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**Herbicidal compositions comprising 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl) pyridine-2-carboxylic acid**

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(71) Applicant(s)
**Dow AgroSciences LLC**

(72) Inventor(s)
**Yerkes, Carla N.;Mann, Richard K.;Satchivi, Norbert M.**

(74) Agent / Attorney
**FPA Patent Attorneys Pty Ltd, Level 43 101 Collins Street, Mebourne, VIC, 3000, AU**

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(71) Applicant: **DOW AGROSCIENCES LLC** [US/US]; 9330 Zionsville Road, Indianapolis, IN 46268 (US).

(72) Inventors: **YERKES, Carla, N.**; 4571 South State Road 47, Crawfordsville, IN 47933 (US). **MANN, Richard, K.**; 1828 South 550 East, Franklin, IN 46131 (US). **SATCHIVI, Norbert, M.**; 3100 Cherub Court, Carmel, IN 46074 (US).

(74) Agent: **BICKLEY, Patrick, M.**; Faegre Baker Daniels LLP, 300 North Meridian Street, Suite 2700, Indianapolis, IN 46204 (US).

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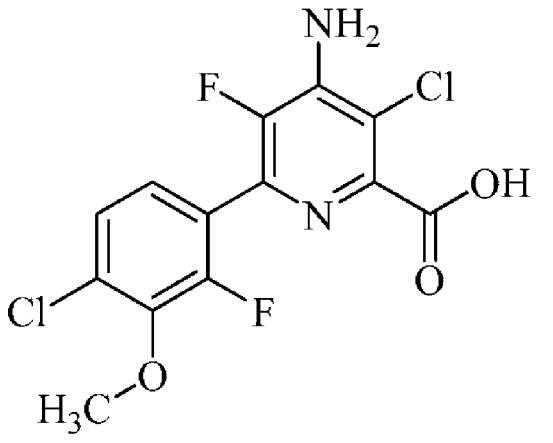
(54) Title: HERBICIDAL COMPOSITIONS COMPRISING 4-AMINO-3-CHLORO-5-FLUORO-6-(4-CHLORO-2-FLUORO-3-METHOXYPHENYL) PYRIDINE-2-CARBOXYLIC ACID




(I)

(57) Abstract: Provided herein are synergistic herbicidal compositions containing (a) a compound of formula (I): 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid or a derivative thereof, or an agriculturally acceptable salt or ester thereof and (b) a cellulose biosynthesis inhibitor, e.g., indaziflam and isoxaben. The methods and compositions described herein provide control of undesirable vegetation, e.g., in direct-seeded, water-seeded and transplanted rice, cereals, wheat, barley, oats, rye, sorghum, corn or maize, sugarcane, sunflower, oilseed rape, canola, sugar beet, soybean, cotton, pineapple, pastures, grasslands, rangelands, fallowland, turf, tree and vine orchards, aquatics, plantation crops, vegetables, industrial vegetation management (IVM) or rights-of-way (ROW).

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# HERBICIDAL COMPOSITIONS COMPRISING 4-AMINO-3-CHLORO-5-FLUORO-6-(4-CHLORO-2-FLUORO-3-METHOXYPHENYL) PYRIDINE-2-CARBOXYLIC ACID

## Priority Claim

This application claims the benefit of United States provisional patent application number 61/675,054 filed on July 24, 2012 and United States patent application number 13/840,419 filed March 15, 2013, the disclosure of each of which is incorporated herein by reference in its entirety.

## Field

Provided herein are herbicidal compositions comprising (a) 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid or an agriculturally acceptable ester or salt thereof and (b) a cellulose biosynthesis inhibitor (CBI).

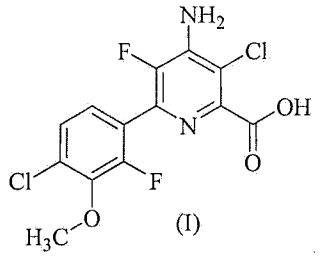
Provided herein are also methods of controlling undesirable vegetation comprising applying (a) 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxyphenyl)pyridine-2-carboxylic acid or an agriculturally acceptable ester or salt thereof and (b) a cellulose biosynthesis inhibitor.

## Background

The protection of crops from weeds and other vegetation which inhibit crop growth is a constantly recurring problem in agriculture. To help combat this problem, researchers in the field of synthetic chemistry have produced an extensive variety of chemicals and chemical formulations effective in the control of such unwanted growth. Chemical herbicides of many types have been disclosed in the literature and a large number are in commercial use. However, there remains a need for compositions and methods that are effective in controlling undesirable vegetation.

## Summary

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



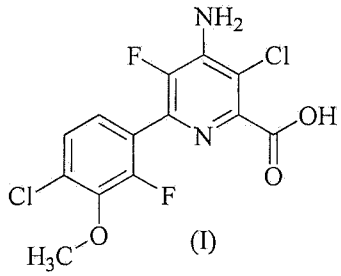

(I)

or an agriculturally acceptable salt or ester of thereof, and (b) a cellulose biosynthesis inhibitor. The compositions may also contain an agriculturally acceptable adjuvant or carrier.

Provided herein are also methods of controlling undesirable vegetation comprising applying (a) a compound of formula (I) or an agriculturally acceptable ester or salt thereof and (b) a cellulose biosynthesis inhibitor.

Several embodiments are recited below. In the embodiments, the ratio of compound (a) to compound (b) can be expressed in units of weight to weight(g to g), gae/ha to gae/ha or gae/ha to gai/ha.

A first embodiment of the invention provided herein includes synergistic herbicidal composition comprising a herbicidally effective amount of (a) a compound of the formula (I)




(I)

or an agriculturally acceptable salt or ester thereof and (b) a cellulose biosynthesis inhibitor.

A second embodiment includes the mixture of the first embodiment in which (a) is a $C_{1-4}$ alkyl or benzyl ester of compound (I).

A third embodiment includes the mixture of the first embodiment in which (a) is a benzyl ester of compound (I).

A fourth embodiment includes the mixture of the first embodiment in which (a) is the compound of formula (I), which is the carboxylic acid.

A fifth embodiment includes the mixture of any of the first through fourth embodiments in which (b) is indaziflam or isoxaben or an agriculturally acceptable salt thereof.

A sixth embodiment includes the mixture of the first embodiment in which (a) is the compound of formula (I) or an agriculturally acceptable benzyl ester and (b) is indaziflam.

A seventh embodiment includes the mixture of the first embodiment in which (a) is the compound of formula (I) or an agriculturally acceptable benzyl ester and (b) is isoxaben.

An eighth embodiment includes the mixture of any of the first through seventh embodiments further comprising a herbicide safener.

A ninth embodiment includes the mixture of the sixth embodiment in which the weight ratio of compound of formula (I) or agriculturally acceptable salt or ester thereof to indaziflam is from about 1:75 to about 15:1.

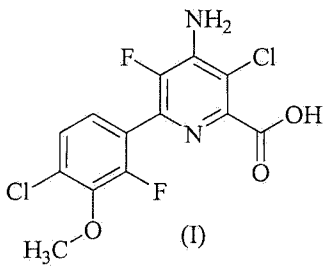
A tenth embodiment includes the mixture of the seventh embodiment in which the weight ratio of the compound of formula (I) or agriculturally acceptable salt or ester thereof to isoxaben is from about 1:560 to about 2:1.

