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(54) Titre : LUTTE EN SYNERGIE CONTRE LES MAUVAISES HERBES
 (54) Title: SYNERGISTIC HERBICIDAL WEED CONTROL

(57) **Abrégé/Abstract:**

Provided herein are herbicidal compositions comprising a mixture comprising (a) the choline salt of 2,4-dichlorophenoxyacetic acid (2,4-D-choline), (b) a salt of N-(phosphonomethyl)glycine (glyphosate), and (c) a salt of 2-amino-4-(hydroxymethylphosphinyl)-butanoic acid (glufosinate). The compositions provide synergistic weed control of undesirable vegetation and improved crop tolerance in 2,4-D-, glyphosate- and glufosinate-tolerant soybeans, corn, or cotton. The compositions also provide synergistic weed control of undesirable vegetation in areas including, but not limited to, non-crop, perennial crop, fruiting crop, and plantation crop areas.

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(54) Title: SYNERGISTIC HERBICIDAL WEED CONTROL

(57) Abstract: Provided herein are herbicidal compositions comprising a mixture comprising (a) the choline salt of 2,4-dichlorophenoxyacetic acid (2,4-D-choline), (b) a salt of N-(phosphonomethyl)glycine (glyphosate), and (c) a salt of 2-amino-4-(hydroxymethylphosphinyl)-butanoic acid (glufosinate). The compositions provide synergistic weed control of undesirable vegetation and improved crop tolerance in 2,4-D-, glyphosate- and glufosinate-tolerant soybeans, corn, or cotton. The compositions also provide synergistic weed control of undesirable vegetation in areas including, but not limited to, non-crop, perennial crop, fruiting crop, and plantation crop areas.



WO 2015/094884 A1

SYNERGISTIC HERBICIDAL WEED CONTROL

Cross Reference to Related Applications

This application claims the benefit of U.S. Provisional Patent Application Serial Nos.
 5 61/918,997 and 61/919,025 filed December 20, 2013.

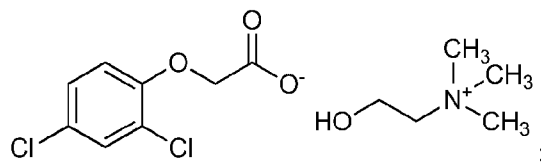
Background

The protection of crops from weeds and other vegetation which inhibit crop growth is a recurring problem in agriculture. To help combat this problem, a variety of chemicals and chemical formulations effective in the control of such unwanted vegetation have been
 10 synthesized and evaluated. Different classes of chemical herbicides have been disclosed in the literature and a large number are in commercial use. However, there remains a need for improved compositions and methods of use thereof that are effective in controlling undesirable vegetation.

Summary

15 Compositions for controlling undesirable vegetation containing a mixture comprising synergistic, herbicidally effective amounts of:

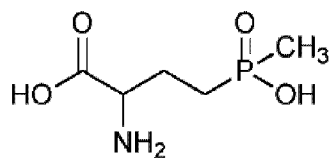
- (a) a choline salt of 2,4-dichlorophenoxyacetic acid (2,4-D-choline)



- (b) a salt of *N*-(phosphonomethyl)glycine (glyphosate)



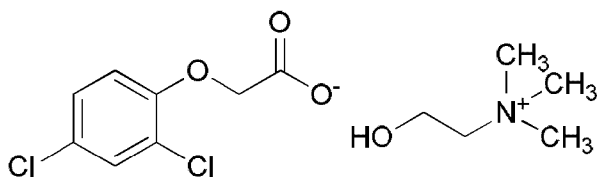
- (c) a salt of 2-amino-4-(hydroxymethylphosphinyl)butanoic acid (glufosinate)



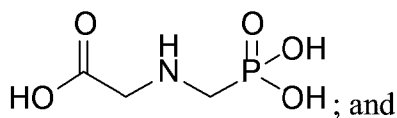
are described herein. The compositions may also contain one or more agriculturally acceptable adjuvants and/or carriers.

In one embodiment, there is provided a composition for controlling undesirable
5 vegetation, comprising a mixture comprising a synergistic, herbicidally effective amount of:

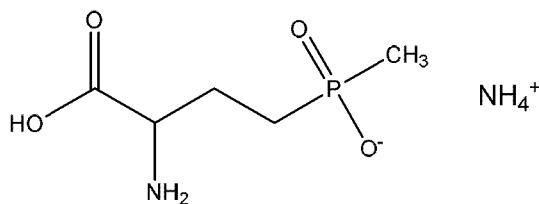
- (a) the choline salt of 2,4-dichlorophenoxyacetic acid (2,4-D-choline)



- (b) a salt of *N*-(phosphonomethyl)glycine (glyphosate)



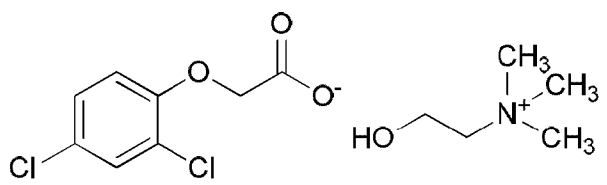
- 10 c) the ammonium salt of 2-amino-4-(hydroxymethylphosphinyl)butanoic acid (glufosinate ammonium)



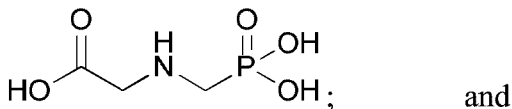
wherein the weight ratio of (a) + (b) to (c) is from 1.5:1 to 8:1.

In another embodiment, there is provided a method of controlling undesirable vegetation and improving crop tolerance in 2,4-D-, glyphosate- and glufosinate-tolerant soybeans, corn, or cotton, comprising contacting undesirable vegetation and 2, 4-D-, glyphosate- and glufosinate-tolerant soybeans, corn, or cotton or the locus thereof, or foliage or soil, with a composition comprising a mixture comprising a synergistic, herbicidally effective amount of:

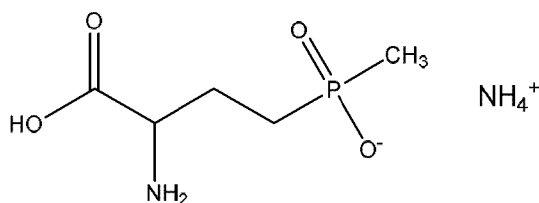
- (a) the choline salt of 2,4-dichlorophenoxyacetic acid (2,4-D-choline)



- (b) a salt of *N*-(phosphonomethyl)glycine (glyphosate)



- (c) an ammonium salt of 2-amino-4-(hydroxymethylphosphinyl)butanoic acid



(glufosinate ammonium)

wherein the weight ratio of (a) + (b) to (c) is from 1.5:1 to 8:1.

15 Additionally, methods of controlling undesirable vegetation and improving crop tolerance in 2,4-D-, glyphosate- and glufosinate-tolerant soybeans, corn, or cotton, including

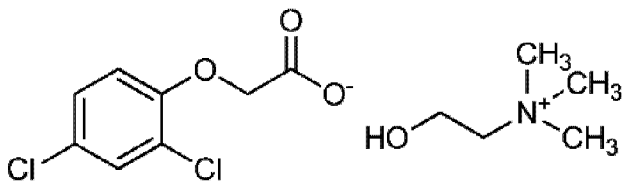
contacting undesirable vegetation and 2,4-D-, glyphosate- and glufosinate-tolerant soybeans, corn, or cotton or the locus thereof, including but not limited to, foliage or soil with a composition containing a mixture containing synergistic, herbicidally effective amounts of (a) 2,4-D-choline, (b) a salt of glyphosate and (c) a salt of glufosinate are described herein. The
5 undesirable vegetation may include herbicide resistant or tolerant weeds and the undesirable vegetation may be located in non-crop, perennial crop, fruiting crop, or plantation crop areas.

In another embodiment, methods of controlling undesirable vegetation in non-crop, perennial crop, fruiting crop, or plantation crop areas including contacting the undesirable vegetation or the locus thereof, including but not limited to foliage, soil or water, with a
10 composition containing a mixture containing synergistic, herbicidally effective amounts of 2,4-D-choline and a salt of glufosinate are described herein.

Detailed Description

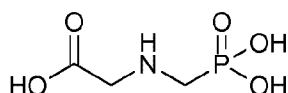
I. Definitions

As used herein, 2,4-D-choline is the choline salt of 2,4-dichlorophenoxyacetic acid or
15 2-hydroxy-*N,N,N*-trimethylethanaminium 2-(2,4-dichlorophenoxy)acetate, which has the following structure:



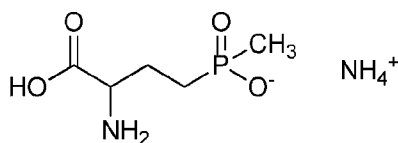
Exemplary uses of 2,4-D-choline include controlling annual and perennial broad-leaved weeds, including glyphosate-resistant broad-leaved weeds. 2,4-D-choline can be used in crops that have been made tolerant to 2,4-D, particularly in 2,4-D-tolerant soybeans, corn, and cotton. 2,4-D-choline is generally, but is not required to be, applied post-emergent.

- 5 As used herein, glyphosate is *N*-(phosphonomethyl)glycine or 2-((phosphonomethyl)-amino)acetic acid, which has the following structure:



- Glyphosate is a non-selective systemic herbicide used to control annual and perennial grasses and broad-leaved weeds, particularly in crops that have been genetically modified to be tolerant of glyphosate. Exemplary chemical forms of glyphosate include, but are not limited to, for example, glyphosate potassium, glyphosate isopropylamine (IPA) salt, glyphosate monoethanolamine (MEA) salt, glyphosate monomethylamine (MMA) salt, and glyphosate dimethylamine (DMA) salt. As used herein, glyphosate salt or salt of glyphosate generally refers to the reaction product of glyphosate with a moiety that can act as a base. Typically, the reaction is an acid-base reaction.

As used herein, glufosinate is 2-amino-4-(hydroxymethylphosphinyl)butanoic acid. An exemplary salt of glufosinate is glufosinate-ammonium, which is also known as the ammonium salt of 2-amino-4-(hydroxymethylphosphinyl)butanoic acid or ammonium (3-amino-3-carboxypropyl)(methyl)phosphinate, and which has the following structure:



- Glufosinate-ammonium is registered for controlling a wide variety of broad-leaved weeds and grasses particularly in glufosinate-tolerant crops like canola, corn, soybean, cotton, and sugar beet. As used herein, glufosinate salt or salt of glufosinate generally refers to the reaction product of glufosinate with a moiety that can act as a base. Typically, the reaction is an acid-base reaction.

The term herbicide, as used herein, means an active ingredient that kills, controls or otherwise adversely modifies the growth of plants. As used herein, a herbicidally effective or vegetation controlling amount is an amount of active ingredient that causes a “herbicidal effect,” *i.e.*, an adversely modifying effect and includes deviations from natural development, killing, regulation, desiccation, retardation.

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

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

As used herein, 2,4-D-tolerant soybeans refer to soybeans that are genetically modified to be tolerant to 2,4-D. Examples of 2,4-D-tolerant soybeans include soybeans containing the *aad-12* gene which confers tolerance to 2,4-D (U.S. Patent 8,283,522 B2). As used herein, 2,4-D-tolerant corn refers to corn that is genetically modified to be tolerant to 2,4-D. Examples of 2,4-D tolerant corn include corn containing the *aad-1* gene which confers tolerance to 2,4-D (U.S. Patent 7,838,733 B2). As used herein, 2,4-D-tolerant cotton refers to cotton that is genetically modified to be tolerant to 2,4-D. Examples of 2,4-D tolerant cotton include cotton containing the *aad-12* gene which confers tolerance to 2,4-D. However, tolerance in each of these crops by the *aad-1* or *aad-12* genes or with alternative genes providing additional or alternative tolerance to transgenic crops [*e.g.*, *aad-13* (U.S. Patent 8,278,505 B2), *tfdA* (U.S. Patent 6,153,401 A), or *24dt02* (CN103060279)] is considered to be included within the scope of the 2,4-D and glufosinate-tolerant soybeans, corn, or cotton described herein.

