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(54) **Title:** HERBICIDAL COMPOSITION CONTAINING HALAUXIFEN-METHYL AND AMINOPYRALID

(57) **Abstract:** Compositions for and methods of controlling undesirable vegetation are provided. The compositions and methods include (a) halauxifen, or an agriculturally acceptable salt or ester thereof, and (b) aminopyralid, or an agriculturally acceptable salt or ester thereof, wherein (a) and (b) are present, contacted or applied in an acid-equivalent weight ratio (g ae/ha) of from about 1:50 to about 1:1. The compositions and methods have demonstrated control of certain woody species, including *Sida glaziovii* ("SIDGZ"), *Sida acuta* ("SIDAC"), and/or *Sida rhombifolia* ("SIDRH")

HERBICIDAL COMPOSITION CONTAINING HALAUXIFEN-METHYL AND AMINOPYRALID

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Patent Application Ser. No. 63/504899 filed on May 30, 2023, the contents of which are hereby incorporated herein by reference.

BACKGROUND

[0001] 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 desirable vegetation.

SUMMARY

[0002] A herbicidal composition is provided. The herbicidal composition comprises a herbicidally effective amount of (a) halauxifen, or an agriculturally acceptable salt or ester thereof, and (b) aminopyralid, or an agriculturally acceptable salt or ester thereof, wherein (a) and (b) are present in an acid-equivalent weight ratio (g ae/ha) of from about 1:50 to about 1:1.

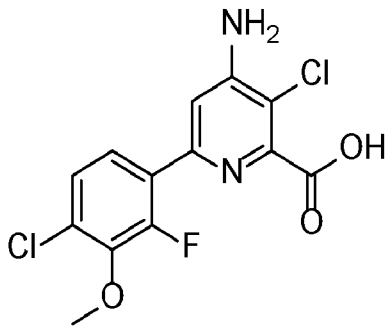
[0003] Additionally, a method of controlling undesirable vegetation is provided. The method comprises contacting the vegetation or the locus thereof with or applying to the soil or water to prevent the emergence or growth of vegetation a herbicidally effective amount of (a) halauxifen, or an agriculturally acceptable salt or ester thereof, and (b) aminopyralid, or an agriculturally acceptable salt or ester thereof, wherein (a) and (b) are contacted or applied in an acid-equivalent weight ratio (g ae/ha) of from about 1:50 to about 1:1.

DETAILED DESCRIPTION

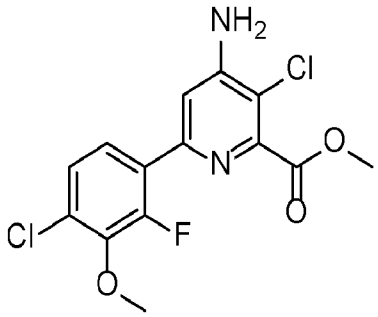
[0004] A herbicidal composition is provided. The herbicidal composition comprises a herbicidally effective amount of (a) halauxifen, or an agriculturally acceptable salt or ester thereof, and (b) aminopyralid, or an agriculturally acceptable salt or ester thereof, wherein (a) and (b) are present in an acid-equivalent weight ratio (g ae/ha) of from about 1:50 to about 1:1.

[0005] Additionally, a method of controlling undesirable vegetation is provided. The method comprises contacting the vegetation or the locus thereof with or applying to the soil or water to prevent the emergence or growth of vegetation a herbicidally effective amount of (a) halauxifen, or an agriculturally acceptable salt or ester thereof, and (b) aminopyralid, or an agriculturally acceptable salt or ester thereof, wherein (a) and (b) are contacted or applied in an acid-equivalent weight ratio (g ae/ha) of from about 1:50 to about 1:1.

[0006] Halauxifen, shown below, is an aryl picolinic acid herbicide that provides broad-spectrum control of broad-leaved weeds.



[0007] Halauxifen-methyl, shown below, is an example of an agriculturally acceptable ester of halauxifen. Halauxifen-methyl is a methyl ester of halauxifen, and also provides broad-spectrum control of broad-leaved weeds. Halauxifen-methyl is known as ARYLEX active ingredient and is present in certain products available from Corteva Agriscience, 9330 Zionsville Road, Indianapolis, IN 46268. In certain embodiments of the compositions and methods provided herein, the halauxifen, or an agriculturally acceptable salt or ester thereof (*i.e.*, the "(a)" component) is halauxifen-methyl.

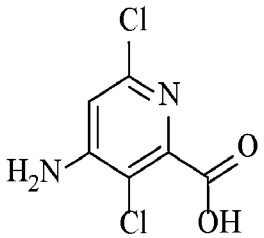


[0008] Halauxifen, or an agriculturally acceptable salt or ester thereof (*e.g.*, halauxifen-methyl), can be applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount sufficient to induce a herbicidal effect. In some aspects of the compositions and methods provided herein, halauxifen 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 (*e.g.*, 2 g ai/ha or more, 3 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, 12.5 g ai/ha or more, 15 g ai/ha or more, 17.5 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, 60 g ai/ha or more, 70 g ai/ha or more, 75 g ai/ha or more, 80 g ai/ha or more, 90 g ai/ha or more, 100 g ai/ha or more, 110 g ai/ha or more, 120 g ai/ha or more, 125 g ai/ha or more, 130 g ai/ha or more, 140 g ai/ha or more, 142.5 g ai/ha or more, 145 g ai/ha or more, 147.5 g ai/ha or more, or 149 g ai/ha or more).