An eleventh embodiment includes the mixture of any of the first through tenth embodiments further comprising an agriculturally acceptable adjuvant or carrier.

A twelfth embodiment includes the mixture of any of the first through eleventh embodiments which is synergistic as determined by the Colby equation.

A thirteenth embodiment includes 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 the composition of any of embodiments 1-12.

A fourteenth embodiment includes 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) a compound of the formula (I)




(I)

or an agriculturally acceptable salt or ester thereof and (b) a cellulose biosynthesis inhibitor.

A fifteenth embodiment includes methods according to either of the thirteenth or fourteenth embodiments wherein the method is practiced in at least one member of the group consisting of direct-seeded, water-seeded and transplanted rice, cereals, wheat, barley, oats, rye, sorghum, corn, maize, sugarcane, sunflower, oilseed rape, canola, sugar beet, soybean, cotton, pineapple, pastures, grasslands, rangelands, fallowland, turf, tree and vine orchards, aquatics, industrial vegetation management (IVM) or rights-of-way (ROW).

A sixteenth embodiment includes methods according to either of the thirteenth or fourteenth embodiments wherein the undesirable vegetation is immature.

A seventeenth embodiment includes methods according to either of the thirteenth or fourteenth embodiments wherein the (a) and (b) are applied to water.

An eighteenth embodiment includes method according to the seventeenth embodiment wherein the water is part of a flooded rice paddy.

A nineteenth embodiment includes methods according to either of the thirteenth or fourteenth embodiments wherein the (a) and (b) are applied pre-emergently to the weed or the crop.

A twentieth embodiment includes methods according to either of the thirteenth or fourteenth embodiments wherein the (a) and (b) are applied post-emergently to the weed or the crop.

A twenty-first embodiment includes methods according to either of the thirteenth or fourteenth embodiments wherein the undesirable vegetation is controlled in glyphosate-, 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase inhibitor-, glufosinate-, glutamine synthetase inhibitor-, dicamba-, phenoxy auxin-, pyridyloxy auxin-, synthetic auxin-, auxin transport inhibitor-, aryloxyphenoxypropionate-, cyclohexanedione-, phenylpyrazoline-, acetyl CoA carboxylase (ACCase) inhibitor-, imidazolinone-, sulfonylurea-, pyrimidinylthiobenzoate-, triazolopyrimidine-sulfonamides, sulfonylaminocarbonyltriazolinone-, acetolactate synthase (ALS) or acetohydroxy acid synthase (AHAS) inhibitor-, 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitor-, phytoene desaturase inhibitor-, carotenoid biosynthesis inhibitor-, protoporphyrinogen oxidase (PPO) inhibitor-, cellulose biosynthesis inhibitor-, mitosis inhibitor-, microtubule inhibitor-, very long chain fatty acid inhibitor-, fatty acid and lipid biosynthesis inhibitor-, photosystem I inhibitor-, photosystem II inhibitor-, triazine-, or bromoxynil- tolerant crops.

A twenty-second embodiment includes method according to the twenty-first embodiment wherein the tolerant crop possesses multiple or stacked traits conferring tolerance to multiple herbicides or multiple modes of action.

A twenty-third embodiment includes methods according to either of the thirteenth or fourteenth embodiments wherein the undesirable vegetation comprises a herbicide resistant or tolerant weed.

A twenty-fourth embodiment includes method according to the twenty-third embodiment wherein the resistant or tolerant weed is a biotype with resistance or tolerance to multiple herbicides, multiple chemical classes, multiple herbicide modes-of-action or via multiple resistance mechanisms.

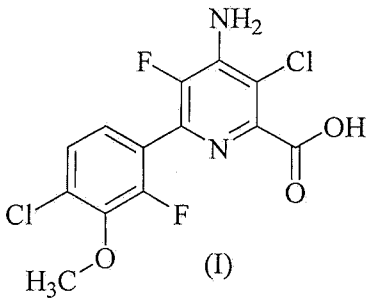
A twenty-fifth embodiment includes method according to the twenty-third embodiment wherein the resistant or tolerant weed is a biotype resistant or tolerant to acetolactate synthase (ALS) or acetohydroxy acid synthase (AHAS) inhibitors, photosystem II inhibitors, acetyl CoA carboxylase (ACCase) inhibitors, synthetic auxins, auxin transport inhibitors, photosystem I inhibitors, 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase inhibitors, microtubule assembly inhibitors, fatty acid and lipid biosynthesis 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.

A twenty-sixth embodiment includes methods according to any of the fourteenth through twenty-fifth embodiments wherein (b) is indaziflam or isoxaben or an agriculturally acceptable salt thereof.

## Detailed Description

### DEFINITIONS

As used herein, the compound of formula (I) has the following structure:



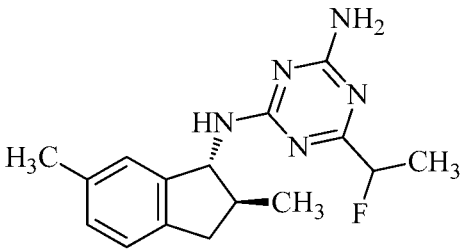

(I)

The compound of formula (I) can be identified by the name 4-amino-3-chloro-6-(4-chloro-2-fluoro-3-methoxyphenyl)-5-fluoropyridine-2-carboxylic acid and has been described in

U.S. Patent 7,314,849 (B2), which is incorporated herein by reference in its entirety. Exemplary uses of the compound of the formula (I) include controlling undesirable vegetation, including grass, broadleaf and sedge weeds, in multiple non-crop and cropping situations.

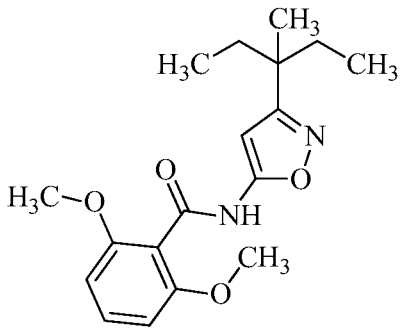
Without being limited to any theory, cellulose biosynthesis inhibitors (CBIs) affect the assembly of cellulose, thereby stopping weed growth by inhibiting the development of root cells. Exemplary CBI herbicides include, but are not limited to, indaziflam and isoxaben and agriculturally acceptable salts thereof.

As used herein, indaziflam is *N*-[(1*R*,2*S*)-2,3-dihydro-2,6-dimethyl-1*H*-inden-1-yl]-6-(1-fluoroethyl)-1,3,5-triazine-2,4-diamine and possesses the following structure:



The compound has been described in: Ahrens et al. Abstracts of Papers, 242nd ACS National Meeting & Exposition, Denver, CO, United States, August 28-September 1, 2011 (2011), AGRO-84.