As used herein, glyphosate tolerance refers to soybeans, corn, or cotton that is genetically modified to be tolerant to glyphosate. Glyphosate tolerance can be provided, for example, by the *CP4* gene (U.S. Patent 5,627,061 A) or *2mEPSPS* (U.S. Patent 6,566,587 B1) as shown herein; however, glyphosate tolerance could also be conferred within the scope of glyphosate-, 2,4-D-, and glufosinate-tolerant-soybeans, corn, or cotton described herein by other genes providing transgenic crop tolerance to glyphosate [*e.g.*, *AroA* and other Class II EPSPS (U.S. Patent 7,893,234 B2); *GLG23* and other Class III EPSPS (U.S. Patent 7,700,842

B2); *GAT* (U.S. Patent 7,405,074 B2), *Gox* (U.S. Patent 5,463,175 A), or other glyphosate-metabolism gene; or *DGT-28* or other Class IV EPSPS (U.S. Patent Application Publication 20130217577A1)] and are considered to be included within the scope of the 2,4-D-, glyphosate- and glufosinate-tolerant soybeans, corn, or cotton described herein.

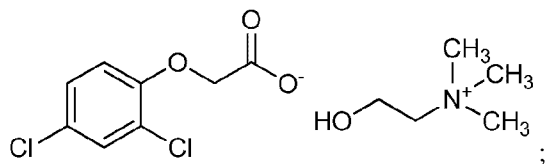
5 As used herein, glufosinate tolerance refers to soybeans, corn, or cotton that is genetically modified to be tolerant to glufosinate. Glufosinate tolerance can be provided, for example, by the *pat* gene (U.S. Patent 5,587,903 A) as shown herein; however, glufosinate tolerance could also be conferred within the scope of the 2,4-D- and glufosinate-tolerant soybeans, corn, or cotton described herein by other genes providing transgenic crop tolerance
10 to glufosinate [*e.g.*, *bar* (U.S. Patent 5,561,236 A) and *dsm2* (PCT International Application WO2008070845)].

II. Compositions

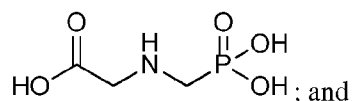
A. Synergistic combinations

15 Provided herein are herbicidal compositions containing a mixture containing synergistic, herbicidally effective amounts of:

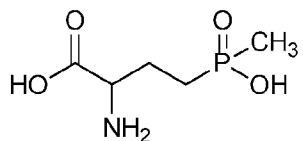
(a) a choline salt of 2,4-dichlorophenoxyacetic acid (2,4-D-choline),



(b) a salt of *N*-(phosphonomethyl)glycine (glyphosate),



20 (c) a salt of 2-amino-4-(hydroxymethylphosphinyl)butanoic acid (glufosinate),



Agriculturally acceptable salts of glyphosate are anticipated to control undesirable vegetation in combination with 2,4-D-choline and a salt of glufosinate. Examples of such agriculturally acceptable salts of glyphosate include, but are not limited to, glyphosate potassium, glyphosate isopropylamine (IPA) salt, glyphosate monoethanolamine (MEA) salt, 5 glyphosate monomethylamine (MMA) salt, and glyphosate dimethylamine (DMA) salt.

Agriculturally acceptable salts of glufosinate are anticipated to control undesirable vegetation in combination with 2,4-D-choline and a salt of glyphosate. An example of such an agriculturally acceptable salt of glufosinate includes glufosinate-ammonium.

Furthermore, in some embodiments, the combination of 2,4-D-choline, a salt of 10 glyphosate, and a salt of glufosinate exhibit synergism, *e.g.*, the herbicidal active ingredients are more effective in combination than when applied individually. Synergism has been defined as “an interaction of two or more factors such that the effect when combined is greater than the predicted effect based on the response of each factor applied separately.” Shaner, D. L., Ed. *Herbicide Handbook*, 10th ed. Lawrence: Weed Science Society of 15 America, 2014. In certain embodiments, the compositions exhibit synergy as determined by the Colby equation (Colby, S. R. Calculation of the synergistic and antagonistic response of herbicide combinations. *Weeds* **1967**, *15*, 20-22).

Additionally, in some embodiments, the combination of 2,4-D-choline, a salt of 20 glyphosate and a salt of glufosinate improves crop tolerance in 2,4-D-, glyphosate- and glufosinate-tolerant soybeans, corn and cotton.

Herbicidal activity is exhibited by the compounds when they are applied pre- and post-emergence directly to the plant or to the locus of the plant at any stage of growth. The effect observed depends upon the plant species to be controlled, the stage of growth of the plant, the application parameters of dilution and spray drop size, the particle size of solid 25 components, the environmental conditions at the time of use, the specific compound employed, the specific adjuvants and carriers employed, the soil type, the amount of chemical applied, and the combinations thereof. These and other factors can be adjusted to promote non-selective or selective herbicidal action. In some embodiments, the compositions described herein are applied as a post-emergence application, to relatively immature and 30 mature undesirable vegetation to achieve the maximum control of weeds.

In some embodiments, 2,4-D-choline, a salt of glyphosate, and a salt of glufosinate are used in combination with herbicides that are selective for the soybeans, corn or cotton being treated and which complement the spectrum of weeds controlled by these compounds at the application rate employed. In some embodiments, the compositions described herein
5 and other complementary herbicides are applied at the same time, either as a combination formulation or as a tank mix, at the same time or as sequential applications.

The present compositions can be applied to weeds or their locus thereof, including but not limited to, foliage or soil, by the use of conventional ground or aerial dusters, sprayers, and granule applicators, and by other conventional means known to those skilled in the art.

10 In some embodiments, the concentration of the active ingredients in the compositions described herein is from about 0.0005 to 98 percent by weight. In some embodiments, the concentration is from about 0.0006 to 90 percent by weight. In compositions designed to be employed as concentrates, the active ingredients, in certain embodiments, are present in a concentration from about 0.1 to 98 weight percent, and in certain embodiments about 0.5 to
15 90 weight percent. Such compositions are, in certain embodiments, diluted with an inert carrier, such as water, before application. The diluted compositions usually applied to weeds or the locus of weeds contain, in certain embodiments, about 0.005 to 99 weight percent active ingredient and in certain embodiments contain about 0.01 to 25.0 weight percent.

In certain embodiments of the compositions and methods described herein, 2,4-D-
20 choline plus a salt of glyphosate is used in combination with a salt of glufosinate. With regard to the compositions, in some embodiments, the weight ratio of 2,4-D-choline plus a salt of glyphosate to a salt of glufosinate is within the range from about 1:100 to about 100:1, from about 1:90 to about 90:1, from about 1:80 to about 80:1, from about 1:70 to about 70:1, from about 1:60 to about 60:1, from about 1:50 to about 50:1, from about 1:40 to about 40:1,
25 from about 1:30 to about 30:1, from about 1:25 to about 25:1, from about 1:20 to about 20:1, from about 1:18 to about 18:1, from about 1:15 to about 15:1, from about 1:13 to about 13:1, from about 1:12 to about 12:1, from about 1:11 to about 11:1, from about 1:10 to about 10:1, from about 1:9 to about 9:1, from about 1:8 to about 8:1, from about 1:7 to about 7:1, from about 1:6 to about 6:1, from about 1:5 to about 5:1, from about 1:4 to about 4:1, from about
30 1:3 to about 3:1, from about 1:2 to about 2:1, from about 1.75:1 to about 7:1, from about 1.5:1 to about 8:1, from about 1.25:1 to about 9:1 and from about 2:1 to about 6:1. In certain

embodiments, the weight ratio of 2,4-D-choline plus a salt of glyphosate to a salt of glufosinate is within the range from about 2:1 to about 8:1, from about 2.5:1 to about 6:1 and from about 2.75:1 to about 5:1. In other embodiments, the weight ratio of 2,4-D-choline plus a salt of glyphosate to a salt of glufosinate is within the range from about 3:1 to about 4:1.

5 In certain embodiments of the compositions and methods described herein, the combination of herbicidally active ingredients consists of (a) 2,4-D-choline, (b) a salt of glyphosate, and (c) a salt of glufosinate and the three components are used in amounts such that the weight ratio of (a) to (b) to (c) is from about 1–10 of (a) to about 1–10 of (b) to about 1–5 of (c). In additional embodiments, the weight ratios of the three components include
10 from about 1–5 of (a) to about 1–5 of (b) to about 1–5 of (c); from about 1–5 of (a) to about 1–5 of (b) to about 1–2 of (c); from about 2–5 of (a) to about 2–5 of (b) to about 1–2 of (c); from about 1–5 of (a) to about 1–5 of (b) to about 1 of (c); from about 1–4 of (a) to about 1–4 of (b) to about 1 of (c); from about 1–3 of (a) to about 1–3 of (b) to about 1 of (c); and from about 1–2 of (a) to about 1–2 of (b) to about 1 of (c). Stated another way, the weight ratio of
15 (a):(b):(c) can be from about 0.5:0.5:1 to about 10:10:1. Further examples of weight ratios of (a):(b):(c) include from about 0.5:0.5:1 to about 5:5:1; from about 0.6:0.6:1 to about 5:5:1; from about 0.7:0.7:1 to about 5:5:1; from about 0.7:0.7:1 to about 4:4:1; from about 0.8:0.8:1 to about 4:4:1; from about 0.9:0.9:1 to about 4:4:1; from about 1:1:1 to about 4:4:1; from about 1:1:1 to about 3:3:1; from about 0.5:0.5:1 to about 7:7:1; from about 1.25:1.25:1 to
20 about 4:4:1; from about 1.6:1.6:1 to about 2:2:1; from about 1:1:1 to about 2:2:1; about 1:1:1; about 2:2:1; about 2.5:2.5:1; about 3:3:1; about 3.5:3.5:1; about 4:4:1; about 4.5:4.5:1; about 5:5:1; about 5.5:5.5:1; about 6:6:1; about 7:7:1; about 8:8:1; about 9:9:1; and about 10:10:1.

With respect to the methods, in certain embodiments, the methods comprise contacting the undesirable vegetation with a composition described herein, *e.g.*, sequentially
25 or simultaneously. In some embodiments, the composition is applied at an application rate from about 500 grams acid equivalent per hectare (g ae/ha) to about 12,200 g ae/ha based on the total amount of active ingredients in the composition. In certain embodiments, the composition is applied at an application rate from about 760 g ae/ha to about 8,220 g ae/ha based on the total amount of active ingredients in the composition. In certain embodiments,
30 the composition is applied at an application rate from about 840 g ae/ha to about 6,000 g ae/ha based on the total amount of active ingredients in the composition. In certain

embodiments, the composition is applied at an application rate from about 2,182 g ae/ha to about 5,454 g ae/ha based on the total amount of active ingredients in the composition.