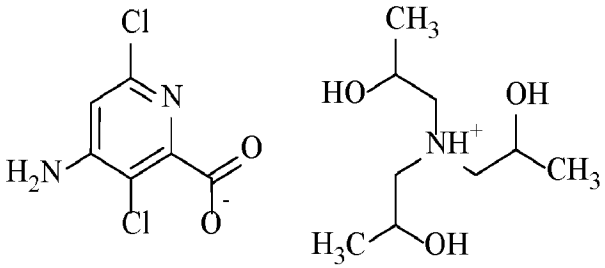
[0009] In some aspects of the compositions and methods provided herein, halauxifen is applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount of 150 g ai/ha or less (*e.g.*, 149 g ai/ha or less, 147.5 g ai/ha or less, 145 g ai/ha or less, 142.5 g ai/ha or less, 140 g ai/ha or less, 130 g ai/ha or less, 125 g ai/ha or less, 120 g ai/ha or less, 110 g ai/ha or less, 100 g ai/ha or less, 90 g ai/ha or less, 80 g ai/ha or less, 75 g ai/ha or less, 70 g ai/ha or less, 60 g ai/ha or less, 50 g ai/ha or less, 45 g ai/ha or less, 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, 17.5 g ai/ha or less, 15 g ai/ha or less, 12.5 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 g ai/ha or less, or 2 g ai/ha or less).

[0010] Halauxifen can be applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount ranging from any of the minimum values described above to any of the maximum values described above, *e.g.*, 1–150 g ai/ha, 2–130 g ai/ha, 2–45 g ai/ha, 3–70 g ai/ha, 4-147.5 g ai/ha, 5–100 g ai/ha, 6–75 g ai/ha, 7–50 g ai/ha, 10–149 g ai/ha, 20–120 g ai/ha, 25–90 g ai/ha, 30–60 g ai/ha, 50–150 g ai/ha, 60–130 g ai/ha, or 100–145 g ai/ha.

[0011] As used herein, aminopyralid is 4-amino-3,6-dichloro-2-pyridinecarboxylic acid and possesses the following structure:



[0012] Exemplary uses of aminopyralid are described in *The Pesticide Manual*, Fifteenth Edition, 2009. Exemplary uses of aminopyralid include its use for long-term control of annual and perennial broadleaf weeds, *e.g.*, in range and pasture. Exemplary chemical forms of aminopyralid include, for example, aminopyralid TIPA, which is 4-amino-3,6-dichloropyridine-2-carboxylic acid compound with 1,1′,1″-nitrilotris[2-propanol] and possesses the following structure:



Aminopyralid (including aminopyralid triisopropylammonium salt ("aminopyralid TIPA")) is available from Corteva Agriscience in a number of products, including MILESTONE herbicide.

[0013] Aminopyralid 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 of the compositions and methods provided herein, aminopyralid 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 (*e.g.*, 2 g ai/ha or more, 3 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, 12.5 g ai/ha or more, 15 g ai/ha or more, 17.5 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, 60 g ai/ha or more, 70 g ai/ha or more, 75 g ai/ha or more, 80 g ai/ha or more, 90 g ai/ha or more, 100 g ai/ha or more, 110 g ai/ha or more, 120 g ai/ha or more, 125 g ai/ha or more, 130 g ai/ha or more, 140 g ai/ha or more, 142.5 g ai/ha or more, 145 g ai/ha or more, 147.5 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, 210 g ai/ha or more, 220 g ai/ha or more, 230 g ai/ha or more, 240 g ai/ha or more, or 250 g ai/ha or more).

[0014] In some aspects of the compositions and methods provided herein, aminopyralid 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 less (*e.g.*, 300 g ai/ha or less, 290 g ai/ha or less, 280 g ai/ha or less, 270 g ai/ha or less, 260 g ai/ha or less, 250 g ai/ha or less, 240 g ai/ha or less, 230 g ai/ha or less, 220 g ai/ha or less, 210 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, 147.5 g ai/ha or less, 145 g ai/ha or less, 142.5 g ai/ha or less, 140 g ai/ha or less, 130 g ai/ha or less, 125 g ai/ha or less, 120 g ai/ha or less, 110 g ai/ha or less, 100 g ai/ha or less, 90 g ai/ha or less, 80 g ai/ha or less, 75 g ai/ha or less, 70 g ai/ha or less, 60 g ai/ha or less, 50 g ai/ha or less, 45 g ai/ha or less, 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, 17.5 g ai/ha or less, 15 g ai/ha or less, 12.5 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 g ai/ha or less, or 2 g ai/ha or less).

[0015] Aminopyralid can be applied to vegetation or an area adjacent the vegetation or applied to soil or water to prevent the emergence or growth of vegetation in an amount ranging from any of the minimum values described above to any of the maximum values described above, *e.g.*, 1–300 g ai/ha, 2–280 g ai/ha, 2–300 g ai/ha, 3–300 g ai/ha, 2–250 g ai/ha, 3–250 g ai/ha, 4-250 g ai/ha, 5–250 g ai/ha, 6–250 g ai/ha, 7–250 g ai/ha, 10–250 g ai/ha, 20–250 g ai/ha,

25–300 g ai/ha, 25–250 g ai/ha, 25–240 g ai/ha, 50–240 g ai/ha, 60–300 g ai/ha, 60–250 g ai/ha, 80–300 g ai/ha, 100–300 g ai/ha, or 100–250 g ai/ha.