As used herein, isoxaben is *N*-[3-(1-ethyl-1-methylpropyl)-5-isoxazolyl]-2, 6-dimethoxybenzamide and possesses the following structure:



The compound has been described in Tomlin, C., ed. A World Compendium The Pesticide Manual. 15th ed. Alton: BCPC Publications, 2009 (hereafter "*The Pesticide Manual*, Fifteenth Edition, 2009."). Exemplary uses of isoxaben include its use for pre-emergence control of autumn- and spring-germinating broadleaf weeds, *e.g.*, in winter and spring cereals, turf, fruit, berries, onions, garlic, vines, forestry, ornamental trees and shrubs, and non-bearing fruit and nut trees.

As used herein, herbicide means a compound, e.g., 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 which causes an adversely modifying effect to the vegetation *e.g.*, causing deviations from natural development, killing, effecting regulation, causing desiccation, causing retardation, and the like.

As used herein, controlling undesirable vegetation means preventing, reducing, killing, or otherwise adversely modifying the development of plants and vegetation. Described herein are methods of controlling undesirable vegetation through the application of certain herbicide combinations or compositions. Methods of application include, but are not

limited to applications to the vegetation or locus thereof, e.g., application to the area adjacent to the vegetation, as well as preemergence, postemergence, foliar (broadcast, directed, banded, spot, mechanical, over-the-top, or rescue), and in-water applications (emerged and submerged vegetation, broadcast, spot, mechanical, water-injected, granular broadcast, granular spot, shaker bottle, or stream spray) via hand, backpack, machine, tractor, or aerial (airplane and helicopter) application methods.

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

As used herein, agriculturally acceptable salts and esters refer to salts and esters that exhibit herbicidal activity, or that are or can be converted in plants, water, or soil to the referenced herbicide. Exemplary agriculturally acceptable esters are those that are or can be hydrolyzed, oxidized, metabolized, or otherwise converted, *e.g.*, in plants, water, or soil, to the corresponding carboxylic acid which, depending on the pH, may be in the dissociated or undissociated form.

Exemplary salts include those derived from alkali or alkaline earth metals and those derived from ammonia and amines. Exemplary cations include sodium, potassium, magnesium, and aminium cations of the formula:

$$R^1R^2R^3R^4N^+$$

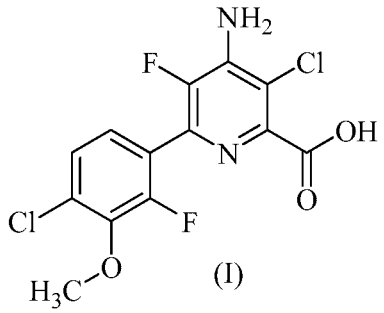
wherein $R^1$, $R^2$, $R^3$ and $R^4$ each, independently represents hydrogen or $C_1$-$C_{12}$ alkyl, $C_3$-$C_{12}$ alkenyl or $C_3$-$C_{12}$ alkynyl, each of which is optionally substituted by one or more hydroxy, $C_1$-$C_4$ alkoxy, $C_1$-$C_4$ alkylthio or phenyl groups, provided that $R^1$, $R^2$,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

Exemplary esters include those derived from $C_1$-$C_{12}$ alkyl, $C_3$-$C_{12}$ alkenyl, $C_3$-$C_{12}$ alkynyl or $C_7$-$C_{10}$ aryl-substituted alkyl alcohols, such as methyl alcohol, isopropyl alcohol, 1-butanol, 2-ethylhexanol, butoxyethanol, methoxypropanol, allyl alcohol, propargyl alcohol,

cyclohexanol or unsubstituted or substituted benzyl alcohols. Benzyl alcohols may be substituted with from 1-3 substituents independently selected from halogen, $C_1$-$C_4$ alkyl or $C_1$-$C_4$ alkoxy. Esters can be prepared by coupling of the acids with the alcohol using any number of suitable activating agents such as those used for peptide couplings such as dicyclohexylcarbodiimide (DCC) or carbonyl diimidazole (CDI); by reacting the acids with alkylating agents such as alkylhalides or alkylsulfonates in the presence of a base such as triethylamine or lithium carbonate; by reacting the corresponding acid chloride of an acid with an appropriate alcohol; by reacting the corresponding acid with an appropriate alcohol in the presence of an acid catalyst or by transesterification.

COMPOSITIONS AND METHODS

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




(I)

or an agriculturally acceptable salt or ester of thereof, and (b) a CBI .

Provided herein are also methods of controlling undesirable vegetation comprising contacting the vegetation or the locus thereof, i.e., the area adjacent to the vegetation, with or applying to the soil or water to prevent the emergence or growth of vegetation a herbicidally effective amount of the compound of formula (I) or agriculturally acceptable salt or ester thereof and (b) a CBI. In certain embodiments, the methods employ the compositions described herein.

Furthermore, in some embodiments, the combination of compound (I) or agriculturally acceptable salt or ester thereof and CBI herbicides, or an agriculturally acceptable salt or ester thereof exhibits 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." Senseman, S., ed. Herbicide Handbook. 9th ed. Lawrence: Weed Science Society of America, 2007. In

certain embodiments, the compositions exhibit synergy as determined by the Colby's equation. Colby, S.R. 1967. Calculation of the synergistic and antagonistic response of herbicide combinations. Weeds 15:20-22. In certain embodiments of the compositions and methods described herein, the compound of formula (I), i.e., the carboxylic acid, is employed. In certain embodiments, a carboxylate salt of the compound of formula (I) is employed. In certain embodiments, an aralkyl or alkyl ester is employed. In certain embodiments, a benzyl, substituted benzyl, or $C_{1-4}$ alkyl, *e.g.*, n-butyl ester is employed. In certain embodiments, the benzyl ester is employed.

In certain embodiments, the CBI is indaziflam and isoxaben or agriculturally acceptable salts thereof

In some embodiments, the compound of formula (I) or salt or ester thereof and indaziflam or isoxaben, or an agriculturally acceptable salt thereof are formulated in one composition, tank mixed, applied simultaneously, or applied sequentially.

Herbicidal activity is exhibited by the compounds when they are applied 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 components, the environmental conditions at the time of use, the specific compound employed, the specific adjuvants and carriers employed, the soil type, and the like, as well as the amount of chemical applied. These and other factors can be adjusted to promote non-selective or selective herbicidal action. In some embodiments, the compositions described herein are applied as a post-emergence application, pre-emergence application, or in-water application to flooded paddy rice or water bodies (*e.g.*, ponds, lakes and streams), to relatively immature undesirable vegetation to achieve the maximum control of weeds.

In some embodiments, the compositions and methods provided herein are utilized to control weeds in crops, including but not limited to direct-seeded, water-seeded and transplanted rice, cereals, wheat, barley, oats, rye, sorghum, corn/maize, sugarcane, sunflower, oilseed rape, canola, sugar beet, soybean, cotton, pineapple, pastures, grasslands, rangelands, fallowland, turf, tree and vine orchards, aquatics, plantation crops, vegetables, industrial vegetation management (IVM) and rights-of–way (ROW).

In certain embodiments, the compositions and methods provided herein are utilized to control weeds in rice. In certain embodiments, the rice is direct-seeded, water-seeded, or transplanted rice.