The components of the mixtures described herein can be applied either separately, sequentially, tank-mixed or as part of a multipart herbicidal system. In some embodiments, all three components may be formulated together (e.g., in the same formulation) or separately (e.g., in separate formulations) and applied simultaneously. Alternatively, two of the three components can be formulated together (e.g., glyphosate and 2,4-D) and the third component formulated separately and the two formulations applied simultaneously. In another embodiment, one or more components may be formulated separately and the components applied sequentially. For example, each component can be formulated separately and the three components applied sequentially. Alternatively, two of the three components can be formulated together (e.g., glyphosate and 2,4-D) and the third component formulated separately and the two formulations applied sequentially. The time period between applications can vary, for example 1, 2, 4, 6, 8, 10, or 12 hours or longer or 1, 2, 3, 4, 5, 6, or 7 days or longer.

In one embodiment, the compositions exhibit synergy against a variety of weed types. In one embodiment, the combination of 2,4-D-choline plus a salt of glyphosate to a salt of glufosinate in a ratio of about 1:1 to about 4:1 exhibits greater than about 5, 6, 7, 8, 9, 10, 11, 13, 15, 18, 20, 21, 22, 23, 24, 25, 30 or 35% control compared to the Colby predicted value at 7–28 days after application (DAA).

In another embodiment, the compositions exhibit synergy in reducing crop injury. In one embodiment, the combination of 2,4-D-choline plus a salt of glyphosate to a salt of glufosinate in a ratio of about 1:1 to about 4:1 exhibits reductions of about 5, 6, 7, 8, 9, 10, 11, 13, 15, 18, 20, 21, 22, 23, 24, 25, 30, 35, 40, 45 or 48% crop injury compared to the Colby predicted value at 1–16 days after application (DAA).

In another embodiment, the compositions exhibit synergy as defined by the efficacy values defined above against a variety of weed types or crops, including but not limited to, *Amaranthus palmeri* (Palmer pigweed, AMAPA), *Ambrosia trifida* L. (giant ragweed, AMBTR), *Conyza canadensis* (horseweed, ERICA), and *Salsola tragus* L. (Russian thistle, SASKR).

In another embodiment, the compositions can be used to control glyphosate-tolerant soybeans (GLXMA) and other crops that have single site tolerance to, including but not limited to, glyphosate, acetolactate synthase (ALS) and other herbicide modes-of-action.

B. Other actives

5 The mixtures described herein can be applied in conjunction with one or more other herbicides to control a wider variety of undesirable vegetation. When used in conjunction with other herbicides, the composition can be formulated with the other herbicide or herbicides, tank-mixed with the other herbicide or herbicides or applied sequentially with the other herbicide or herbicides. Some of the herbicides that can be employed in conjunction with the compositions and methods described herein include, but are not limited to acid, salt and ester forms of the following herbicides: 4-CPA, 4-CPB, 4-CPP, 3,4-DA, 2,4-DB, 3,4-DB, 3,4-DP, 2,3,6-TBA, 2,4,5-T, 2,4,5-TB, acetochlor, acifluorfen, acetonif, acrolein, alachlor, allidochlor, alloxym, allyl alcohol, alorac, ametrifone, ametryn, amibuzin, amicarbazone, amidosulfuron, aminocyclopyrachlor, aminopyralid, amiprofos-methyl, 15 amitrrole, ammonium sulfamate, anilofos, anisuron, asulam, atraton, atrazine, azafenidin, azimsulfuron, aziprotryne, barban, BCPC, beflubutamid, benazolin, bencarbazone, benfluralin, benfuresate, bensulfuron-methyl, bensulide, bentazon, benthioncarb, benzadox, benzfendazole, benzipram, benzobicyclon, benzofenap, benzofluor, benzoylprop, benzthiazuron, bicyclopiron, bifeno, bilanafos, bispyribac-sodium, borax, bromacil, 20 bromobonil, bromobutide, bromofenoxim, bromoxynil, brompyrazon, butachlor, butafenacil, butamifos, butenachlor, buthidazole, buthiuron, butralin, butoxydim, buturon, butylate, cacodylic acid, cafenstrole, calcium chlorate, calcium cyanamide, cambendichlor, carbasulam, carbetamide, carboxazole, chlorprocarb, carfentrazone (e.g., carfentrazone-ethyl), CDEA, CEPC, chlomethoxyfen, chloramben, chloranocryl, chlorazifop, chlorazine, 25 chlorbromuron, chlorbufam, chloreturon, chlorfenac, chlorfenprop, chlorflurazole, chlorflurenol, chloridazon, chlorimuron, chlornitrofen, chloropon, chlorotoluron, chloroxuron, chloroxynil, chlorpropham, chlorsulfuron, chlorthal, chlorthiamid, cinidon (e.g., cinidon-ethyl), cinmethylin, cinosulfuron, cisanilide, clethodim, clodinate, clodinafop-propargyl, clofop, clomazone, clomeprop, cloprop, cloproxydim, clopyralid, cloransulam-methyl, CMA, copper sulfate, CPMF, CPPC, credazine, cresol, cumyluron, cyanatryl, 30 cyanazine, cycloate, cyclopyrimorate, cyclosulfamuron, cycloxydim, cycluron, cyhalofop (e.g., 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,

5 dimidazon, dinitramine, dinofenate, dinoprop, dinosam, dinoseb, dinoterb, diphenamid, dipropetryn, diquat, disul, dithiopyr, diuron, DMPA, DNOC, DSMA, EBEP, eglinazine, endothal, epronaz, EPTC, erbon, esprocarb, ethbenzamide, ethalfuralin, ethametsulfuron, ethidimuron, ethiolate, ethobenzamid, etobenzamid, ethofumesate, ethoxyfen, ethoxysulfuron, etinofen, etnipromid, etobenzanid, EXD, fenasulam, fenoprop, fenoxaprop

10 (e.g., fenoxaprop-P-ethyl), fenoxaprop-P-ethyl + isoxadifen-ethyl, fenoxasulfone, fenquinotriene, fenteracol, fenthiafrop, fentrazamide, fenuron, ferrous sulfate, flamprop, flamprop-M, flazasulfuron, florasulam, fluazifop (e.g., fluazifop-P-butyl), fluzolate, flucarbazone, flucetosulfuron, fluchloralin, flufenacet, flufenican, flufenpyr (e.g., flufenpyr-ethyl), flumetsulam, flumezin, flumiclorac (e.g., flumiclorac-pentyl), flumioxazin,

15 flumipropyn, fluometuron, fluorodifen, fluoroglycofen, fluoromidine, fluoronitrofen, fluothiuron, flupoxam, flupropacil, flupropanate, flupyrsulfuron, fluridone, flurochloridone, fluroxypyr, flurtamone, fluthiacet, fomesafen, foramsulfuron, fosamine, fumiclorac, furyloxyfen, halauxifen, halosafen, halosulfuron (e.g., halosulfuron-methyl), haloxydine, haloxyfop-methyl, haloxyfop-P (e.g., haloxyfop-P-methyl), hexachloroacetone, hexaflurate,

20 hexazinone, imazamethabenz, imazamox, imazapic, imazapyr, imazaquin, 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,

25 MAMA, MCPA esters and amines, MCPA-thioethyl, MCPB, mecoprop, mecoprop-P, medinoterb, mefenacet, mefluidide, mesoprazine, mesosulfuron, mesotriene, metam, metamifop, metamitron, metazachlor, metazosulfuron, metflurazon, methabenzthiazuron, methalpropalin, methazole, methiobencarb, methiozolin, methiuron, methometon, methoprotryne, methyl bromide, methyl isothiocyanate, methyl dymron, metobenzuron,

30 metobromuron, metolachlor, metosulam, metoxuron, metribuzin, metsulfuron, metsulfuron-methyl, molinate, monalide, monisouron, monochloroacetic acid, monolinuron, monuron, morfamquat, MSMA, naproanilide, napropamide, napropamide-M, naptalam, neburon, nicosulfuron, nipyraclufen, nitralin, nitrofen, nitrofluorfen, norflurazon, noruron, OCH,

orbencarb, *ortho*-dichlorobenzene, orthosulfamuron, oryzalin, oxadiargyl, oxadiazon, oxapyrazon, oxasulfuron, oxaziclomefone, oxyfluorfen, paraflufen-ethyl, parafluron, paraquat, pebulate, pelargonic acid, pendimethalin, penoxsulam, pentachlorophenol, pentanochlor, pentoxazone, perfluidone, pethoxamid, phenisopham, phenmedipham (e.g.,
5 phenmedipham-ethyl), phenobenzuron, phenylmercury acetate, picloram, picolinafen, pinoxaden, piperophos, potassium arsenite, potassium azide, potassium cyanate, pretilachlor, primisulfuron (e.g., primisulfuron-methyl), procyazine, prodiamine, profluzol, profluralin, profoxydim, proglinazine, prohexadione-calcium, prometon, prometryn, propachlor, propanil, propaquizafoxop, propazine, propham, propisochlor, propoxycarbazone, propyrisulfuron,
10 propyzamide, prosulfalin, prosulfocarb, prosulfuron, proxan, prynachlor, pydanon, pyraclonil, pyraflufen (e.g., pyraflufen-ethyl), pyrasulfotole, pyrazogyl, pyrazolynate, pyrazosulfuron-ethyl, pyrazoxyfen, pyribenzoxim, pyributicarb, pyriclor, pyridafof, pyridate, pyrifitalid, pyriminobac, pyrimisulfan, pyriithiobac-sodium, pyroxasulfone, pyroxsulam, quinclorac, quinmerac, quincloamine, quinonamid, quizalofop, quizalofop-P-ethyl,
15 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, terbutryn,
20 tetrafluron, thenylchlor, thiazafluron, thiazopyr, thidiazimin, thidiazuron, thiencarbazone-methyl, thifensulfuron, thifensulfuron-methyl, thiobencarb, tiafenacil, tiocarbazil, tioclorim, topramezone, tralkoxydim, triafamone, tri-allate, triasulfuron, triaziflam, tribenuron (e.g., tribenuron-methyl), tricamba, triclopyr (e.g., triclopyr choline salt), triclopyr esters and salts, tridiphane, trietazine, trifloxysulfuron, trifluralin, triflusulfuron, trifop, trifopsime,
25 trihydroxytriazine, trimeturon, tripropindan, tritac tritosulfuron, vernolate, xylachlor, benzyl 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylate and salts, choline salts, esters, optically active isomers and mixtures thereof.

C. Safeners

In some embodiments, the compositions described herein are employed in
30 combination with one or more herbicide safeners, such as AD-67 (MON 4660), benoxacor, benthioicarb, brassinolide, cloquintocet (mexyl), cyometrinil, daimuron, dichlormid, dicyclonon, dimepiperate, disulfoton, fenclorazole-ethyl, fenclorim, flurazole, fluxofenim,

furilazole, harpin proteins, isoxadifen-ethyl, jiecaowan, jiecaoxi, mefenpyr-diethyl, mephenate, naphthalic anhydride (NA), oxabetrinil, R29148 and *N*-phenyl-sulfonylbenzoic acid amides, to enhance their selectivity. In some embodiments, the safeners are employed in rice, cereal, corn, or maize settings. In some embodiments, the safener is cloquintocet or an ester or salt thereof. In certain embodiments, cloquintocet is utilized to antagonize harmful effects of the compositions on rice and cereals. In some embodiments, the safener is cloquintocet (mexyl).

D. Adjuvants/Carriers

In some embodiments, compositions provided herein further comprise at least one agriculturally acceptable adjuvant or carrier. Suitable adjuvants or carriers should not be phytotoxic to valuable crops, particularly at the concentrations employed in applying the compositions for selective weed control in the presence of crops, and should not react chemically with herbicidal components or other composition ingredients. Such mixtures can be designed for application directly to weeds or their locus or can be concentrates or formulations that are normally diluted with additional carriers and adjuvants before application. They can be solids, such as, for example, dusts, granules, water-dispersible granules, microcapsules or wettable powders, or liquids, such as, for example, emulsifiable concentrates, solutions, emulsions or suspensions. They can also be provided as a pre-mix or tank mixed.