[0016] A composition comprising (a) halauxifen, or an agriculturally acceptable salt or ester thereof, may be mixed with or applied in combination with (b) aminopyralid, or an agriculturally acceptable salt or ester thereof.

[0017] In some aspects of the compositions and methods provided herein, (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 than expected) while still showing good compatibility with desirable vegetation (*e.g.*, no increased damage to desirable vegetation) when compared to the individual application of the herbicidal compounds (a) or (b). In some aspects of the compositions and methods provided herein, 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.

[0018] In some aspects of the compositions and methods provided herein, the joint action of (a) halauxifen, or an agriculturally acceptable salt or ester thereof, and (b) aminopyralid, 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. Thus, it is believed that the compositions and methods provided herein, based on the individual components, can be used at lower application rates to achieve a herbicidal effect comparable to the effect produced by the individual components at normal application rates.

[0019] In some aspects of the compositions and methods provided herein, the acid-equivalent weight ratio (g ae/ha) of (a) halauxifen, or an agriculturally acceptable salt or ester thereof, and (b) aminopyralid, or an agriculturally acceptable salt or ester thereof, is 1:50 or more (*e.g.*, 1:49 or more, 1:48 or more, 1:47 or more, 1:46 or more, 1:45 or more, 1:44 or more, 1:43 or more, 1:42 or more, 1:41 or more, 1:40 or more, 1:39 or more, 1:38 or more, 1:37 or more, 1:36 or more, 1:35 or more, 1:34 or more, 1:33 or more, 1:32 or more, 1:31 or more, 1:30 or more, 1:29

or more, 1:28 or more, 1:27 or more, 1:26 or more, 1:25 or more, 1:24 or more, 1:23 or more, 1:22 or more, 1:21 or more, 1:20 or more, 1:19 or more, 1:18 or more, or 1:17 or more).

[0020] In some aspects of the compositions and methods provided herein, the acid-equivalent weight ratio (g ae/ha) of (a) halauxifen, or an agriculturally acceptable salt or ester thereof, and (b) aminopyralid, or an agriculturally acceptable salt or ester thereof, is 1:15 or less (*e.g.*, 1:15 or less, 1:14 or less, 1:13 or less, 1:12 or less, 1:11 or less, 1:10 or less, 1:9 or less, 1:8 or less, 1:7 or less, 1:6 or less, 1:5 or less, 1:4 or less, 1:3 or less, 1:2 or less, or 1:1 or less).

[0021] In some aspects of the compositions and methods provided herein, the acid-equivalent weight ratio (g ae/ha) of (a) halauxifen, or an agriculturally acceptable salt or ester thereof, and (b) aminopyralid, or an agriculturally acceptable salt or ester thereof, is can range from any of the minimum ratios to any of the maximum ratios provided above, *e.g.*, from about 1:50 to about 1:1, from about 1:40 to about 1:5, from about 1:30 to about 1:10, from about 1:20 to about 1:12, from about 1:36 to about 1:1, from about 1:22 to about 1:9, from about 1:20 to about 1:15, or from about 1:18 to about 1:15.

[0022] In some aspects of the compositions and methods provided herein, the active ingredients in the compositions disclosed herein consist of (a) halauxifen, or an agriculturally acceptable salt or ester thereof, and (b) aminopyralid, or an agriculturally acceptable salt or ester thereof.

[0023] The present disclosure also includes formulations of the compositions and methods provided herein.

[0024] The compositions and methods provided herein can also be mixed with or applied with an additive. In some aspects of the compositions and methods provided herein, the additive is added sequentially. In some aspects of the compositions and methods provided herein, the additive is added simultaneously. In some aspects of the compositions and methods provided herein, the additive is premixed with the halauxifen, or an agriculturally acceptable salt or ester thereof, or with the aminopyralid, or an agriculturally acceptable salt or ester thereof.

[0025] In some aspects of the compositions and methods provided herein, the additive is an additional pesticide. 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; florpyrauxifen, florpyrauxifen-benzyl, and those described in U.S. Patent Nos. 7,314,849 and 7,432,227 to Balko, et al.; 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; florpyrauxifen, *e.g.*, florpyrauxifen-benzyl; 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; indolauxipyr, *e.g.*, indolauxipyr-cyanomethyl; 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.

[0026] In some aspects of the compositions and methods provided herein, 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 of the compositions and methods provided herein, the halauxifen, or an agriculturally acceptable salt or ester thereof, is provided in a premixed formulation with an additional pesticide. In some aspects of the

compositions and methods provided herein, the aminopyralid, or an agriculturally acceptable salt or ester thereof, is provided in a premixed formulation with an additional pesticide.

[0027] In some aspects of the compositions and methods provided herein, the compositions may include one or more herbicidal active ingredients in addition to (a). In some aspects of the compositions and methods provided herein, the compositions do not include an herbicidal active ingredient in addition to (a). In some aspects of the compositions and methods provided herein, the compositions may exclude one or more herbicidal active ingredients specified above. In some aspects of the compositions and methods provided herein, the compositions may include one or more herbicidal active ingredients in addition to (a), but may exclude one or more herbicidal ingredients specified above. In some aspects of the compositions and methods provided herein, the composition may include two and only two herbicidal active ingredients: (a) and (b).