The compositions and methods described herein may be used to control undesirable vegetation in glyphosate-tolerant-, 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase inhibitor-tolerant-, glufosinate-tolerant-, glutamine synthetase inhibitor-tolerant-, dicamba-tolerant-, phenoxy auxin-tolerant-, pyridyloxy auxin-tolerant-, auxin-tolerant-, auxin transport inhibitor-tolerant-, aryloxyphenoxypropionate-tolerant-, cyclohexanedione-tolerant-, phenylpyrazoline-tolerant-, acetyl CoA carboxylase (ACCase) inhibitor-tolerant-, imidazolinone-tolerant-, sulfonylurea-tolerant-, pyrimidinylthiobenzoate-tolerant-, triazolopyrimidine-sulfonamide tolerant-, sulfonylaminocarbonyltriazolinone-tolerant-, acetolactate synthase (ALS) or acetohydroxy acid synthase (AHAS) inhibitor-tolerant-, 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitor -tolerant-, phytoene desaturase inhibitor-tolerant-, carotenoid biosynthesis inhibitor-tolerant-, protoporphyrinogen oxidase (PPO) inhibitor -tolerant-, cellulose biosynthesis inhibitor-tolerant-, mitosis inhibitor-tolerant-, microtubule inhibitor-tolerant-, very long chain fatty acid inhibitor-tolerant-, fatty acid and lipid biosynthesis inhibitor-tolerant-, photosystem I inhibitor-tolerant-, photosystem II inhibitor-tolerant-, triazine-tolerant-, and bromoxynil-tolerant- crops (such as, but not limited to, soybean, cotton, canola/oilseed rape, rice, cereals, corn, sorghum, sunflower, sugar beet, sugarcane, turf, etc.), for example, in conjunction with glyphosate, EPSP synthase inhibitors, glufosinate, glutamine synthase inhibitors, dicamba, phenoxy auxins, pyridyloxy auxins, synthetic auxins, auxin transport inhibitors, aryloxyphenoxypropionates, cyclohexanediones, phenylpyrazolines, ACCase inhibitors, imidazolinones, sulfonylureas, pyrimidinylthiobenzoates, triazolopyrimidines, sulfonylaminocarbonyltriazolinones, ALS or AHAS inhibitors, HPPD inhibitors, phytoene desaturase 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 crops possessing multiple or stacked traits conferring tolerance to multiple chemistries and/or inhibitors of multiple modes of action. In some embodiments, the compound of formula (I) or salt or ester thereof and complementary herbicide or salt or ester thereof are used in

combination with 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 embodiments, the compositions described herein and other complementary herbicides are applied at the same time, either as a combination formulation, as a tank mix, or sequentially.

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).

The compositions and methods provided herein are utilized to control undesirable vegetation. Undesirable vegetation includes, but is not limited to, undesirable vegetation that occurs in rice, cereals, cereals, wheat, barley, oats, rye, sorghum, corn/maize, sugarcane, sunflower, oilseed rape, canola, sugar beet, soybean, cotton, pineapple, pastures, grasslands, rangelands, fallowland, turf, tree and vine orchards, aquatics plantation crops, vegetables, industrial vegetation management (IVM) and rights of way (ROW)..

In some embodiments, the methods provided herein are utilized to control undesirable vegetation in rice. In certain embodiments, the undesirable vegetation is *Brachiaria platyphylla* (Groseb.) Nash or *Urochloa platyphylla* (Nash) R.D. Webster (broadleaf signalgrass, BRAPP), *Digitaria sanguinalis* (L.) Scop. (large crabgrass, DIGSA), *Echinochloa* species (ECHSS), *Echinochloa crus-galli* (L.) P. Beauv. (barnyardgrass, ECHCG), *Echinochloa crus-pavonis* (Kunth) Schult. (gulf cockspur, ECHCV), *Echinochloa colonum* (L.) LINK (junglerice, ECHCO), *Echinochloa oryzoides* (Ard.) Fritsch (early watergrass, ECHOR), *Echinochloa oryzicola* (Vasinger) Vasinger (late watergrass, ECHPH), *Echinochloa phyllopogon* (Stapf) Koso-Pol. (rice barnyardgrass, ECHPH), *Echinochloa polystachya* (Kunth) Hitchc. (creeping river grass, ECHPO), *Ischaemum rugosum* Salisb. (saramollagrass, ISCRU), *Leptochloa chinensis* (L.) Nees (Chinese sprangletop, LEFCH), *Leptochloa fascicularis* (Lam.) Gray (bearded sprangletop, LEFFA), *Leptochloa panicoides* (Presl.) Hitchc. (Amazon sprangletop, LEFPA), *Oryza* species (red and weedy rice, ORYSS), *Panicum dichotomiflorum* (L.) Michx. (fall panicum, PANDI), *Paspalum dilatatum* Poir. (dallisgrass, PASDI), *Rottboellia cochinchinensis* (Lour.) W.D. Clayton (itchgrass, ROOEX),

*Cyperus* species (CYPSS), *Cyperus difformis* L. (smallflower flatsedge, CYPDI), *Cyperus dubius* Rottb. (MAPDU), *Cyperus esculentus* L. (yellow nutsedge, CYPES), *Cyperus iria* L. (rice flatsedge, CYPIR), *Cyperus rotundus* L. (purple nutsedge, CYPRO), *Cyperus serotinus* Rottb./C.B.Clarke (tidalmarsh flatsedge, CYPSE), *Eleocharis* species (ELOSS), *Fimbristylis miliacea* (L.) Vahl (globe fringerush, FIMMI), *Schoenoplectus* species (SCPSS), *Schoenoplectus juncoides* Roxb. (Japanese bulrush, SCPJU), *Bolboschoenus maritimus* (L.) Palla or *Schoenoplectus maritimus* L. Lye (sea clubrush, SCPMA), *Schoenoplectus mucronatus* L. (ricefield bulrush, SCPMU), *Aeschynomene* species, (jointvetch, AESSS), *Alternanthera philoxeroides* (Mart.) Griseb. (alligatorweed, ALRPH), *Alisma plantago-aquatica* L. (common waterplantain, ALSPA), *Amaranthus* species, (pigweeds and amaranths, AMASS), *Ammannia coccinea* Rottb. (redstem, AMMCO), *Commelina benghalensis* L. (Benghal dayflower, COMBE), *Eclipta alba* (L.) Hassk. (American false daisy, ECLAL), *Heteranthera limosa* (SW.) Willd./Vahl (ducksalad, HETLI), *Heteranthera reniformis* R. & P. (roundleaf mudplantain, HETRE), *Ipomoea* species (morningglories, IPOSS), *Ipomoea hederacea* (L.) Jacq. (ivyleaf morningglory, IPOHE), *Lindernia dubia* (L.) Pennell (low false pimpernel, LIDDU), *Ludwigia* species (LUDSS), *Ludwigia linifolia* Poir. (southeastern primrose-willow, LUDLI), *Ludwigia octovalvis* (Jacq.) Raven (longfruited primrose-willow, LUDOC), *Monochoria korsakowii* Regel & Maack (monochoria, MOOKA), *Monochoria vaginalis* (Burm. F.) C. Presl ex Kuhth, (monochoria, MOOVA), *Murdannia nudiflora* (L.) Brenan (doveweed, MUDNU), *Polygonum pensylvanicum* L., (Pennsylvania smartweed, POLPY), *Polygonum persicaria* L. (ladysthumb, POLPE), *Polygonum hydropiperoides* Michx. (POLHP, mild smartweed), *Rotala indica* (Willd.) Koehne (Indian toothcup, ROTIN), *Sagittaria* species, (arrowhead, SAGSS), *Sesbania exaltata* (Raf.) Cory/Rydb. Ex Hill (hemp sesbania, SEBEX), or *Sphenoclea zeylanica* Gaertn. (gooseweed, SPDZE).