Suitable agricultural adjuvants and carriers include, but are not limited to, crop oil concentrate; nonylphenol ethoxylate; benzylcocoalkyldimethyl quaternary ammonium salt; blend of petroleum hydrocarbon, alkyl esters, organic acid, and anionic surfactant; C₉-C₁₁ alkylpolyglycoside; phosphated alcohol ethoxylate; natural primary alcohol (C₁₂-C₁₆) ethoxylate; di-*sec*-butylphenol EO-PO block copolymer; polysiloxane-methyl cap; nonylphenol ethoxylate + urea ammonium nitrate; emulsified methylated seed oil; tridecyl alcohol (synthetic) ethoxylate (8EO); tallow amine ethoxylate (15 EO); PEG(400) dioleate-99.

Liquid carriers that can be employed include water and organic solvents. The organic solvents include, but are not limited to, petroleum fractions or hydrocarbons such as mineral oil, aromatic solvents, paraffinic oils, and the like; vegetable oils such as soybean oil, rapeseed oil, olive oil, castor oil, sunflower seed oil, coconut oil, corn oil, cottonseed oil,

linseed oil, palm oil, peanut oil, safflower oil, sesame oil, tung oil and the like; esters of the above vegetable oils; esters of monoalcohols or dihydric, trihydric, or other lower polyalcohols (4-6 hydroxy containing), such as 2-ethyl hexyl stearate, *n*-butyl oleate, isopropyl myristate, propylene glycol dioleate, di-octyl succinate, di-butyl adipate, di-octyl
5 phthalate and the like; esters of mono, di and polycarboxylic acids and the like. Specific organic solvents include, but are not limited to toluene, xylene, petroleum naphtha, crop oil, acetone, methyl ethyl ketone, cyclohexanone, trichloroethylene, perchloroethylene, ethyl acetate, amyl acetate, butyl acetate, propylene glycol monomethyl ether and diethylene glycol monomethyl ether, methyl alcohol, ethyl alcohol, isopropyl alcohol, amyl alcohol, ethylene
10 glycol, propylene glycol, glycerine, *N*-methyl-2-pyrrolidinone, *N,N*-dimethyl alkylamides, dimethyl sulfoxide, liquid fertilizers and the like. In certain embodiments, water is the carrier for the dilution of concentrates.

Suitable solid carriers include but are not limited to talc, pyrophyllite clay, silica, attapulgus clay, kaolin clay, kieselguhr, chalk, diatomaceous earth, lime, calcium carbonate,
15 bentonite clay, Fuller's earth, cottonseed hulls, wheat flour, soybean flour, pumice, wood flour, walnut shell flour, lignin, cellulose, and the like.

In some embodiments, the compositions described herein further comprise one or more surface-active agents. In some embodiments, such surface-active agents are employed in both solid and liquid compositions, and in certain embodiments those designed to be
20 diluted with carrier before application. The surface-active agents can be anionic, cationic or nonionic in character and can be employed as emulsifying agents, wetting agents, suspending agents, or for other purposes. Surfactants which may also be used in the present formulations are described, *inter alia*, in *McCutcheon's Detergents and Emulsifiers Annual*, MC Publishing Corporation: Ridgewood, NJ, 1998 and in *Encyclopedia of Surfactants, Vol. I-III*,
25 Chemical Publishing Company: New York, 1980-81. Surface-active agents include, but are not limited to salts of alkyl sulfates, such as diethanolammonium lauryl sulfate; alkylarylsulfonate salts, such as calcium dodecylbenzenesulfonate; alkylphenol-alkylene oxide addition products, such as nonylphenol-C₁₈ ethoxylate; alcohol-alkylene oxide addition products, such as tridecyl alcohol-C₁₆ ethoxylate; soaps, such as sodium stearate; alkyl-
30 naphthalene-sulfonate salts, such as sodium dibutyl-naphthalenesulfonate; dialkyl esters of sulfosuccinate salts, such as sodium di(2-ethylhexyl) sulfosuccinate; sorbitol esters, such as sorbitol oleate; quaternary amines, such as lauryl trimethylammonium chloride; polyethylene

glycol esters of fatty acids, such as polyethylene glycol stearate; block copolymers of ethylene oxide and propylene oxide; salts of mono and dialkyl phosphate esters; vegetable or seed oils such as soybean oil, rapeseed/canola oil, olive oil, castor oil, sunflower seed oil, coconut oil, corn oil, cottonseed oil, linseed oil, palm oil, peanut oil, safflower oil, sesame oil, tung oil and the like; and esters of the above vegetable oils, and in certain embodiments, methyl esters.

In some embodiments, these materials, such as vegetable or seed oils and their esters, can be used interchangeably as an agricultural adjuvant, as a liquid carrier or as a surface active agent.

Other exemplary additives for use in the compositions provided herein include but are not limited to compatibilizing agents, antifoam agents, sequestering agents, neutralizing agents and buffers, corrosion inhibitors, dyes, odorants, spreading agents, penetration aids, sticking agents, dispersing agents, thickening agents, freezing point depressants, antimicrobial agents, and the like. The compositions may also contain other compatible components, for example, other herbicides, plant growth regulants, fungicides, insecticides, and the like and can be formulated with liquid fertilizers or solid, particulate fertilizer carriers such as ammonium nitrate, urea and the like.

III. Methods of use

Methods of controlling undesirable vegetation in 2,4-D-, glyphosate- and glufosinate-tolerant soybeans, corn, or cotton, comprising contacting the vegetation or the locus thereof, including but not limited to foliage, soil or water, with a composition containing a mixture containing synergistic herbicidally effective amounts of (a) 2,4-D-choline, (b) a salt of glyphosate, and (c) a salt of glufosinate. In certain embodiments, the methods employ the compositions described herein.

In another embodiment, methods of controlling undesirable vegetation in non-crop, perennial crop, fruiting crop, or plantation crop areas, comprising contacting undesirable vegetation or the locus thereof, including but not limited to foliage, soil or water, with a composition containing a mixture containing synergistic herbicidally effective amounts of (a) 2,4-D-choline, (b) a salt of glyphosate, and (c) a salt of glufosinate are described herein. In certain embodiments, the methods employ the compositions described herein.

Agriculturally acceptable salts of glyphosate are anticipated to control undesirable vegetation in combination with 2,4-D-choline and a salt of glufosinate. Examples of such agriculturally acceptable salts of glyphosate include, but are not limited to, glyphosate potassium, glyphosate isopropylamine (IPA) salt, glyphosate monoethanolamine (MEA) salt, 5 glyphosate monomethylamine (MMA) salt, and glyphosate dimethylamine (DMA) salt.

Agriculturally acceptable salts of glufosinate are anticipated to control undesirable vegetation in combination with 2,4-D-choline and a salt of glyphosate. An example of such an agriculturally acceptable salt of glufosinate includes glufosinate-ammonium.

The compositions and methods provided herein are utilized to control undesirable 10 vegetation. Undesirable vegetation includes, but is not limited to, undesirable vegetation that occurs in 2,4-D-, glyphosate- and glufosinate-tolerant soybeans, corn, or cotton; non-crop areas, including but not limited to pastures, grasslands, rangelands, fallowland, fencerows, parking areas, tank farms, storage areas, rights-of-way, utility areas, turf, forestry, aquatics, industrial vegetation management (IVM) and fallow-bed prior to planting crops; perennial 15 crops where the application contacts the undesirable vegetation but does not contact the crop foliage, such as tree and vine orchards, including but not limited to citrus, grapes, almond, apple, apricot, avocado, beechnut, Brazil nut, butternut, cashew, cherry, chestnut, chinquapin, crab apple, date, feijoa, fig, filbert, hickory nut, kiwi, lemon, lime, loquat, macadamia nut, mandarin, mayhaw, nectarine, olive, oranges, peach, pear, pecan, persimmon, pistachio, 20 plum, pome fruit, pomegranate, prune, quince, stone fruit, tree nuts and walnut; fruiting crops (e.g., blueberries, guava, papaya, strawberries, taro, blackberries and raspberries); and plantation crops (including, but not limited to, coffee, cacao, rubber and palm oil).

The compositions and methods provided herein are utilized to control undesirable 25 vegetation. Undesirable vegetation includes, but is not limited to, undesirable vegetation that occurs in annual crops such as 2,4-D-, glyphosate- and glufosinate-tolerant cereal crops, including but not limited to rice, wheat, barley, oats, rye and sorghum.

In some embodiments, the methods provided herein are utilized to control undesirable vegetation found in row crops, tree and vine crops, perennial crops and non-crop. In certain 30 embodiments, the undesirable vegetation is *Alopecurus myosuroides* Huds. (blackgrass, ALOMY), *Amaranthus palmeri* S. Wats. (Palmer amaranth, AMAPA), *Avena fatua* L. (wild oat, AVEFA), *Brachiaria decumbens* Stapf. or *Urochloa decumbens* (Stapf) R.D. Webster

- (Surinam grass, BRADC), *Brachiaria brizantha* (Hochst. ex A. Rich.) Stapf. or *Urochloa brizantha* (Hochst. ex A. Rich.) R.D. (beard grass, BRABR), *Brachiaria platyphylla* (Groseb.) Nash or *Urochloa platyphylla* (Nash) R.D. Webster (broadleaf signalgrass, BRAPP), *Brachiaria plantaginea* (Link) Hitchc. or *Urochloa plantaginea* (Link) R.D. Webster (alexandergrass, BRAPL), *Cenchrus echinatus* L. (southern sandbur, CENEC), *Digitaria horizontalis* Willd. (Jamaican crabgrass, DIGHO), *Digitaria insularis* (L.) Mez ex Ekman (sourgrass, TRCIN), *Digitaria sanguinalis* (L.) Scop. (large crabgrass, DIGSA), *Echinochloa crus-galli* (L.) P. Beauv. (barnyardgrass, ECHCG), *Echinochloa colonum* (L.) Link (junglerice, ECHCO), *Eleusine indica* (L.) Gaertn. (goosegrass, ELEIN), *Lolium multiflorum* Lam. (Italian ryegrass, LOLMU), *Panicum dichotomiflorum* Michx. (fall panicum, PANDI), *Panicum miliaceum* L. (wild-proso millet, PANMI), *Sesbania exaltata* (Raf.) Cory/Rydb. Ex Hill (hemp sesbania, SEBEX), *Setaria faberi* Herrm. (giant foxtail, SETFA), *Setaria viridis* (L.) Beauv. (green foxtail, SETVI), *Sorghum halepense* (L.) Pers. (Johnsongrass, SORHA), *Sorghum bicolor* (L.) Moench ssp. *Arundinaceum* (shattercane, SORVU), *Cyperus esculentus* L. (yellow nutsedge, CYPES), *Cyperus rotundus* L. (purple nutsedge, CYPRO), *Abutilon theophrasti* Medik. (velvetleaf, ABUTH), *Amaranthus* species (pigweeds and amaranths, AMASS), *Ambrosia artemisiifolia* L. (common ragweed, AMBEL), *Ambrosia psilostachya* DC. (western ragweed, AMBPS), *Ambrosia trifida* L. (giant ragweed, AMBTR), *Anoda cristata* (L.) Schlecht. (spurred anoda, ANVCR), *Asclepias syriaca* L. (common milkweed, ASCSY), *Bidens pilosa* L. (hairy beggarticks, BIDPI), *Borreria* species (BOISS), *Borreria alata* (Aubl.) DC., *Spermacoce alata* Aubl. or *Spermacoce latifolia* (broadleaf buttonweed, BOILF), *Chenopodium album* L. (common lambsquarters, CHEAL), *Cirsium arvense* (L.) Scop. (Canada thistle, CIRAR), *Commelina benghalensis* L. (tropical spiderwort, COMBE), *Datura stramonium* L. (jimsonweed, DATST), *Daucus carota* L. (wild carrot, DAUCA), *Euphorbia heterophylla* L. (wild poinsettia, EPHHL), *Euphorbia hirta* L. or *Chamaesyce hirta* (L.) Millsp. (garden spurge, EPHHL), *Euphorbia dentata* Michx. (toothed spurge, EPHDE), *Erigeron bonariensis* L. or *Conyza bonariensis* (L.) Cronq. (hairy fleabane, ERIBO), *Erigeron canadensis* L. or *Conyza canadensis* (L.) Cronq. (horseweed, ERICA), *Conyza sumatrensis* (Retz.) E. H. Walker (tall fleabane, ERIFL), *Helianthus annuus* L. (common sunflower, HELAN), *Jacquemontia tamnifolia* (L.) Griseb. (smallflower morningglory, IAQTA), *Ipomoea hederacea* (L.) Jacq. (ivyleaf morningglory, IPOHE), *Ipomoea lacunosa* L. (white morningglory, IPOLA), *Lactuca serriola* L./Torn. (prickly lettuce, LACSE), *Portulaca oleracea* L. (common