[0028] In some aspects of the compositions and methods provided herein, 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.

[0029] 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.

[0030] 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.

[0031] Exemplary thickeners include, but are not limited to, polysaccharides (*e.g.*, xanthan gum), organic and inorganic sheet minerals, and mixtures thereof.

[0032] Exemplary antifoam agents include, but are not limited to, silicone emulsions, long-chain alcohols, fatty acids, fatty acid salts, organofluorine compounds, and mixtures thereof.

[0033] 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.

[0034] Exemplary antifreeze agents, include, but are not limited to ethylene glycol, propylene glycol, urea, glycerol, and mixtures thereof.

[0035] 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.

[0036] Exemplary adhesives include, but are not limited to, polyvinylpyrrolidone, polyvinyl acetate, polyvinyl alcohol, tylose, and mixtures thereof.

[0037] In some aspects of the compositions and methods provided herein, the additive is a safener. Safeners are compounds leading to better crop plant compatibility when applied with a herbicide. In some aspects of the compositions and methods provided herein, the safener itself is herbicidally active. In some aspects of the compositions and methods provided herein, 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 (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 of the compositions and methods provided herein, the safener can be cloquintocet or an ester or salt or ester thereof, such as cloquintocet (mexyl). In some aspects of the compositions and methods provided herein, the safener can be dichlormid. In some aspects, the safener is employed in rice, cereal, or maize. For example, dichlormid or cloquintocet can be used to antagonize harmful effects of the compositions on rice, row crops, and cereals.

[0038] In some aspects of the compositions and methods provided herein, the additive includes a carrier. In some aspects of the compositions and methods provided herein, the additive includes a liquid or solid carrier. In some aspects of the compositions and methods provided herein, 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, solid fertilizers, *e.g.*, ammonium sulfate, ammonium phosphate, ammonium nitrate, and ureas, cereal meal, tree bark meal, wood meal and nutshell meal, cellulose powders, and mixtures thereof.

[0039] In some aspects of the compositions and methods provided herein, the formulation of (a) halauxifen, or an agriculturally acceptable salt or ester thereof, and (b) aminopyralid, 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.

[0040] In some aspects of the compositions and methods provided herein, (a) and (b) may be aqueous solutions that can be diluted before use. In some aspects of the compositions and methods provided herein, (a) and (b) may be provided as a high-strength formulation such as a concentrate. In some aspects of the compositions and methods provided herein, 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 of

the compositions and methods provided herein, the concentrate does not exhibit any precipitation of solids at temperatures of -10 °C or higher. In some aspects of the compositions and methods provided herein, 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 of the compositions and methods provided herein, the concentrate exhibits a viscosity of less than 50 centipoise (50 megapascals), even at temperatures as low as 5 °C. In some aspects of the compositions and methods provided herein, 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).

[0041] In some aspects of the compositions and methods provided herein, 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.

[0042] In some aspects of the compositions and methods provided herein, 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.

[0043] In some aspects of the compositions and methods provided herein, granules (*e.g.*, coated granules, impregnated granules and homogeneous granules) can be prepared by binding the (a) and (b) to solid carriers.

[0044] In some aspects of the compositions and methods provided herein, 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.

[0045] In some aspects of the compositions and methods provided herein, the formulation can be in the form of a single package formulation including both: (a) the halauxifen, or an agriculturally acceptable salt or ester thereof; and (b) the aminopyralid, or an agriculturally acceptable salt or ester thereof. In some aspects of the compositions and methods provided herein, 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 of the compositions and methods provided herein, 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 of the compositions and methods provided herein, the mixing is performed as a tank mix (*e.g.*, the formulations are mixed immediately before or upon dilution with water). In some aspects of the compositions and methods provided herein, 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.

[0046] 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 of the compositions and methods provided herein, the method of application can be chosen to ensure the finest possible distribution of the compositions disclosed herein.

[0047] In some aspects of the compositions and methods provided herein, 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 provided.

[0048] 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 of the compositions and methods provided herein, the composition is applied post-emergence to the undesirable vegetation. In some aspects of the compositions and methods provided herein, the (a) halauxifen, or an agriculturally acceptable salt or ester thereof, and (b) aminopyralid, or an agriculturally acceptable salt or ester thereof, are applied simultaneously. In some aspects of the compositions and methods provided herein, (a) halauxifen, or an agriculturally acceptable salt or ester thereof, and (b) aminopyralid, or an agriculturally acceptable salt or ester thereof, 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.

[0049] 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 of the compositions and methods provided herein, 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 of the compositions and methods provided herein, when the compositions are used in crops, the compositions can be applied before seeding of the crop plants.

[0050] In some aspects of the compositions and methods provided herein, 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 of the compositions and methods provided herein, 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 of the compositions and methods provided herein, 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 of the compositions and methods provided herein, 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 of the compositions and methods provided herein, the compositions disclosed herein can be applied as dry formulations (*e.g.*, granules, powders, or dusts).