In some embodiments, the methods provided herein are utilized to control undesirable vegetation in cereals. In certain embodiments, the undesirable vegetation is *Alopecurus myosuroides* Huds. (blackgrass, ALOMY), *Apera spica-venti* (L.) Beauv. (windgrass, APESV), *Avena fatua* L. (wild oat, AVEFA), *Bromus tectorum* L. (downy brome, BROTE), *Lolium multiflorum* Lam. (Italian ryegrass, LOLMU), *Phalaris minor* Retz. (littleseed canarygrass, PHAMI), *Poa annua* L. (annual bluegrass, POANN), *Setaria pumila* (Poir.) Roemer & J.A. Schultes (yellow foxtail, SETLU), *Setaria viridis* (L.) Beauv. (green foxtail,

SETVI), *Amaranthus retroflexus* L. (redroot pigweed, AMARE), *Brassica* species (BRSSS), *Chenopodium album* L. (common lambsquarters, CHEAL), *Cirsium arvense* (L.) Scop. (Canada thistle, CIRAR), *Galium aparine* L. (catchweed bedstraw, GALAP), *Kochia scoparia* (L.) Schrad. (kochia, KCHSC), *Lamium purpureum* L. (purple deadnettle , LAMPU), *Matricaria recutita* L. (wild chamomile, MATCH), *Matricaria matricarioides* (Less.) Porter (pineappleweed, MATMT), *Papaver rhoeas* L. (common poppy, PAPRH), *Polygonum convolvulus* L. (wild buckwheat, POLCO), *Salsola tragus* L. (Russian thistle, SASKR), *Sinapis* species (SINSS), *Sinapis arvensis* L. (wild mustard, SINAR), *Stellaria media* (L.) Vill. (common chickweed, STEME), *Veronica persica* Poir. (Persian speedwell, VERPE), *Viola arvensis* Murr. (field violet, VIOAR), or *Viola tricolor* L. (wild violet, VIOTR).

In some embodiments, the methods provided herein are utilized to control undesirable vegetation in range and pasture, fallowland, IVM and ROW. In certain embodiments, the undesirable vegetation is *Ambrosia artemisiifolia* L. (common ragweed, AMBEL), *Cassia obtusifolia* (sickle pod, CASOB), *Centaurea maculosa* auct. non Lam. (spotted knapweed, CENMA), *Cirsium arvense* (L.) Scop. (Canada thistle, CIRAR), *Convolvulus arvensis* L. (field bindweed, CONAR), *Daucus carota* L. (wild carrot, DAUCA), *Euphorbia esula* L. (leafy spurge, EPHES), *Lactuca serriola* L./Torn. (prickly lettuce, LACSE), *Plantago lanceolata* L. (buckhorn plantain, PLALA), *Rumex obtusifolius* L. (broadleaf dock, RUMOB), *Sida spinosa* L. (prickly sida, SIDSP), *Sinapis arvensis* L. (wild mustard, SINAR), *Sonchus arvensis* L. (perennial sowthistle, SONAR), *Solidago* species (goldenrod, SOOSS), *Taraxacum officinale* G.H. Weber ex Wiggers (dandelion, TAROF), *Trifolium repens* L. (white clover, TRFRE), or *Urtica dioica* L. (common nettle, URTDI).

In some embodiments, the methods provided herein are utilized to control undesirable vegetation found in row crops, tree and vine crops, and perennial crops. In certain embodiments, the undesirable vegetation is *Alopecurus myosuroides* Huds. (blackgrass, ALOMY), *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), *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. or *Spermacoce alata* Aubl. (broadleaf buttonweed, BOILF), *Spermacose latifolia* (broadleaved button weed, 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, EPHHI), *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. (Canadian fleabane, 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 purslane, POROL), *Richardia* species (pusley, RCHSS), *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 cocklebur, XANST).

In some embodiments, the methods provided herein are utilized to control undesirable vegetation in turf. In certain embodiments, the undesirable vegetation is *Bellis perennis* L. (English daisy, BELPE), *Cyperus esculentus* L. (yellow nutsedge, CYPES), *Cyperus* species (CYPSS), *Digitaria sanguinalis* (L.) Scop. (large crabgrass, DIGSA), *Diodia virginiana* L. (Virginia buttonweed, DIQVI), *Euphorbia* species (spurge, EPHSS), *Glechoma hederacea* L. (ground ivy, GLEHE), *Hydrocotyle umbellata* L. (dollarweed, HYDUM), *Kyllinga* species (kyllinga, KYLSS), *Lamium amplexicaule* L. (henbit, LAMAM), *Murdannia nudiflora* (L.) Brenan (doveweed, MUDNU), *Oxalis* species (woodsorrel, OXASS), *Plantago major* L. (broadleaf plantain, PLAMA), *Plantago lanceolata* L. (buckhorn/narrowleaf plantain, PLALA), *Phyllanthus urinaria* L. (chamberbitter, PYLTE), *Rumex obtusifolius* L. (broadleaf dock, RUMOB), *Stachys floridana* Shuttlew. (Florida betony, STAFL), *Stellaria media* (L.) Vill. (common chickweed, STEME), *Taraxacum officinale* G.H. Weber ex Wiggers (dandelion, TAROF), *Trifolium repens* L. (white clover, TRFRE), or *Viola* species (wild violet, VIOSS).

In some embodiments, the compositions and methods provided herein are utilized to control undesirable vegetation consisting of grass, broadleaf and sedge weeds. In certain embodiments, the compositions and methods provided herein are utilized to control undesirable vegetation including, but not limited to, *Abutilon, Amaranthus, Brachiaria, Brassica, Chenopodium, Cirsium, Cyperus, Digitaria, Galium, Ipomoea,* and *Leptochloa, Setaria, Sinapis, Stellaria,* and *Xanthium*In some embodiments, the combination of compound (I) or agriculturally acceptable ester or salt thereof and indaziflam and isoxaben, or agriculturally acceptable salt or ester thereof, is used to control *Abutilon theophrasti* Medik. (velvetleaf, ABUTH), *Amaranthus retroflexus* L. (redroot pigweed, AMARE), *Brachiaria platyphylla* (Griseb.) Nash or *Urochloa platyphylla* (Nash) R.D. Webster (broadleaf signalgrass, BRAPP), *Brassica napus* L. (oilseed rape, BRSNW), *Chenopodium album* L. (common lambsquarters, CHEAL), *Cirsium arvense* (L.) Scop. (Canada thistle, CIRAR), C*yperus iria* L. (rice flatsedge, CYPIR), *Digitaria sanguinalis* (L.) Scop. (large crabgrass, DIGSA), *Galium aparine* L. (catchweed bedstraw), *Ipomoea hederacea* Jacq. (ivyleaf morningglory, IPOHE), *Leptochloa chinensis* (L.) Nees (Chinese sprangletop, LEFCH), *Setaria faberi* Herrm. (giant foxtail, SETFA), *Sinapis arvensis* L. (wild mustard,

SINAR), *Stellaria media* (L.) Vill. (common chickweed, STEME), and *Xanthium strumarium* L. (common cocklebur, XANST).