5 purslane, POROL), *Richardia* species (pusley, RCHSS), *Salsola tragus* L. (Russian thistle, SASKR), *Sida* species (sida, SIDSS), *Sida spinosa* L. (prickly sida, SIDSP), *Sinapis arvensis* L. (wild mustard, SINAR), *Solanum ptychanthum* Dunal (eastern black nightshade, SOLPT), *Tridax procumbens* L. (coat buttons, TRQPR), or *Xanthium strumarium* L. (common
5 cocklebur, XANST).

In some embodiments, the methods provided herein are utilized to control undesirable vegetation in range and pasture. In certain embodiments, the undesirable vegetation is *Amaranthus palmeri* S. Wats. (Palmer amaranth, AMAPA), *Ambrosia artemisiifolia* L. (common ragweed, AMBEL), *Ambrosia trifida* L. (giant ragweed, AMBTR), *Cassia*
10 *obtusifolia* (sickle pod, CASOB), *Centaurea maculosa* auct. non Lam. (spotted knapweed, CENMA), *Cirsium arvense* (L.) Scop. (Canada thistle, CIRAR), *Convolvulus arvensis* L. (field bindweed, CONAR), *Conyza canadensis* (L.) Cronq. (horseweed, ERICA), *Euphorbia esula* L. (leafy spurge, EPHES), *Lactuca serriola* L./Torn. (prickly lettuce, LACSE), *Plantago lanceolata* L. (buckhorn plantain, PLALA), *Rumex obtusifolius* L. (broadleaf dock,
15 RUMOB), *Salsola tragus* L. (Russian thistle, SASKR), *Sesbania exaltata* (Raf.) Cory/Rydb. Ex Hill (hemp sesbania, SEBEX), *Sida spinosa* L. (prickly sida, SIDSP), *Sinapis arvensis* L. (wild mustard, SINAR), *Sonchus arvensis* L. (perennial sowthistle, SONAR), *Solidago* species (goldenrod, SOOSS), *Taraxacum officinale* G.H. Weber ex Wiggers (dandelion, TAROF), *Trifolium repens* L. (white clover, TRFRE), or *Urtica dioica* L. (common nettle,
20 URTDI).

In some embodiments, the combination 2,4-D-choline plus a salt of glyphosate and a salt of glufosinate are used to synergistically control *Amaranthus palmeri* S. Wats. (Palmer amaranth, AMAPA), *Ambrosia trifida* L. (giant ragweed, AMBTR), *Conyza canadensis* (L.) Cronq. (horseweed, ERICA) and *Salsola tragus* L. (Russian thistle, SASKR).

25 2,4-D-choline, a salt of glyphosate, and a salt of glufosinate may be used to control herbicide resistant or tolerant weeds. The methods employing the combination of 2,4-D-choline, a salt of glyphosate, and a salt of glufosinate and the compositions described herein may also be employed to control herbicide resistant or tolerant weeds. Exemplary resistant or tolerant weeds include, but are not limited to, biotypes resistant or tolerant to acetolactate
30 synthase (ALS) or acetohydroxy acid synthase (AHAS) inhibitors (e.g., imidazolinones, sulfonyleureas, pyrimidinylthiobenzoates, dimethoxy-pyrimidines, triazolopyrimidine

sulfonamides, sulfonylaminocarbonyltriazolinones), photosystem II inhibitors (e.g., phenylcarbamates, pyridazinones, triazines, triazinones, uracils, amides, ureas, benzothiadiazinones, nitriles, phenylpyridazines), acetyl CoA carboxylase (ACCase) inhibitors (e.g., aryloxyphenoxy-propionates, cyclohexanediones, phenylpyrazolines),

5 synthetic auxins (e.g., benzoic acids, phenoxy-carboxylic acids, pyridine carboxylic acids, quinoline carboxylic acids), auxin transport inhibitors (e.g., phthalamates, semicarbazones), photosystem I inhibitors (e.g., bipyridyliums), 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase inhibitors (e.g., glyphosate), glutamine synthetase inhibitors (e.g., glufosinate, bialafos), microtubule assembly inhibitors (e.g., benzamides, benzoic acids, dinitroanilines,

10 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,

15 pyrimidinediones, thiadiazoles, triazolinones), carotenoid biosynthesis inhibitors (e.g., clomazone, amitrole, acetonifene), phytoene desaturase (PDS) inhibitors (e.g., amides, anilidex, furanones, phenoxybutan-amides, pyridiazinones, pyridines), 4-hydroxyphenyl-pyruvate-dioxygenase (HPPD) inhibitors (e.g., callistemonones, isoxazoles, pyrazoles, triketones), cellulose biosynthesis inhibitors (e.g., nitriles, benzamides, quinclorac,

20 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 single or multiple herbicides, biotypes with resistance or tolerance to single or multiple chemical classes, biotypes with resistance or tolerance to

25 single or multiple herbicide modes-of-action, and biotypes with single or multiple resistance or tolerance mechanisms (e.g., target site resistance or metabolic resistance).

The compositions and methods described herein are used to control undesirable vegetation in glyphosate-, 2,4-D- and glufosinate-tolerant soybeans, corn, or cotton which may also be combined with traits providing dicamba-tolerance (e.g., *DMO*), pyridyloxy

30 auxin-tolerance (e.g., *aad-12*, *aad-13*), auxin-tolerance, auxin transport inhibitor-tolerance, acetyl CoA carboxylase (ACCase) inhibitor-herbicide tolerance [e.g., aryloxyphenoxypropionate, cyclohexanedione, and phenylpyrazoline chemistries

(*e.g.*, various ACCase genes and *aad-I* gene)], acetolactate synthase (ALS)-inhibiting herbicide tolerance (*e.g.*, imidazolinone, sulfonyleurea, triazolopyrimidine sulfonamide, pyrimidinylthiobenzoate, and other chemistries = AHAS, *Csr1*, *SurA*), 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitor-tolerance, phytoene desaturase (PDS) inhibitor-tolerance (*e.g.*, *pds*, *CYP1A1*, *CYP2B6*, *CYP2C19*), carotenoid biosynthesis inhibitor-tolerance, protoporphyrinogen oxidase (PPO) inhibitor-tolerance, cellulose biosynthesis inhibitor-tolerance (*e.g.*, *ixr2-1*, *CYP1A1*), mitosis inhibitor-tolerance, microtubule inhibitor-tolerance, very long chain fatty acid (VLCFA) inhibitor-tolerance (*e.g.*, *CYP1A1*, *CYP2B6*, *CYP2C19*), fatty acid and lipid biosynthesis inhibitor-tolerance (*e.g.*, *CYP1A1*), photosystem I inhibitor-tolerance (*e.g.*, SOD), photosystem II inhibitor (triazine, nitrile, and phenylurea chemistries) tolerance (*e.g.*, *psbA*, *CYP1A1*, *CYP2B6*, *CYP2C19*, and *Bxn*), in crops (such as, but not limited to, soybean, corn, cotton, canola/oilseed rape, rice, cereals, sorghum, sunflower, sugar beet, sugarcane, and turf), for example, in conjunction with glyphosate, 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase inhibitors, glutamine synthase inhibitors, dicamba, phenoxy auxins, pyridyloxy auxins, synthetic auxins, auxin transport inhibitors, aryloxyphenoxypropionates, cyclohexanediones, phenylpyrazolines, ACCase inhibitors, imidazolinones, sulfonyleureas, pyrimidinylthiobenzoates, dimethoxy-pyrimidines, triazolopyrimidine sulfonamides, sulfonylaminocarbonyltriazolinones, ALS or acetoxy acid synthase (AHAS) inhibitors, HPPD inhibitors, PDS inhibitors, carotenoid biosynthesis inhibitors, PPO inhibitors, cellulose biosynthesis inhibitors, mitosis inhibitors, microtubule inhibitors, very long chain fatty acid inhibitors, fatty acid and lipid biosynthesis inhibitors, photosystem I inhibitors, photosystem II inhibitors, triazines, and bromoxynil. The compositions and methods may be used in controlling undesirable vegetation in soybeans, corn, or cotton possessing single and multiple or stacked traits conferring tolerance to single or multiple chemistries and/or inhibitors of multiple modes-of-action.

The described embodiments and following examples are for illustrative purposes and are not intended to limit the scope of the claims. Other modifications, uses, or combinations with respect to the compositions described herein will be apparent to a person of ordinary skill in the art without departing from the spirit and scope of the claimed subject matter.

30

Examples

Example 1. Evaluation of Herbicidal Activity of Mixtures under Field Conditions

Methodology

Field trials were conducted under agricultural field conditions in multiple states in the United States, including but not limited to Arkansas, Iowa, Illinois, Indiana, Kansas, Minnesota, Mississippi, Missouri, New York, Tennessee and Wisconsin. Trials were established as RCB (randomized complete block) design, with 3-4 replicates per treatment, and plot sizes varying from 5-10 feet (ft) wide by 12-30 ft long. Treatments were applied with small plot backpack sprayers, using pressurized carbon dioxide (CO₂) as propellant. Pressure varied from 17-52 pounds per square inch (psi), with spray tips typically of a Flat Fan type applying water diluent at 15 gallons per acre (GPA). Boom sizes varied from 5-11 ft in width. Treatments were applied to soybean, cotton, corn or fallow crop land. Weed sizes varied, but all treatments were applied as post-emergence treatments to weeds from 2 leaf to 2 tiller growth stages varying from 3 to 17 inches in height. The weed spectrum included, but was not limited to, *Amaranthus palmeri* S. Wats. (Palmer amaranth, AMAPA), *Ambrosia trifida* L. (giant ragweed, AMBTR), *Conyza canadensis* (L.) Cronq. (horseweed, ERICA) and *Salsola tragus* L. (Russian thistle, SASKR).

Glyphosate-, 2,4-D- and glufosinate-tolerant soybeans, corn or cotton comprising genes for tolerance for each herbicide as described above were used in all trials either as a breeding stack of one to three herbicide-tolerant events or as a molecular stack where all three herbicide tolerance traits were transformed into a single event.