[0051] In some aspects of the compositions and methods provided herein, wherein the undesirable vegetation is treated post-emergence, the compositions disclosed herein are applied by foliar application. In some aspects of the compositions and methods provided herein, 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 of the compositions and methods provided herein, these and other factors can be adjusted to promote non-selective or selective herbicidal action.

[0052] The compositions and methods disclosed herein can be utilized to control undesirable vegetation in a variety of applications. The compositions and methods disclosed herein can be utilized 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 of the compositions and methods provided herein, 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, pasture and range land (*e.g.*, pasture grasses). In some aspects of the compositions and methods provided herein, the compositions and methods disclosed herein can be used for controlling undesirable vegetation in maize, wheat, barley, rice, sorghum, millet, oats, or a combination thereof. In some aspects of the compositions and methods provided herein, the compositions and methods disclosed herein can be used in industrial vegetation management (IVM) or for utility, pipeline, roadside, natural or wildlife habitat, conservation areas, and railroad rights−of−way applications. In some aspects of the compositions and methods provided herein, 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 of the compositions and methods provided herein, 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 of the compositions and methods provided herein, 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. In some aspects of the compositions and methods provided herein, the compositions and methods disclosed herein can be used on certain desirable species with little to no damage, which can be described as being selective to the desirable species. In some aspects of the compositions and methods provided herein, the compositions and methods disclosed herein are selective to *Brachiaria brizantha* forage.

[0053] 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 of the compositions and methods provided herein, 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 of the compositions and methods provided herein, 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 of the compositions and methods provided herein, the compositions and methods disclosed herein can be used in crop plants that are resistant to attack by insects owing to genetic engineering or breeding. Exemplary resistant crops include, but are not limited to, crops that are resistant to photosystem II inhibitors, or crop plants that, owing to introduction of the gene for Bacillus thuringiensis (or Bt) toxin by genetic modification, are resistant to attack by certain insects. In some aspects, the compositions and methods described herein can be used in conjunction with glyphosate, glufosinate, dicamba, phenoxy auxins, pyridyloxy auxins, aryloxyphenoxypropionates, acetyl CoA carboxylase (ACCase) inhibitors, imidazolinones, acetolactate synthase (ALS) inhibitors, 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitors, protoporphyrinogen oxidase (PPO) inhibitors, triazines, and bromoxynil to control vegetation in crops tolerant to glyphosate, glufosinate, dicamba, phenoxy auxins, pyridyloxy auxins, aryloxyphenoxypropionates, ACCase inhibitors, imidazolinones, synthetic auxin herbicide, HPPD inhibitors, PPO inhibitors, triazines, bromoxynil, or combinations thereof. In some aspects, the undesirable vegetation is controlled in glyphosate, glufosinate, dicamba, phenoxy auxins, pyridyloxy auxins, aryloxyphenoxypropionates, ACCase inhibitors, synthetic auxin herbicide, HPPD inhibitors, PPO inhibitors, triazines, and bromoxynil tolerant crops possessing single, multiple or stacked traits conferring tolerance to single or multiple chemistries and/or multiple modes of action. In some aspects, the undesirable vegetation can be controlled in a crop that is ACCase-tolerant, ALS-tolerant, or a combination thereof. The combination of (a) 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 of the compositions and methods provided herein, 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).

[0054] In some aspects of the compositions and methods provided herein, the compositions disclosed herein can be used for controlling undesirable vegetation including grasses, broadleaf weeds, sedge weeds, and combinations thereof. In some aspects of the compositions and methods provided herein, the compositions disclosed herein can be used for controlling undesirable vegetation including, but not limited to, *Polygonum* species, *Amaranthus* species, *Chenopodium* species, *Sida* species, *e.g.*, *Sida glaziovii* ("SIDGZ"), *Sida acuta* ("SIDAC"), and *Sida rhombifolia* ("SIDRH"), *Ambrosia* species, *Cyperus* species, *Setaria* species, *Sorghum* species, *Acanthospermum* species, *Anthemis* species, *Atripl, ex* species, *Brassica* species, *Carduus* 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 of the compositions and methods provided herein, 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*), thistle (*Cirsium arvense*), nutsedge (*Cyperus esculentus*), poinsettia (*Euphorbia heterophylla*), 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 convolvulus*), giant foxtail (*Setaria faberi*), green foxtail (*Setaria*

viridis), common sorghum (*Sorghum vulgare*), wild pansy (*Viola tricolor*), or a combination thereof.