The compounds of formula I or agriculturally acceptable salt or ester thereof may be used to control herbicide resistant or tolerant weeds. The methods employing the combination of a compound of formula I or agriculturally acceptable salt or ester thereof 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 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 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, 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).

In certain embodiments of the compositions and methods described herein, the compound of formula (I) or salt or ester thereof is used in combination with indaziflam or salt thereof. With regard to the compositions, in some embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to indaziflam or salt thereof is within the range of from about 1:75 to about 15:1. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to indaziflam or salt thereof is within the range of from 1:22 to about 2:1; from about 1:1 to about 1:3; or from about 1:3 to about 1:6. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to indaziflam or salt thereof is within the range of from 1:10 to about 9.5:1. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to indaziflam or salt thereof is within the range of from about 2:1 to about 1:20. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to indaziflam or salt thereof is within the range of from about 1:1 to about 1:9.6. In certain embodiments, the compositions provided herein comprise the compound of formula (I) or its benzyl or *n*-butyl ester and indaziflam. In one embodiment, the composition comprises the compound of formula (I) and indaziflam, wherein the weight ratio of the compound of formula (I) to indaziflam is about 1:1 to about 1:8. In one embodiment, the composition comprises the benzyl ester of the compound of formula (I) and indaziflam, wherein the weight ratio of the benzyl ester of the compound of formula (I) to indaziflam is about 1:1.2 to about 1:9.6. With respect to the methods, in certain embodiments, the methods comprise contacting the undesirable vegetation or locus thereof or applying to the soil or water to prevent the emergence or growth of vegetation a composition described herein. The application rate will depend upon the particular type of weed to be controlled, the degree of control required, and the timing and method of application. In some embodiments, the composition is applied at an application rate of from about 23 grams active ingredient per hectare (g ai/ha) to about 450 g ai/ha based on the total amount of active ingredients in the composition. In certain embodiments, the composition is applied at an application rate of from about 25 grams active ingredient per hectare (g ai/ha) to about 63 g ai/ha based on the total amount of active ingredients in the composition. In some embodiments, the methods

comprise contacting the undesirable vegetation or locus thereof or applying to the soil or water to prevent the emergence or growth of vegetation with a compound of formula (I) or salt or ester thereof and indaziflam or salt thereof, *e.g.*, sequentially or simultaneously. In some embodiments, the indaziflam or salt thereof is applied at a rate from about 8.75 g ai/ha to about 140 g ai/ha and the compound of formula (I) of salt or ester thereof is applied at a rate from about 2 g ae/ha to about 300 g ae/ha. In some embodiments, the indaziflam or salt thereof is applied at a rate from about 42 g ai/ha to about 84 g ai/ha and the compound of formula (I) of salt or ester thereof is applied at a rate from about 2 g acid equivalent per hectare (g ae/ha) to about 43 g ae/ha. In some embodiments, the indaziflam or salt thereof is applied at a rate from about 21 g ai/ha to about 42 g ai/ha and the compound of formula (I) of salt or ester thereof is applied at a rate from about 4.38 g acid equivalent per hectare (g ae/ha) to about 21.2 g ae/ha. In certain embodiments, the methods utilize the compound of formula (I), or its benzyl or *n*-butyl ester and indaziflam. In one embodiment, the methods utilize the compound of formula (I) and indaziflam, wherein the compound of formula (I) is applied at a rate of from about 5.3 g acid equivalent per hectare (g ae/ha) to about 21.2 g ae/ha, and indaziflam is applied at a rate of about 21 g ai/ha to about 42 g ai/ha. In one embodiment, the methods utilize the compound of formula (I) and indaziflam, wherein the compound of formula (I) is applied at a rate of from about 4.38 g acid equivalent per hectare (g ae/ha) to about 32 g ae/ha, and indaziflam is applied at a rate of about 17.5 g ai/ha to about 95 g ai/ha. In one embodiment, the methods utilize the benzyl ester of the compound of formula (I) and indaziflam, wherein the benzyl ester of the compound of formula (I) is applied at a rate of from about 4.38 g acid equivalent per hectare (g ae/ha) to about 17.5 g ae/ha, and indaziflam is applied at a rate of about 21 g ai/ha to about 42 g ai/ha. In certain embodiments, the methods and compositions utilizing the compound of formula (I) or salt or ester thereof in combination with indaziflam or salt thereof are used to control BRAPP, DIGSA, IPOHE, LEFCH, SETFA, and XANST.

In certain embodiments of the compositions and methods described herein, the compound of formula (I) or salt or ester thereof is used in combination with isoxaben. With regard to the compositions, in some embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to isoxaben is within the range of from about 1:560 to about 2:1. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to isoxaben is within the range of from 1:448 to about 1:1; from about 1:12 to

about 1:35; from about 1:8 to about 1:64; or from about 1:4 to about 1:35. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to isoxaben is within the range of from 1:127 to about 1:8. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to isoxaben is within the range of from about 1:4 to about 1:260. In certain embodiments, the weight ratio of the compound of formula (I) or salt or ester thereof to isoxaben is within the range of from about 1:8 to about 1:128. In certain embodiments, the compositions provided herein comprise the compound of formula (I) or its benzyl or *n*-butyl ester and isoxaben. In one embodiment, the composition comprises the compound of formula (I) and isoxaben, wherein the weight ratio of the compound of formula (I) to isoxaben is about 1:16 to about 1:128. In one embodiment, the composition comprises the benzyl ester of the compound of formula (I) and isoxaben, wherein the weight ratio of the benzyl ester of the compound of formula (I) to isoxaben is about 1:8 to about 1:128. With respect to the methods, in certain embodiments, the methods comprise contacting the undesirable vegetation or locus thereof or applying to the soil or water to prevent the emergence or growth of vegetation a composition described herein. In some embodiments, the composition is applied at an application rate of from about 142 grams active ingredient per hectare (g ai/ha) to about 1420 g ai/ha based on the total amount of active ingredients in the composition. In certain embodiments, the composition is applied at an application rate of from about 144 grams active ingredient per hectare (g ai/ha) to about 578 g ai/ha based on the total amount of active ingredients in the composition. In some embodiments, the methods comprise contacting the undesirable vegetation or locus thereof or applying to the soil or water to prevent the emergence or growth of vegetation with a compound of formula (I) or salt or ester thereof and isoxaben, *e.g.*, sequentially or simultaneously. In some embodiments, the isoxaben is applied at a rate from about 140 to about 1120 g ai/ha and the compound of formula (I) of salt or ester thereof is applied at a rate from about 2 g ae/ha to about 300 g ae/ha. In some embodiments, the isoxaben is applied at a rate from about 70 g ai/ha to about 1120 g ai/ha and the compound of formula (I) of salt or ester thereof is applied at a rate from about 2 g acid equivalent per hectare (g ae/ha) to about 45 g ae/ha. In some embodiments, the isoxaben is applied at a rate from about 140 g ai/ha to about 560 g ai/ha and the compound of formula (I) of salt or ester thereof is applied at a rate from about 4.38 g acid equivalent per hectare (g ae/ha) to about 17.5 g ae/ha. In certain embodiments, the methods utilize the compound of formula (I), or its benzyl or *n*-butyl ester