Evaluation

Commercially available product of glufosinate-ammonium (Ignite[®] 280SL (Soluble Concentrate)), containing 256 grams acid equivalent per liter (g ae/L)) was utilized in all trials, either applied alone or tank-mixed with ammonium sulfate liquid (2.5% volume per volume (vol/vol)). The 2,4-D-choline salt plus glyphosate premix formulation was a 400 g ae/L SL containing 195 g ae/L 2,4-D-choline salt and 205 g ae/L glyphosate-dimethylammonium (DMA) salt. If ammonium sulfate was mixed with glufosinate-ammonium, then ammonium sulfate was also mixed with the 2,4-D-choline salt + glyphosate-dimethylammonium plus glufosinate mixture. All treatments were mixed in

water at appropriate formulated product rates to achieve the desired rates as shown based on a unit area of application (hectare). Treatments were rated at 1 to 28 days after application (DAA) as compared to the untreated control plants. The trial sites had naturally occurring populations of weeds. The treated plots and control plots were rated blind at various
 5 intervals after application. Ratings were based on a Percent (%) Visual basis, where 0 corresponds to no visual effect as seen as exemplified by weed control or crop injury and 100 corresponds to complete kill of the target weeds or complete crop injury.

Data were collected for all trials and analyzed using various statistical methods.

Colby's equation was used to determine the herbicidal effects expected from the
 10 mixtures (Colby, S. R. Calculation of the synergistic and antagonistic response of herbicide combinations. *Weeds* **1967**, *15*, 20-22). A t-test (alpha=0.05) between Colby predictions and observed combinations was used to test for significant differences indicating synergy or antagonism using replicate data. The results presented in the Tables were significant according to the described criteria.

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

$$\text{Expected} = A + B + C - (AB + AC + BC)/100 + (ABC)/10,000$$

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

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

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

25 However, the experiments described herein were performed such that active ingredients A and B were combined and only the efficacy of the combination was determined. As such, Colby's equation simplifies to

$$\text{Expected} = Z + C - (ZC/100)$$

Z = observed efficacy of a combination of active ingredient A (2,4-D-choline) and active ingredient B (glyphosate-DMA) at the same concentration as used in the mixture;

30 C = observed efficacy of active ingredient C (glufosinate-ammonium) at the same concentration as used in the mixture.

The results are summarized in Tables 1-7.

Table 1. Synergistic Herbicidal Weed Control (%Visual Control) from Combinations of 2,4-D-Choline + Glyphosate-Dimethylammonium (DMA) plus Glufosinate-Ammonium in Multiple Field Trials at 7 to 28 Days After Application (DAA).

Weed Bayer Code	Evaluation Interval	2,4-D-Choline + Glyphosate-DMA		Glufosinate-Ammonium		Combination	
		g ae/ha	Mean % Weed Control	g ae/ha	Mean % Weed Control	Measured Mean % Weed Control	Colby Predicted Mean % Weed Control
AMAPA	7DAA	2185	50.0	542	67.5	88.5	83.8
AMAPA	8DAA	1640	40.0	542	32.5	67.5	59.5
AMBTR	8DAA	2185	36.7	542	56.7	80.0	72.3
AMAPA	11DAA	1640	50.0	542	33.8	88.8	66.6
AMAPA	11DAA	2185	60.0	542	33.8	84.3	73.5
AMAPA	13DAA	1640	43.8	542	31.3	72.5	61.2
AMAPA	14DAA	2185	67.5	542	10.0	85.0	70.8
ERICA	14DAA	2185	30.0	542	76.8	92.5	83.7
AMAPA	16DAA	2185	51.7	542	36.7	81.7	69.2
AMAPA	21DAA	2185	41.3	542	38.8	81.3	63.9
AMBTR	21DAA	1640	77.3	542	36.7	99.0	86.0
SASKR	21DAA	1640	66.3	542	13.8	83	71.3
AMAPA	23DAA	2185	41.7	542	21.7	76.7	54.4
SASKR	28DAA	1640	67.5	542	15	85	73.5

5

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Table 2. Improved AAD12 Soybean (GLXMA) Crop Tolerance Results (%Visual Chlorosis) from Combinations of 2,4-D-Choline + Glyphosate-DMA plus Glufosinate-Ammonium in Multiple Field Trials at 1 to 6DAA.

5

Crop Bayer Code	Evaluation Interval	2,4-D-Choline + Glyphosate-DMA		Glufosinate-Ammonium		Combination	
		g ac/ha	Mean % Visual Chlorosis	g ac/ha	Mean % Visual Chlorosis	Measured Mean % Visual Chlorosis	Colby Predicted Mean % Visual Chlorosis
GLXMA	1DAA	2185	3.8	542	12.5	5.0	15.8
GLXMA	1DAA	4370	3.8	822	16.3	12.5	19.4
GLXMA	1DAA	4370	3.8	1084	20.0	11.3	23.0
GLXMA	2DAA	4370	5.0	822	9.5	8.3	14.0
GLXMA	2DAA	4370	5.8	822	12.3	8.8	17.2
GLXMA	2DAA	4370	5.0	822	12.3	8.8	16.6
GLXMA	2DAA	4370	0.0	822	11.3	5.0	11.3
GLXMA	2DAA	4370	0.0	822	8.3	4.0	8.3
GLXMA	2DAA	4370	1.5	822	7.5	3.8	8.9
GLXMA	2DAA	4370	2.3	822	7.3	4.0	9.3
GLXMA	2DAA	4370	0.0	822	13.8	1.3	13.8
GLXMA	2DAA	4370	5.0	1084	13.0	8.8	17.4
GLXMA	2DAA	4370	5.8	1084	15.5	10.0	20.3
GLXMA	2DAA	4370	0.0	1084	11.3	5.3	11.3
GLXMA	2DAA	4370	0.0	1084	11.8	3.0	11.8
GLXMA	2DAA	4370	1.5	1084	8.5	4.8	9.9
GLXMA	2DAA	4370	2.3	1084	8.5	4.5	10.5
GLXMA	2DAA	4370	1.8	1084	7.8	5.8	9.4
GLXMA	2DAA	4370	1.5	1084	7.5	5.0	8.9
GLXMA	3DAA	4370	0.0	822	6.0	2.3	6.0
GLXMA	3DAA	4370	0.8	822	7.5	2.8	8.2
GLXMA	3DAA	4370	0.0	822	7.3	2.3	7.3
GLXMA	3DAA	4370	0.0	822	5.5	1.5	5.5
GLXMA	3DAA	4370	0.0	822	6.8	2.8	6.8
GLXMA	3DAA	4370	0.0	822	13.0	0.0	13.0
GLXMA	3DAA	4370	1.3	822	9.0	5.8	10.2
GLXMA	3DAA	4370	0.0	822	17.5	6.8	17.5
GLXMA	3DAA	4370	2.3	822	10.8	4.3	12.9
GLXMA	3DAA	4370	0.0	1084	8.5	2.3	8.5

GLXMA	3DAA	4370	0.8	1084	10.0	3.0	10.7
GLXMA	3DAA	4370	0.0	1084	11.3	4.0	11.3
GLXMA	3DAA	4370	0.0	1084	10.5	3.8	10.5
GLXMA	3DAA	4370	2.5	1084	16.3	11.3	18.3
GLXMA	3DAA	4370	1.3	1084	16.3	10.0	17.3
GLXMA	3DAA	4370	0.0	1084	13.0	1.3	13.0
GLXMA	3DAA	4370	0.0	1084	11.7	0.0	11.7
GLXMA	3DAA	4370	0.0	1084	16.7	1.7	16.7
GLXMA	3DAA	4370	0.0	1084	7.5	2.8	7.5
GLXMA	3DAA	4370	0.0	1084	20.0	12.5	20.0
GLXMA	3DAA	4370	2.3	1084	18.8	8.0	20.6
GLXMA	4DAA	2185	0.0	542	3.8	0.5	3.8
GLXMA	4DAA	2185	1.0	542	2.8	1.8	3.7
GLXMA	4DAA	2185	1.0	542	2.8	1.8	3.7
GLXMA	4DAA	2185	0.0	542	6.3	0.0	6.3
GLXMA	4DAA	4370	0.0	822	6.5	0.0	6.5
GLXMA	4DAA	4370	0.0	822	6.3	0.0	6.3
GLXMA	4DAA	4370	0.5	822	6.0	4.5	6.5
GLXMA	4DAA	4370	0.0	822	6.3	0.0	6.3
GLXMA	4DAA	4370	0.0	822	50.0	1.7	50.0
GLXMA	4DAA	4370	0.0	822	20.5	6.3	20.5
GLXMA	4DAA	4370	0.0	1084	10.3	0.0	10.3
GLXMA	4DAA	4370	0.0	1084	9.0	0.0	9.0
GLXMA	4DAA	4370	0.5	1084	7.5	3.5	8.0
GLXMA	4DAA	4370	0.0	1084	11.3	0.0	11.3
GLXMA	4DAA	4370	0.0	1084	50.0	6.7	50.0
GLXMA	4DAA	4370	0.0	1084	12.5	8.5	12.5
GLXMA	4DAA	4370	0.0	1084	29.5	8.8	29.5
GLXMA	4DAA	4370	0.0	1084	30.0	8.8	30.0
GLXMA	5DAA	2185	0.0	542	4.0	0.0	4.0
GLXMA	5DAA	4370	2.3	1084	7.8	0.0	9.8
GLXMA	5DAA	4370	2.3	1084	7.8	0.0	9.8
GLXMA	6DAA	4370	15.0	823	33.3	8.3	43.2

Table 3. Improved AAD12 Soybean (GLXMA) Crop Tolerance Results (%Visual Chlorosis) from Combinations of 2,4-D-Choline + Glyphosate-DMA plus Glufosinate-Ammonium in Multiple Field Trials at 7 to 9DAA.

		2,4-D-Choline + Glyphosate-DMA		Glufosinate- Ammonium		Combination	
Crop Bayer Code	Evaluation Interval	g ae/ha	Mean % Visual Chlorosis	g ae/ha	Mean % Visual Chlorosis	Measured Mean % Visual Chlorosis	Colby Predicted Mean % Visual Chlorosis
GLXMA	7DAA	2185	0.0	542	3.3	1.5	3.3
GLXMA	7DAA	4370	0.0	822	3.5	0.8	3.5
GLXMA	7DAA	4370	0.5	822	5.0	2.0	5.5
GLXMA	7DAA	4370	0.0	822	7.5	1.3	7.5
GLXMA	7DAA	4370	5.0	822	8.5	7.0	13.1
GLXMA	7DAA	4370	0.0	822	10.0	1.3	10.0
GLXMA	7DAA	4370	21.3	822	0.0	15.0	21.3
GLXMA	7DAA	4370	0.0	822	8.3	5.8	8.3
GLXMA	7DAA	4370	0.0	822	11.3	3.8	11.3
GLXMA	7DAA	4370	0.0	1084	6.3	1.3	6.3
GLXMA	7DAA	4370	0.5	1084	8.0	2.8	8.5
GLXMA	7DAA	4370	0.0	1084	11.3	1.3	11.3
GLXMA	7DAA	4370	1.3	1084	8.5	5.8	9.7
GLXMA	7DAA	4370	5.0	1084	12.3	7.5	16.6
GLXMA	7DAA	4370	0.0	1084	11.0	8.5	11.0
GLXMA	7DAA	4370	4.0	1084	7.0	4.0	10.7
GLXMA	7DAA	4370	0.0	1084	3.0	0.0	3.0
GLXMA	7DAA	4370	0.0	1084	12.5	7.5	12.5
GLXMA	8DAA	2185	0.0	542	2.8	0.5	2.8
GLXMA	8DAA	4370	1.0	822	3.8	0.8	4.7
GLXMA	8DAA	4370	0.8	822	4.8	1.3	5.5
GLXMA	8DAA	4370	0.3	822	7.7	1.7	8.0
GLXMA	8DAA	4370	1.0	822	5.5	4.5	6.5
GLXMA	8DAA	4370	0.0	822	17.5	8.0	17.5
GLXMA	8DAA	4370	0.0	822	5.0	0.5	5.0
GLXMA	8DAA	4370	0.8	1084	7.0	1.5	7.7
GLXMA	8DAA	4370	1.0	1084	8.0	1.8	8.9
GLXMA	8DAA	4370	0.8	1084	8.8	2.3	9.4
GLXMA	8DAA	4370	0.3	1084	8.3	3.7	8.6
GLXMA	8DAA	4370	1.0	1084	7.3	3.5	8.2
GLXMA	8DAA	4370	0.0	1084	8.8	3.0	8.8
GLXMA	8DAA	4370	0.0	1084	6.0	0.3	6.0