[0055] The compositions described herein can be used to control herbicide resistant or tolerant weeds. The methods employing the compositions described herein may also be employed to control herbicide resistant or tolerant weeds. Exemplary resistant or tolerant weeds include, but are not limited to, biotypes resistant or tolerant to acetolactate synthase (ALS) or acetohydroxy acid synthase (AHAS) inhibitors (*e.g.*, imidazolinones, sulfonylureas, pyrimidinylthiobenzoates, triazolopyrimidines, sulfonylaminocarbonyltriazolinones), photosystem II inhibitors (*e.g.*, phenylcarbamates, pyridazinones, triazines, triazinones, uracils, amides, ureas, benzothiadiazinones, nitriles, phenylpyridazines), acetyl CoA carboxylase (ACCase) inhibitors (*e.g.*, aryloxyphenoxypropionates, cyclohexanediones, phenylpyrazolines), synthetic auxins (*e.g.*, benzoic acids, phenoxycarboxylic acids, pyridine carboxylates, quinoline carboxylic acids), auxin transport inhibitors (*e.g.*, phthalamates, semicarbazones), photosystem I inhibitors (*e.g.*, bipyridyliums), 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase inhibitors (*e.g.*, glyphosate), glutamine synthetase inhibitors (*e.g.*, glufosinate, bialafos), microtubule assembly inhibitors (*e.g.*, benzamides, benzoic acids, dinitroanilines, phosphoramidates, pyridines), mitosis inhibitors (*e.g.*, carbamates), very long chain fatty acid (VLCFA) inhibitors (*e.g.*, acetamides, chloroacetamides, oxyacetamides, tetrazolinones), fatty acid and lipid synthesis inhibitors (*e.g.*, phosphorodithioates, thiocarbamates, benzofuranes, chlorocarbonic acids), protoporphyrinogen oxidase (PPO) inhibitors (*e.g.*, diphenylethers, N-phenylphthalimides, oxadiazoles, oxazolidinediones, phenylpyrazoles, pyrimidindiones, thiadiazoles, triazolinones), carotenoid biosynthesis inhibitors (*e.g.*, clomazone, amitrole, aclonifen), phytoene desaturase (PDS) inhibitors (*e.g.*, amides, anilidex, furanones, phenoxybutan-amides, pyridiazinones, pyridines), 4-hydroxyphenyl-pyruvate-dioxygenase (HPPD) inhibitors (*e.g.*, callistemones, isoxazoles, pyrazoles, triketones), cellulose biosynthesis inhibitors (*e.g.*, nitriles, benzamides, quinclorac, triazolocarboxamides), herbicides with multiple modes of action such as quinclorac, and unclassified herbicides such as arylaminopropionic acids, difenzoquat, endothall, and organoarsenicals. Exemplary resistant or tolerant weeds include, but are not limited to, biotypes with resistance or tolerance to multiple herbicides,

biotypes with resistance or tolerance to multiple chemical classes, biotypes with resistance or tolerance to multiple herbicide modes of action, and biotypes with multiple resistance or tolerance mechanisms (*e.g.*, target site resistance or metabolic resistance).

[0056] 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.

(1) A herbicidal composition comprising a herbicidally effective amount of (a) halauxifen, or an agriculturally acceptable salt or ester thereof, and (b) aminopyralid, or an agriculturally acceptable salt or ester thereof, wherein (a) and (b) are present in an acid-equivalent weight ratio (g ae/ha) of from about 1:50 to about 1:1.

(2) The aspect of (1), wherein (a) is halauxifen-methyl.

(3) The aspect of (1) or (2), wherein (b) is aminopyralid triisopropylammonium salt.

(4) The aspect of any one of the aforementioned aspects, wherein (a) and (b) are present in an acid-equivalent weight ratio (g ae/ha) of from about 1:40 to about 1:5, or from about 1:30 to about 1:10, or from about 1:20 to about 1:12, or from about 1:18 to about 1:15.

(5) The aspect of any one of the aforementioned aspects, further comprising a herbicide safener.

(6) The aspect of any one of the aforementioned aspects, further comprising an agriculturally acceptable adjuvant or carrier.

(7) 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 a herbicidally effective amount of (a) halauxifen, or an agriculturally acceptable salt or ester thereof, and (b) aminopyralid, or an agriculturally acceptable salt or ester thereof, wherein (a) and (b) are contacted or applied in an acid-equivalent weight ratio (g ae/ha) of from about 1:50 to about 1:1.

(8) The method of aspect (7), wherein (a) is halauxifen-methyl.

(9) The method of aspect (7) or (8), wherein (b) is aminopyralid triisopropylammonium salt.

(10) The method of any one of aspects (7)–(9), wherein (a) and (b) are present in an acid-equivalent weight ratio (g ae/ha) of from about 1:40 to about 1:5, or from about 1:30 to about 1:10, or from about 1:20 to about 1:12, or from about 1:18 to about 1:15.

(11) The method of any one of aspects (7)–(10), wherein the undesirable vegetation is controlled in pastures, grasslands, rangelands, fallowland, turf, tree and vine orchards, aquatics, industrial vegetation management (IVM) or rights of way (ROW).

(12) The method of any one of aspects (7)–(11), wherein the undesirable vegetation comprises a herbicide resistant or tolerant weed.

(13) The method of any one of aspects (7)–(12), wherein the undesirable vegetation comprises *Sida* species.

(14) The method of aspect (13), wherein the *Sida* species comprises *Sida glaziovii* ("SIDGZ"), *Sida acuta* ("SIDAC"), and/or *Sida rhombifolia* ("SIDRH").

(15) The method of any one of aspects (7)–(14), wherein the method is selective to *Brachiaria brizantha* forage.

[0057] The following examples further illustrate the invention but, of course, should not be construed as in any way limiting its scope.

EXAMPLE 1

[0058] In order to study the possible activity of halauxifen and aminopyralid on SIDGZ in pasture land, field studies were conducted, with dosing of halauxifen-methyl and/or aminopyralid TIPA shown below in Table 1, as well as control and selectivity observations. Percent visual plant defoliation or injury was reported at various days after application as shown in Table 1.