and isoxaben. In one embodiment, the methods utilize the compound of formula (I) and isoxaben, wherein the compound of formula (I) is applied at a rate of from about 2.5 g acid equivalent per hectare (g ae/ha) to about 32 g ae/ha, and isoxaben is applied at a rate of about 31 g ai/ha to about 1120 g ai/ha. In one embodiment, the methods utilize the compound of formula (I) and isoxaben, wherein the compound of formula (I) is applied at a rate of from about 4.38 g acid equivalent per hectare (g ae/ha) to about 17.5 g ae/ha, and isoxaben is applied at a rate of about 140 g ai/ha to about 560 g ai/ha. In one embodiment, the methods utilize the compound of formula (I) and isoxaben, wherein the compound of formula (I) is applied at a rate of from about 4.38 g acid equivalent per hectare (g ae/ha) to about 35 g ae/ha, and isoxaben is applied at a rate of about 140 g ai/ha to about 1,120 g ai/ha. In one embodiment, the methods utilize the benzyl ester of the compound of formula (I) and isoxaben, wherein the benzyl ester of the compound of formula (I) is applied at a rate of from about 4.38 g acid equivalent per hectare (g ae/ha) to about 17.5 g ae/ha, and isoxaben is applied at a rate of about 140 g ai/ha to about 560 g ai/ha. In certain embodiments, the methods and compositions utilizing the compound of formula (I) or salt or ester thereof in combination with isoxaben are used to control ABUTH, AMARE, BRAPP, BRSNW, CHEAL, CIRAR, CYPIR, DIGSA, GALAP, IPOHE, LEFCH, SINAR, or STEME.

The components of the mixtures described herein can be applied either separately or as part of a multipart herbicidal system.

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: 4-CPA; 4-CPB; 4-CPP; 2,4-D; 2,4-D choline salt, 2,4-D esters and amines, 2,4-DB; 3,4-DA; 3,4-DB; 2,4-DEB; 2,4-DEP; 3,4-DP; 2,3,6-TBA; 2,4,5-T; 2,4,5-TB; acetochlor, acifluorfen, aclonifen, acrolein, alachlor, allidochlor, alloxydim, allyl alcohol, alorac, ametridione, ametryn, amibuzin, amicarbazone, amidosulfuron, aminocyclopyrachlor, aminopyralid, amiprofos-methyl, amitrole, ammonium sulfamate, anilofos, anisuron, asulam, atraton, atrazine, azafenidin, azimsulfuron, aziprotryne, barban, BCPC, beflubutamid, benazolin, bencarbazone, benfluralin, benfuresate, bensulfuron-methyl, bensulide, benthiocarb,

bentazon-sodium, benzadox, benzfendizone, benzipram, benzobicyclon, benzofenap, benzofluor, benzoylprop, benzthiazuron, bialaphos, bicyclopyrone, bifenox, bilanafos, bispyribac-sodium, 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, chlorbromuron, chlorbufam, chloreturon, chlorfenac, chlorfenprop, chlorflurazole, chlorflurenol, chloridazon, chlorimuron, chlornitrofen, chloropon, chlorotoluron, chloroxuron, chloroxynil, chlorpropham, chlorsulfuron, chlorthal, chlorthiamid, cinidon-ethyl, cinmethylin, cinosulfuron, cisanilide, 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, ethbenzamide, ethametsulfuron, ethidimuron, ethiolate, ethobenzamid, etobenzamid, ethofumesate, ethoxyfen, ethoxysulfuron, etinofen, etnipromid, etobenzanid, EXD, fenasulam, fenoprop, fenoxaprop, fenoxaprop-P-ethyl, fenoxaprop-P-ethyl + isoxadifen-ethyl, fenoxasulfone, fenteracol, fenthiaprop, fentrazamide, fenuron, ferrous sulfate, flamprop, flamprop-M, flazasulfuron, florasulam, fluazifop, fluazifop-P-butyl, fluazolate, flucarbazone, flucetosulfuron, fluchloralin, flufenacet, flufenican, flufenpyr-ethyl, flumetsulam, flumezin, flumiclorac-pentyl, flumioxazin, flumipropyn, fluometuron, fluorodifen, fluoroglycofen, fluoromidine, fluoronitrofen, fluothiuron, flupoxam, flupropacil, flupropanate, flupyrsulfuron, fluridone, flurochloridone, fluroxypyr, fluroxypyr-meptyl, flurtamone, fluthiacet, fomesafen, foramsulfuron, fosamine, fumiclorac, furyloxyfen, glufosinate, glufosinate salts and esters,

glufosinate-ammonium, glufosinate-P-ammonium, glyphosate, glyphosate salts and esters, halauxifen, halauxifen-methyl, halosafen, halosulfuron-methyl, haloxydine, haloxyfop-methyl, haloxyfop-P-methyl, hexachloroacetone, hexaflurate, hexazinone, imazamethabenz, imazamox, imazapic, imazapyr, imazaquin, imazosulfuron, imazethapyr, indanofan, iodobonil, iodomethane, iodosulfuron, iodosulfuron-ethyl-sodium, iofensulfuron, ioxynil, ipazine, ipfencarbazone, iprymidam, isocarbamid, isocil, isomethiozin, isonoruron, isopolinate, isopropalin, isoproturon, isouron, 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, metazosulfuron, metflurazon, methabenzthiazuron, methalpropalin, methazole, methiobencarb, methiozolin, methiuron, methometon, methoprotryne, methyl bromide, methyl isothiocyanate, methyldymron, metobenzuron, metobromuron, metolachlor, metosulam, metoxuron, metribuzin, metsulfuron, metsulfuron-methyl, molinate, monalide, monisouron, monochloroacetic acid, monolinuron, monuron, morfamquat, MSMA, naproanilide, napropamide, 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-methyl, procyazine, prodiamine, profluazol, profluralin, profoxydim, proglinazine, prohexadione-calcium, prometon, prometryn, pronamide, propachlor, propanil, propaquizafop, propazine, propham, propisochlor, propoxycarbazone, propyrisulfuron, propyzamide, prosulfalin, prosulfocarb, prosulfuron, proxan, prynachlor, pydanon, pyraclonil, pyraflufen-ethyl, pyrasulfotole, pyrazogyl, pyrazolynate, pyrazosulfuron-ethyl, pyrazoxyfen, pyribenzoxim, pyributicarb, pyriclor, pyridafol, pyridate, pyriftalid, pyriminobac, pyrimisulfan, pyrithiobac-sodium, pyroxasulfone, pyroxsulam, quinclorac, quinmerac, quinoclamine, quinonamid, quizalofop, quizalofop-P-ethyl, 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, SYN-523, TCA, tebutam, tebuthiuron, tefuryltrione, tembotrione, tepraloxydim, terbacil, terbucarb, terbuchlor, terbumeton, terbuthylazine, terbutryn, tetrafluron, thenylchlor, thiazafluron, thiazopyr, thidiazimin, thidiazuron, thiencarbazone-methyl, thifensulfuron, thifensulfurn-methyl, thiobencarb, tiocarbazil, tioclorim, topramezone, tralkoxydim, triafamone, tri-allate, triasulfuron, triaziflam, tribenuron, tribenuron-methyl, tricamba, triclopyr choline salt, triclopyr esters and salts, tridiphane, trietazine, trifloxysulfuron, trifluralin, triflusulfuron, trifop, trifopsime, trihydroxytriazine, trimeturon, tripropindan, tritac tritosulfuron, vernolate, xylachlor and salts, esters, optically active isomers and mixtures thereof.