GLXMA	8DAA	4370	0.0	1084	5.8	0.3	5.8
GLXMA	8DAA	4370	0.0	1084	16.3	11.3	16.3
GLXMA	8DAA	4370	0.0	1084	7.3	0.5	7.3
GLXMA	8DAA	4370	0.0	1084	6.3	0.5	6.3
GLXMA	9DAA	4370	0.0	822	5.5	0.0	5.5
GLXMA	9DAA	4370	0.0	1084	6.0	0.0	6.0

Table 4. Improved AAD12 Soybean (GLXMA) Crop Tolerance Results (% Visual Chlorosis) from Combinations of 2,4-D-Choline + Glyphosate-DMA plus Glufosinate-Ammonium in Multiple Field Trials at 10 to 14DAA.

Crop Bayer Code	Evaluation Interval	2,4-D-Choline + Glyphosate-DMA salt		Glufosinate-ammonium		Combination	
		g ae/ha	Mean % Visual Chlorosis	g ae/ha	Mean % Visual Chlorosis	Measured Mean % Visual Chlorosis	Colby Predicted Mean % Visual Chlorosis
GLXMA	10DAA	4370	0.0	822	3.0	0.5	3.0
GLXMA	10DAA	4370	0.0	822	6.8	0.0	6.8
GLXMA	10DAA	4370	0.8	822	13.0	0.8	13.7
GLXMA	10DAA	4370	0.0	822	2.5	0.5	2.5
GLXMA	10DAA	4370	0.0	1084	8.5	1.3	8.5
GLXMA	10DAA	4370	0.8	1084	10.0	0.8	10.7
GLXMA	13DAA	4370	0.0	823	10.7	0.0	10.7
GLXMA	13DAA	4370	0.0	1084	8.5	3.8	8.5
GLXMA	14DAA	2185	8.3	542	5.8	7.8	13.5
GLXMA	14DAA	2185	0.3	542	12.5	6.8	12.7
GLXMA	14DAA	4370	0.0	822	8.5	0.0	8.5
GLXMA	14DAA	4370	0.0	822	6.3	1.3	6.3
GLXMA	14DAA	4370	3.8	822	2.0	3.0	5.7
GLXMA	14DAA	4370	0.0	822	15.0	5.0	15.0
GLXMA	14DAA	4370	11.3	1084	8.3	12.5	18.6
GLXMA	14DAA	4370	0.0	1084	11.3	0.0	11.3
GLXMA	14DAA	4370	0.0	1084	7.8	0.0	7.8
GLXMA	14DAA	4370	0.0	1084	10.0	7.0	10.0
GLXMA	14DAA	4370	0.0	1084	4.0	0.0	4.0
GLXMA	14DAA	4370	3.8	1084	2.8	3.3	6.4
GLXMA	14DAA	4370	3.3	1084	2.3	3.3	5.4
GLXMA	14DAA	4370	0.0	1084	16.3	5.0	16.3

Table 5. Improved AAD12 Soybean (GLXMA) Crop Tolerance Results (% Visual Chlorosis) from Combinations of 2,4-D-Choline + Glyphosate-DMA plus Glufosinate-Ammonium in Multiple Field Trials at 15 to 21DAA.

Crop Bayer Code	Evaluation Interval	2,4-D-Choline + Glyphosate-DMA		Glufosinate-Ammonium		Combination	
		g ae/ha	Mean % Visual Chlorosis	g ae/ha	Mean % visual Chlorosis	Measured Mean % Visual Chlorosis	Colby Predicted Mean % Visual Chlorosis
GLXMA	15DAA	2185	0.5	542	4.5	0.5	5.0
GLXMA	15DAA	4370	0.8	822	2.3	0.5	3.0
GLXMA	15DAA	4370	0.0	822	5.0	0.5	5.0
GLXMA	15DAA	4370	0.8	1084	5.5	1.0	6.2
GLXMA	15DAA	4370	0.0	1084	8.5	0.0	8.5
GLXMA	15DAA	4370	0.8	1084	2.3	0.5	3.0
GLXMA	16DAA	2185	0.0	542	3.0	0.0	3.0
GLXMA	16DAA	4370	0.0	822	4.0	0.0	4.0
GLXMA	16DAA	4370	0.0	1084	5.0	1.3	5.0
GLXMA	16DAA	4370	0.0	1084	5.5	0.5	5.5
GLXMA	21DAA	2185	0.0	542	4.0	0.8	4.0
GLXMA	21DAA	4370	0.0	822	5.0	0.0	5.0
GLXMA	21DAA	4370	0.0	1084	6.0	0.8	6.0

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Table 6. Improved AAD12 Soybean (GLXMA) Crop Tolerance Results (% Visual Necrosis) from Combinations of 2,4-D-Choline + Glyphosate-DMA plus Glufosinate-Ammonium in Multiple Field Trials at 2 to 7DAA.

Crop Bayer Code	Evaluation Interval	2,4-D-Choline + Glyphosate-DMA		Glufosinate-Ammonium		Combination	
		g ae/ha	Mean % Visual Necrosis	g ae/ha	Mean % Visual Necrosis	Measured Mean % Visual Necrosis	Colby Predicted Mean % Visual Necrosis
GLXMA	2DAA	4370	21.3	822	21.3	23.8	37.9
GLXMA	2DAA	4370	21.3	1084	25.0	27.5	41.0
GLXMA	3DAA	2185	2.3	542	0.0	1.0	2.3
GLXMA	3DAA	4370	8.5	822	0.8	5.0	9.2
GLXMA	3DAA	4370	10.8	1084	3.0	11.5	13.4
GLXMA	3DAA	4370	11.0	1084	8.5	15.0	18.6
GLXMA	3DAA	4370	8.5	1084	1.5	6.3	9.9
GLXMA	3DAA	4370	7.5	1084	1.3	5.5	8.7
GLXMA	5DAA	2185	5.0	542	2.8	5.5	7.6
GLXMA	7DAA	2185	2.3	542	0.5	0.5	2.7
GLXMA	7DAA	2185	1.5	542	0.3	0.3	1.8
GLXMA	7DAA	4370	6.3	822	0.8	3.3	7.0
GLXMA	7DAA	4370	21.3	822	0.0	15.0	21.3
GLXMA	7DAA	4370	0.0	822	10.0	1.3	10.0
GLXMA	7DAA	4370	6.5	822	1.0	3.3	7.4
GLXMA	7DAA	4370	5.5	822	1.3	3.3	6.7
GLXMA	7DAA	4370	10.0	1084	3.3	10.0	12.9
GLXMA	7DAA	4370	6.3	1084	1.3	4.0	7.4
GLXMA	7DAA	4370	20.0	1084	1.3	12.8	21.0
GLXMA	7DAA	4370	17.5	1084	10.0	17.5	25.8
GLXMA	7DAA	4370	17.5	1084	10.0	17.5	25.8
GLXMA	7DAA	4370	6.5	1084	2.0	4.3	8.4
GLXMA	7DAA	4370	5.5	1084	2.3	4.3	7.6

Table 7. Improved AAD12 Soybean (GLXMA) Crop Tolerance Results (% Visual Necrosis) from Combinations of 2,4-D-Choline + Glyphosate-DMA plus Glufosinate-Ammonium in Multiple Field Trials at 8 to 16DAA.

Crop Bayer Code	Evaluation Interval	2,4-D-Choline + Glyphosate-DMA		Glufosinate-Ammonium		Combination	
		g ac/ha	Mean % Visual Necrosis	g ac/ha	Mean % Visual Necrosis	Measured Mean % Visual Necrosis	Colby Predicted Mean % Visual Necrosis
GLXMA	8DAA	4370	18.8	822	7.5	18.8	24.8
GLXMA	8DAA	4370	10.0	1084	10.0	15.0	19.0
GLXMA	8DAA	4370	17.5	1084	12.5	17.5	27.8
GLXMA	8DAA	4370	18.8	1084	12.5	17.5	28.9
GLXMA	8DAA	4370	21.8	1084	6.5	23.0	26.8
GLXMA	8DAA	4370	19.5	1084	6.5	20.0	24.7
GLXMA	9DAA	4370	8.5	822	6.0	8.5	14.0
GLXMA	10DAA	4370	4.5	1084	2.3	5.3	6.7
GLXMA	14DAA	4370	2.3	822	0.0	1.3	2.3
GLXMA	14DAA	4370	2.5	822	1.0	1.8	3.5
GLXMA	14DAA	4370	5.0	1084	5.0	5.0	9.8
GLXMA	14DAA	4370	2.5	1084	2.0	2.5	4.5
GLXMA	16DAA	2185	3.0	542	3.0	4.0	5.9
GLXMA	16DAA	4370	6.5	822	5.0	6.0	11.2
GLXMA	16DAA	4370	7.5	1084	1.8	7.8	9.1

5

The following abbreviations are used in the tables above:

2,4-D-choline = choline salt of 2,4-dichlorophenoxyacetic acid or 2-hydroxy-*N,N,N*-trimethylethanaminium 2-(2,4-dichlorophenoxy)acetate

10 glyphosate-DMA = glyphosate-dimethylammonium, dimethylamine salt of *N*-(phosphonomethyl)glycine or dimethylammonium hydrogen(((carboxymethyl)amino)methyl)-phosphonate

glufosinate-ammonium = ammonium salt of 2-amino-4-(hydroxymethylphosphinyl)butanoic acid or ammonium (3-amino-3-carboxypropyl)(methyl)phosphinate

15

AMAPA = *Amaranthus palmeri* S. Wats. (Palmer amaranth)

AMBTR = *Ambrosia trifida* L. (giant ragweed)

ERICA = *Conyza canadensis* (L.) Cronq. (horseweed)

GLXMA = *Glycine max* L. (soybean)

20

SASKR = *Salsola tragus* L. (Russian thistle)

g ac/ha = grams acid equivalent per hectare

DAA = Days After Application

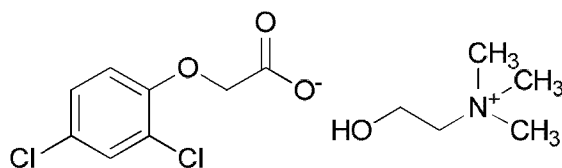
The compositions and methods of the appended claims are not limited in scope by the specific compositions and methods described herein, which are intended as illustrations of a few aspects of the claims and any compositions and methods that are functionally equivalent
5 are intended to fall within the 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 composition materials and method steps disclosed herein are specifically described, other combinations of the composition materials and method steps also are intended to fall within the scope of the
10 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
15 terms. Although the terms “comprising” and “including” have been used herein to describe various embodiments, the terms “consisting essentially of” and “consisting of” can be used in place of “comprising” and “including” to provide for more specific embodiments of the invention and are also disclosed.