Table 1:

Test	Halauxifen-methyl (g ae/ha)	Aminopyralid TIPA (g ae/ha)	SIDGZ Control, % Visual Plant Defoliation Observed at 30; 60; and 102 days after application	*Brachiaria brizantha* Selectivity, % Visual Plant Injury Observed at 30 days after application
A	0	0	0; 0; 0	0

B	4.5	0	55; 40; 88	0
C	0	75	10; 8; 13	0
D	4.5	75	100, 100, 100	1

EXAMPLE 2

[0059] In order to further study the possible activity of halauxifen and aminopyralid on SIDGZ in pasture land, field studies were conducted, with dosing of halauxifen-methyl and aminopyralid TIPA shown below in Table 2, as well as control and selectivity observations. Percent visual plant defoliation or injury was reported at various days after application as shown in Table 2.

Table 2:

Test	Halauxifen -methyl (g ae/ha)	Aminopyralid TIPA (g ae/ha)	SIDGZ Control, % Visual Plant Defoliation Observed at 15; 30; 60; and 90 days after application	*Brachiaria brizantha* Selectivity, % Visual Plant Injury Observed at 15; 30; and 60 days after application
E	1.5	25	36; 46; 75; 78	0; 0; 0
F	3	50	51; 62; 94; 97	0; 0; 0
G	4.5	75	62; 77; 99; 100	0; 1; 0
H	5.25	87.5	71; 80; 98; 100	0; 1; 0
J	6	100	74; 85; 99; 100	2; 3; 0
K	6.75	112.5	78; 86; 99; 100	2; 3; 0
L	7.5	125	81; 91; 100; 100	3; 4; 1
M	8.25	137.5	85; 91; 99; 100	3; 4; 1
N	9	150	85; 92; 100; 100	4; 5; 1

Example 3

[0060] In order to further study the possible activity of halauxifen and aminopyralid on *Sida acuta* ("SIDAC") and *Sida rhombifolia* ("SIDRH") in pasture land, field studies were conducted, with dosing of halauxifen-methyl and aminopyralid TIPA shown below in Table 3. Percent visual plant defoliation or injury was reported at various days after application as shown in Table 3.

Table 3:

Test	Halauxifen -methyl (g ae/ha)	Aminopyralid TIPA (g ae/ha)	SIDAC Control, mean % Visual Plant Defoliation Observed at 51–120 days after application	SIDRH Control, mean % Visual Plant Defoliation Observed at 55–95 days after application
P	4.5	75	68	96
Q	5	60	70	82
R	5	120	68	98
S	6	100	91	98
T	7.5	130	90	97
U	9	150	96	99
V	10	60	71	98
W	10	120	71	97

[0061] Example 4

Table 4

Efficacy of (aminopyralid potassium, 500 g ae/kg + halauxifen-methyl, 30 g ae/kg)
Efficacy data (0-100%) evaluated 90 days after application.

Rate (g cp/ha)	CASOB	CVNGL	HPYSU	MIMPU	SENBR	SIDAC	SIDGZ	SIDRH	SOLAC	VENWE
25	43	54	19	76	72	30	65	---	12	3
50	58	51	56	82	88	56	81	34	18	27
100	88	72	65	95	94	63	90	66	36	49
150	93	89	78	97	98	72	97	68	50	70
200	94	88	88	98	98	78	99	68	55	71
250	98	88	97	98	100	85	99	83	73	89
300	100	89	98	100	99	98	99	91	77	93

Species: CASOB (*Senna obtusifolia*), CVNGL (*Croton glandulosus*), HPYSU (*Hyptis suaveolens*), MIMPU (*Mimosa pudica*), SENBR (*Senescio brasiliensis*), SIDAC (*Sida acuta*), SIDGZ (Sida glaziovii), SIDRH (*Sida rhombifolia*), SOLAC (*Solanum aculeatissimum*) and VENWE (*Vernonia westiniana*).

[0062] Example 5

Table 5

Crop safety of (aminopyralid potassium, 500 g ae/kg + halauxifen-methyl, 30 g ae/kg)
Crop injury data (0-100%) evaluated 15 days after application.

Rate (g cp/ha)	ANOGE	BRASS	DIHAN	PANMA	PANSS
25	0	1.6	0	0	0
50	0	0.9	0	1.2	0
100	0	1.1	0	0.5	0
150	0	2.5	0	0.9	0
200	0	2.8	0	2.4	0
250	3.3	4	0	3.5	0
300	5	5	0	7	0

Species: ANOGE (*Andropogon gerardii*), BRASS (*Brachiaria* spp.), DIHAN (*Digitaria annulatum*), PANMA (*Panicum maximum*) and PANSS (*Paspalum* spp.).

[0063] All references, including publications, patent applications, and patents, cited herein are hereby incorporated by reference to the same extent as if each reference were individually and specifically indicated to be incorporated by reference and were set forth in its entirety herein.

[0064] The use of the terms "a" and "an" and "the" and "at least one" and similar referents in the context of describing the invention (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. The use of the term "at least one" followed by a list of one or more items (for example, "at least one of A and B") is to be construed to mean one item selected from the listed items (A or B) or any combination of two or more of the listed items (A and B), unless otherwise indicated herein or clearly contradicted by context. The terms "comprising," "having," "including," and "containing" are to be construed as open-ended terms (i.e., meaning "including, but not limited to,") unless otherwise noted. Recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (*e.g.*, "such as") provided herein, is intended merely to better illuminate the invention and does not pose a limitation on the scope of the invention unless otherwise claimed. No language in the specification should be construed as indicating any non-claimed element as essential to the practice of the invention.

