs	10	40	78	90	90
	Exp	-	-	-	80	87
	△				10	4

g/ha = grams per hectare
ABUTH = *Abutilon theophrasti* (velvetleaf)
CIRAR = *Cirsium arvense* (Canadian thistle)
VIOTR = *Viola tricolor* (wild pansy)

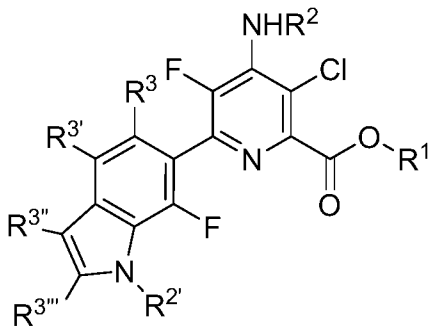
[0135] The compositions and methods of the appended claims are not limited in scope by the specific compositions and methods described herein, which are intended as illustrations of a few aspects of the claims and any compositions and methods that are functionally equivalent are intended to fall within 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;

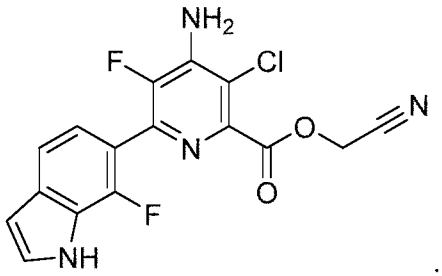
R^3, $R^{3'}$, $R^{3''}$, and $R^{3'''}$ are independently hydrogen;

or an agriculturally acceptable salt thereof; and

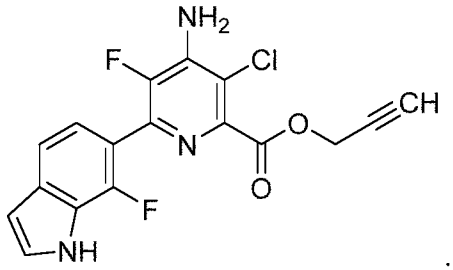
(b) an HPPD inhibitor herbicide or an agriculturally acceptable salt or ester thereof;

wherein the weight ratio of the pyridine carboxylate herbicide in g ae/ha to the HPPD inhibitor herbicide in g ai/ha is from 1:1000 to 50:1.

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 HPPD inhibitor herbicide is selected from the group consisting of benzobicyclon, benzofenap, bicyclopyrone, fenquinotrione, isoxachlortole, isoxaflutole, lancotrione, mesotrione, pyrasulfotole, pyrazolynate, pyrazoxyfen, sulcotrione, tefuryltrione, tembotrione, tolpyralate, topramezone, agriculturally acceptable salts and esters thereof, and a combination thereof.

5. The composition of any one of claims 1-3, wherein the weight ratio of the pyridine carboxylate herbicide in g ae/ha to the HPPD inhibitor herbicide in g ai/ha is from 1:50 to 1:1.

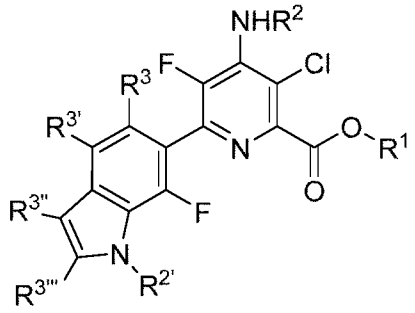
6. The composition of any one of claims 1-3, further comprising a safener.

7. The composition of any one of claims 1-3, further comprising an additional pesticide.

8. The composition of any one of claims 1-3, wherein the composition does not include a herbicidal active ingredient in addition to (a) and (b).

9. 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;

R^3, $R^{3'}$, $R^{3''}$, and $R^{3'''}$ are independently hydrogen;

or an agriculturally acceptable salt thereof; and

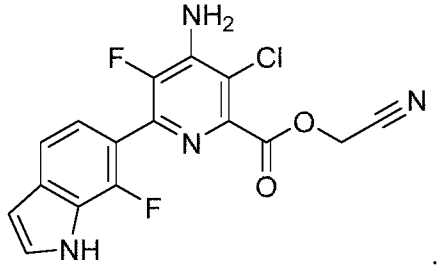
(b) an HPPD inhibitor herbicide or an agriculturally acceptable salt or ester thereof;

wherein the pyridine carboxylate herbicide is applied in an amount of at least 0.1 g ae/ha;

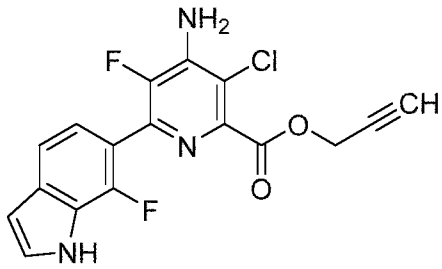
wherein the HPPD inhibitor herbicide is applied in an amount of at least 1 g ai/ha; and

wherein the weight ratio of the pyridine carboxylate herbicide in g ae/ha to the HPPD inhibitor herbicide in g ai/ha is from 1:1000 to 50:1.

10. The method of claim 9, wherein the pyridine carboxylate herbicide compound is cyanomethyl 4-amino-3-chloro-5-fluoro-6-(7-fluoro-1H-indol-6-yl)pyridine-2-carboxylate:



11. The method of claim 9, wherein the pyridine carboxylate herbicide compound is propargyl 4-amino-3-chloro-5-fluoro-6-(7-fluoro-1H-indol-6-yl)pyridine-2-carboxylate:



12. The method of any one of claims 9-11, wherein the HPPD inhibitor herbicide is selected from the group consisting of benzobicyclon, benzofenap, bicyclopyrone, fenquinotrione, isoxachlortole, isoxaflutole, lancotrione, mesotrione, pyrasulfotole, pyrazolynate, pyrazoxyfen,

sulcotrione, tefuryltrione, tembotrione, tolpyralate, topramezone, agriculturally acceptable salts and esters thereof, and a combination thereof.

13. The method of any one of claims 9-11, wherein the pyridine carboxylate herbicide is provided in amount of 0.1 g ae/ha to 300 g ae/ha.

14. The method of any one of claims 9-11, wherein weight ratio of the pyridine carboxylate herbicide in g ae/ha to the HPPD inhibitor herbicide in g ae/ha is from 1:50 to 1:1.

15. The method of any one of claims 9-11, further comprising applying a safener.

16. The method of any one of claims 9-11, further comprising applying an additional pesticide.

17. The method of any one of claims 9-11, wherein the composition does not include a herbicidal active ingredient in addition to (a) and (b).