CLAIMS:

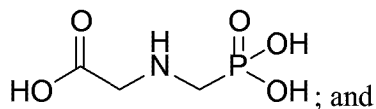
1. A composition for controlling undesirable vegetation, comprising a mixture comprising a synergistic, herbicidally effective amount of:

(a) the choline salt of 2,4-dichlorophenoxyacetic acid (2,4-D-choline)

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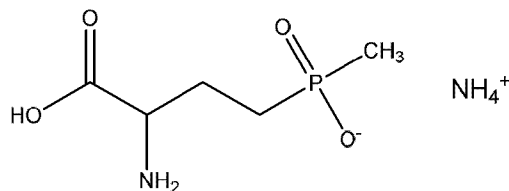


(b) a salt of *N*-(phosphonomethyl)glycine (glyphosate)



(c) the ammonium salt of 2-amino-4-(hydroxymethylphosphinyl)butanoic acid (glufosinate ammonium)

10



wherein the weight ratio of (a) + (b) to (c) is from 1.5:1 to 8:1.

2. The composition of claim 1, wherein the salt of glyphosate is selected from the group consisting of potassium salt, isopropylammonium (IPA) salt, monoethanolammonium (MEA) salt, monomethylammonium (MMA) salt, and dimethylammonium (DMA) salt, and combinations thereof.

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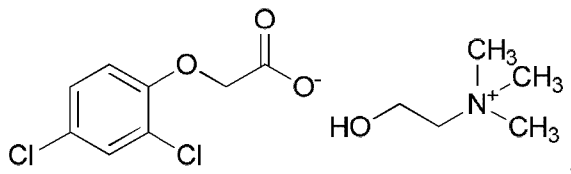
3. The composition of claim 2, wherein the salt of glyphosate is the dimethylammonium salt.

4. The composition of any one of claims 1-3, wherein the weight ratio of (a) to (b) to (c) is from 1-4 of (a) to 1-4 of (b) to 1 of (c) or from 1:1:1 to 4:4:1.
5. The composition of any one of claims 1-4, further comprising a herbicidally effective amount of an additional herbicide.
- 5 6. The composition of any one of claims 1-5, further comprising an agriculturally acceptable adjuvant.
7. A method of controlling undesirable vegetation comprising contacting undesirable vegetation or the locus thereof, or foliage, water or soil, with any one of the compositions of claims 1-6.
- 10 8. The method of claim 7, wherein the composition is applied post-emergence to the undesirable vegetation.
9. The method of claim 7, wherein the composition is applied pre-emergence to the undesirable vegetation.
10. The method of claim 7, wherein the undesirable vegetation is contacted prior to
15 planting a crop.
11. The method of claim 7, wherein the salt of glyphosate is selected from the group consisting of potassium salt, isopropylammonium (IPA) salt, monoethanolammonium (MEA) salt, monomethylammonium (MMA) salt, dimethylammonium (DMA) salt, and combinations thereof.
- 20 12. The method of claim 11, wherein the salt of glyphosate is the dimethylammonium (DMA) salt.
13. The method of any one of claims 7-12, wherein the weight ratio of (a) to (b) to (c) is from 1 – 4 of (a) to 1 – 4 of (b) to 1 of (c) or from 1:1:1 to 4:4:1.
14. The method of any one of claims 7-13, wherein (a), (b) and/or (c) are applied
25 simultaneously.
15. The method of any one of claims 7-14, wherein the undesirable vegetation comprises a herbicide resistant or tolerant weed.

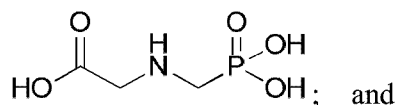
16. The method of claim 15, wherein the resistant or tolerant weed is a biotype with resistance or tolerance to single or multiple herbicides or single or multiple chemical classes, or inhibitors of single or multiple herbicide modes-of-action.
17. The method of claim 15 or claim 16, wherein the resistant or tolerant weed is a biotype resistant or tolerant to acetolactate synthase (ALS) or acetohydroxy acid synthase (AHAS) inhibitors, photosystem II inhibitors, acetyl CoA carboxylase (ACCase) inhibitors, photosystem I inhibitors, 5-enolpyruvyl-shikimate-3-phosphate (EPSP) synthase inhibitors, microtubule assembly inhibitors, lipid synthesis inhibitors, protoporphyrinogen oxidase (PPO) inhibitors, carotenoid biosynthesis inhibitors, very long chain fatty acid (VLCFA) inhibitors, phytoene desaturase (PDS) inhibitors, glutamine synthetase inhibitors, 4-hydroxyphenyl-pyruvate-dioxygenase (HPPD) inhibitors, mitosis inhibitors, cellulose biosynthesis inhibitors, herbicides with multiple modes-of-action, quinclorac, arylaminopropionic acids, difenzoquat, endothall or organoarsenicals.
18. The method of any one of claims 7-17, further comprising contacting the undesirable vegetation with a herbicidally effective amount of an additional herbicide.
19. The method of any one of claims 7-18, wherein the undesirable vegetation is controlled in a non-crop, perennial crop, fruiting crop, or plantation crop area, comprising contacting undesirable vegetation or the locus thereof, or water or soil, in a non-crop, perennial crop, fruiting crop, or plantation crop area.
20. The method of claim 19, wherein the undesirable vegetation is in a non-crop area and the non-crop area is a pasture, grassland, rangeland, fallowland, fencerow, parking area, tank farm, storage area, rights-of-way, utility area, turf, forestry, aquatics, industrial vegetation management (IVM) or fallow-bed.
21. The method of claim 19, wherein the undesirable vegetation is in a perennial crop area and the foliage of the perennial crop is not contacted when the undesirable vegetation is contacted.
22. The method of claim 21, wherein the perennial crop is a tree and vine orchard.
23. The method of claim 22, wherein the tree and vine orchard is selected from the group consisting of citrus, grapes, almond, apple, apricot, avocado, beechnut, Brazil nut,

butternut, cashew, cherry, chestnut, chinquapin, crab apple, date, feijoa, fig, filbert, hickory nut, kiwi, lemon, lime, loquat, macadamia nut, mandarin, mayhaws, oranges, nectarine, olives, peach, pear, pecan, persimmon, pistachio, plum, pomegranate, prune, quince, tree nut and walnut.

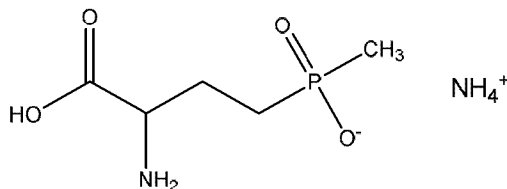
- 5 24. The method of claim 19, wherein the undesirable vegetation is in a fruiting crop area and the foliage of the fruiting crop is not contacted when the undesirable vegetation is contacted.
25. The method of claim 24, wherein fruiting crop is selected from the group consisting of blueberries, guava, papaya, strawberries, taro, blackberries and raspberries.
- 10 26. The method of claim 19, wherein the undesirable vegetation is in a plantation crop area and the foliage of the plantation crop is not contacted when the undesirable vegetation is contacted.
27. The method of claim 26, wherein plantation crop is selected from the group consisting of coffee, cacao, rubber and palm oil.
- 15 28. A method of controlling undesirable vegetation and improving crop tolerance in 2,4-D-, glyphosate- and glufosinate-tolerant soybeans, corn, or cotton, comprising contacting undesirable vegetation and 2,4-D-, glyphosate- and glufosinate-tolerant soybeans, corn, or cotton or the locus thereof, or foliage or soil, with a composition comprising a mixture comprising a synergistic, herbicidally effective amount of:
- 20 (a) the choline salt of 2,4-dichlorophenoxyacetic acid (2,4-D-choline)



- (b) a salt of *N*-(phosphonomethyl)glycine (glyphosate)



(c) an ammonium salt of 2-amino-4-(hydroxymethylphosphinyl)butanoic acid (glufosinate ammonium)



wherein the weight ratio of (a) + (b) to (c) is from 1.5:1 to 8:1.

29. The method of claim 28, wherein the 2,4-D-choline, the salt of glyphosate and the ammonium salt of glufosinate are applied post-emergence to the undesirable vegetation or locus thereof, or foliage or soil, in the 2,4-D-, glyphosate- and glufosinate-tolerant soybeans, corn, or cotton.

30. The method of claim 28, wherein the 2,4-D-choline, the salt of glyphosate and the ammonium salt of glufosinate are applied pre-emergence to the undesirable vegetation or locus thereof, or foliage or soil, in the 2,4-D-, glyphosate- and glufosinate-tolerant soybeans, corn, or cotton.

31. The method of claim 28, wherein the undesirable vegetation is contacted prior to planting a crop.

32. The method of claim 28, wherein the salt of glyphosate is selected from the group consisting of potassium salt, isopropylammonium (IPA) salt, monoethanolammonium (MEA) salt, monomethylammonium (MMA) salt, and dimethylammonium (DMA) salt, and combinations thereof.

33. The method of claim 32, wherein the salt of glyphosate is the dimethylammonium (DMA) salt.

34. The method of any one of claims 28-33, wherein the weight ratio of (a) to (b) to (c) is from 1 – 4 of (a) to 1 – 4 of (b) to 1 of (c) or from 1:1:1 to 4:4:1.

35. The method of any one of claims 28-34, wherein the 2,4-D-, glyphosate- and glufosinate-tolerant soybeans, corn, or cotton possess single or multiple or stacked traits conferring tolerance to single or multiple herbicides or inhibitors of single or multiple modes-of-action.

36. A method of any one of claims 28-35, wherein improving crop tolerance comprises reducing injury in the 2,4-D- and glufosinate-tolerant soybeans, corn, or cotton.
37. The method of any one of claims 28-36, wherein the undesirable vegetation comprises a herbicide resistant or tolerant weed.
- 5 38. The method of claim 37, wherein the resistant or tolerant weed is a biotype with resistance or tolerance to single or multiple herbicides or single or multiple chemical classes, or inhibitors of single or multiple herbicide modes-of-action.
39. The method of claim 37 or claim 38, wherein the resistant or tolerant weed is a
10 biotype resistant or tolerant to acetolactate synthase (ALS) or acetohydroxy acid synthase (AHAS) inhibitors, photosystem II inhibitors, acetyl CoA carboxylase (ACCase) inhibitors, photosystem I inhibitors, 5-enolpyruvyl-shikimate-3-phosphate (EPSP) synthase inhibitors, microtubule assembly inhibitors, lipid synthesis inhibitors, protoporphyrinogen oxidase (PPO) inhibitors, carotenoid biosynthesis inhibitors, very long
15 chain fatty acid (VLCFA) inhibitors, phytoene desaturase (PDS) inhibitors, glutamine synthetase inhibitors, 4-hydroxyphenyl-pyruvate-dioxygenase (HPPD) inhibitors, mitosis inhibitors, cellulose biosynthesis inhibitors, herbicides with multiple modes-of-action, quinclorac, arylaminopropionic acids, difenzoquat, endothall or organoarsenicals.
40. The method of any one of claims 28-39, further comprising contacting the
20 undesirable vegetation and the 2,4-D-, glyphosate- and glufosinate-tolerant soybeans, corn and cotton or the locus thereof, or water or soil, with a herbicidally effective amount of an additional herbicide.
41. The method of any one of claims 28-40, further comprising contacting the undesirable vegetation and the 2,4-D-, glyphosate- and glufosinate-tolerant soybeans, corn and cotton or the locus thereof with a herbicide safener.