[0065] Preferred embodiments of this invention are described herein, including the best mode known to the inventors for carrying out the invention. Variations of those preferred embodiments may become apparent to those of ordinary skill in the art upon reading the foregoing description. The inventors expect skilled artisans to employ such variations as appropriate, and the inventors intend for the invention to be practiced otherwise than as specifically described herein. Accordingly, this invention includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the invention unless otherwise indicated herein or otherwise clearly contradicted by context.

CLAIM(S):

1. A herbicidal composition comprising a herbicidally effective amount of (a) halauxifen, or an agriculturally acceptable salt or ester thereof, and (b) aminopyralid, or an agriculturally acceptable salt or ester thereof, wherein (a) and (b) are present in an acid-equivalent weight ratio (g ae/ha) of from about 1:50 to about 1:1.

2. The herbicidal composition of claim 1, wherein (a) is halauxifen-methyl.

3. The herbicidal composition of claim 1 or 2, wherein (b) is aminopyralid triisopropylammonium salt.

4. The herbicidal composition of any one of claims 1–3, wherein (a) and (b) are present in an acid-equivalent weight ratio (g ae/ha) of from about 1:40 to about 1:5, or from about 1:30 to about 1:10, or from about 1:20 to about 1:12, or from about 1:18 to about 1:15.

5. The herbicidal composition of any one of claims 1–4, further comprising a herbicide safener.

6. The herbicidal composition of any one of claims 1–5, further comprising an agriculturally acceptable adjuvant or carrier.

7. 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 a herbicidally effective amount of (a) halauxifen, or an agriculturally acceptable salt or ester thereof, and (b) aminopyralid, or an agriculturally acceptable salt or ester thereof, wherein (a) and (b) are contacted or applied in an acid-equivalent weight ratio (g ae/ha) of from about 1:50 to about 1:1.

8. The method of claim 7, wherein (a) is halauxifen-methyl.

9. The method of claim 7 or 8, wherein (b) is aminopyralid triisopropylammonium salt.

10. The method of any one of claims 7–9, wherein (a) and (b) are present in an acid-equivalent weight ratio (g ae/ha) of from about 1:40 to about 1:5, or from about 1:30 to about 1:10, or from about 1:20 to about 1:12, or from about 1:18 to about 1:15.

11. The method of any one of claims 7–10, wherein the undesirable vegetation is controlled in pastures, grasslands, rangelands, fallowland, turf, tree and vine orchards, aquatics, industrial vegetation management (IVM) or rights of way (ROW).

12. The method of any one of claims 7–11, wherein the undesirable vegetation comprises a herbicide resistant or tolerant weed.

13. The method of any one of claims 7–12, wherein the undesirable vegetation comprises a *Sida* species.

14. The method of claim 13, wherein the *Sida* species comprises *Sida glaziovii* ("SIDGZ"), *Sida acuta* ("SIDAC"), and/or *Sida rhombifolia* ("SIDRH").

15. The method of any one of claims 7–14, wherein the method is selective to *Brachiaria brizantha* forage.

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2024/029585

A. CLASSIFICATION OF SUBJECT MATTER
INV. A01N43/40 A01P13/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

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

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2009/062121 A1 (SATCHIVI NORBERT M [US] ET AL) 5 March 2009 (2009-03-05) claim 7; tables 52, 57	1-15
A	EP 3 987 932 A1 (ADAMA AGAN LTD [IL]) 27 April 2022 (2022-04-27) claims 1, 9, 10	1-15
A	WO 2020/096926 A1 (DOW AGROSCIENCES LLC [US]) 14 May 2020 (2020-05-14) paragraphs [0255] - [0256] paragraphs [0265] - [0266]; example 48; table 48	1-15

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

[x] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 August 2024	05/09/2024

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Sawicki, Marcin

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2024/029585

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	AGNES ZOTZ ET AL: "BELKAR(TM) - a new herbicide for the control of a wide range of broadleaf weeds in winter oilseed rape applied post-emergence in autumn", JULIUS-KÜHN-ARCHIV, no. 458, 1 March 2018 (2018-03-01), pages 344-348, XP93192489, DE ISSN: 1868-9892, DOI: 10.5073/jka.2018.458.050 Retrieved from the Internet: URL:https://ojs.openagrar.de/index.php/JKA/article/view/8949/8228>	1,2,6-8, 12
Y	pages 347-348; table 3	3,5,9, 11,13-15
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X	LUDWIG-MÜLLER JUTTA ET AL: "Two Auxinic Herbicides Affect Brassica napus Plant Hormone Levels and Induce Molecular Changes in Transcription", BIOMOLECULES, vol. 11, no. 8, 4 August 2021 (2021-08-04), page 1153, XP93192413, CH ISSN: 2218-273X, DOI: 10.3390/biom11081153 table 1	1,2,6

Y	Corteva: "ForageMax Label", , 17 February 2021 (2021-02-17), pages 1-10, XP93192713, Retrieved from the Internet: URL:https://www.corteva.com.au/products-and-solutions/crop-protection/foragemax-arylex-active.html page 1	3,9,11, 13-15

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2024/029585

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