The compositions and methods described herein, can further be used in conjunction with glyphosate, 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase inhibitors, glufosinate, glutamine synthetase inhibitors, dicamba, phenoxy auxins, pyridyloxy auxins, synthetic auxins, auxin transport inhibitors, aryloxyphenoxypropionates, cyclohexanediones, phenylpyrazolines, acetyl CoA carboxylase (ACCase) inhibitors, imidazolinones, sulfonylureas, pyrimidinylthiobenzoates, triazolopyrimidines, sulfonylaminocarbonyltriazolinones, acetolactate synthase (ALS) or acetohydroxy acid synthase (AHAS) inhibitors, 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitors, phytoene desaturase inhibitors, carotenoid biosynthesis inhibitors, protoporphyrinogen oxidase (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 on glyphosate-tolerant, EPSP synthase inhibitor-tolerant, glufosinate-tolerant, glutamine synthetase inhibitor-tolerant, dicamba-tolerant, phenoxy auxin-tolerant, pyridyloxy auxin-tolerant, auxin-tolerant, auxin transport inhibitor-tolerant, aryloxyphenoxypropionate-tolerant, cyclohexanedione-tolerant, phenylpyrazoline-tolerant, ACCase-tolerant, imidazolinone-tolerant, sulfonylurea-tolerant, pyrimidinylthiobenzoate-tolerant, triazolopyrimidine-sulfonamide-tolerant, sulfonylaminocarbonyltriazolinone-tolerant, ALS- or AHAS-tolerant, HPPD-tolerant, phytoene desaturase inhibitor-tolerant, carotenoid biosynthesis inhibitor tolerant, PPO-tolerant, cellulose biosynthesis inhibitor-tolerant, mitosis inhibitor-tolerant, microtubule inhibitor-tolerant, very long chain fatty acid inhibitor-tolerant, fatty acid and lipid biosynthesis inhibitor-tolerant, photosystem I inhibitor-tolerant, photosystem II

inhibitor-tolerant, triazine-tolerant, bromoxynil-tolerant, and crops possessing multiple or stacked traits conferring tolerance to multiple chemistries and/or multiple modes of action via single and/or multiple resistance mechanisms. In some embodiments, the compound of formula (I) or salt or ester thereof and complementary herbicide or salt or ester thereof are used in combination with 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 embodiments, the compositions described herein and other complementary herbicides are applied at the same time, either as a combination formulation, as a tank mix, or as a sequential application. In some embodiments, the compositions described herein are employed in combination with one or more herbicide safeners, such as AD-67 (MON 4660), benoxacor, benthiocarb, brassinolide, cloquintocet (mexyl), cyometrinil, daimuron, dichlormid, dicyclonon, dimepiperate, disulfoton, fenchlorazole-ethyl, fenclorim, flurazole, fluxofenim, furilazole, harpin proteins, isoxadifen-ethyl, jiecaowan, jiecaoxi, mefenpyr-diethyl, mephenate, naphthalic anhydride (NA), oxabetrinil, R29148 and *N*-phenyl-sulfonylbenzoic acid amides, to enhance their selectivity. In some embodiments, the safeners are employed in 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).

In some embodiments, the compositions described herein are employed in combination with one or more plant growth regulators, such as 2,3,5-tri-iodobenzoic acid, IAA, IBA, naphthaleneacetamide, α-naphthaleneacetic acids, benzyladenine, 4-hydroxyphenethyl alcohol, kinetin, zeatin, endothal, ethephon, pentachlorophenol, thidiazuron, tribufos, aviglycine, gibberellins, gibberellic acid, abscisic acid, ancymidol, fosamine, glyphosine, isopyrimol, jasmonic acid, maleic hydrazide, mepiquat, 2,3,5-tri-iodobenzoic acid, morphactins, dichlorflurenol, flurprimidol, mefluidide, paclobutrazol, tetcyclacis, uniconazole, brassinolide, brassinolide-ethyl, cycloheximide, ethylene, methasulfocarb, prohexadione, triapenthenol and trinexapac.

In some embodiments, the plant growth regulators are employed in one or more crops or settings, such as rice, cereal crops, corn, maize, broadleaf crops, oilseed rape/canola, turf, pineapple, sugarcane, sunflower, pastures, grasslands, rangelands, fallowland, turf, tree and vine orchards, plantation crops, vegetables, and non-crop (ornamentals) settings. In some

embodiments, the plant growth regulator is mixed with the compound of formula (I), or mixed with the compound of formula (I) and cellulose biosynthesis inhibitors to cause a preferentially advantageous effect on plants.

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, 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; $C_9$-$C_{11}$ alkylpolyglycoside; phosphated alcohol ethoxylate; natural primary alcohol ($C_{12}$-$C_{16}$) ethoxylate; di-*sec*-butylphenol EO-PO block copolymer; polysiloxane-methyl cap; nonylphenol ethoxylate + urea ammonium nitrate; emulsified methylated seed oil; tridecyl alcohol (synthetic) ethoxylate (8EO); tallow amine ethoxylate (15 EO); PEG(400) dioleate-99.

Liquid carriers that can be employed include water and organic solvents. The organic solvents include, but are not limited to, petroleum fractions or hydrocarbons such as mineral oil, aromatic solvents, paraffinic oils, and the like; vegetable oils such as soybean oil, rapeseed oil, olive oil, castor oil, sunflower seed oil, coconut oil, corn oil, cottonseed oil, linseed oil, palm oil, peanut oil, safflower oil, sesame oil, tung oil and the like; esters of the above vegetable oils; esters of monoalcohols or dihydric, trihydric, or other lower polyalcohols (4-6 hydroxy containing), such as 2-ethyl hexyl stearate, *n*-butyl oleate, isopropyl myristate, propylene glycol dioleate, di-octyl succinate, di-butyl adipate, di-octyl phthalate and the like; esters of mono, di and polycarboxylic acids and the like. Specific organic solvents include, but are not limited to toluene, xylene, petroleum naphtha, crop oil, acetone, methyl ethyl ketone, cyclohexanone, trichloroethylene, perchloroethylene, ethyl

acetate, amyl acetate, butyl acetate, propylene glycol monomethyl ether and diethylene glycol monomethyl ether, methyl alcohol, ethyl alcohol, isopropyl alcohol, amyl alcohol, ethylene glycol, propylene glycol, glycerine, *N*-methyl-2-pyrrolidinone, *N,N*-dimethyl alkylamides, dimethyl sulfoxide, liquid fertilizers and the like. In certain embodiments, Water is the carrier for the dilution of concentrates.

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

In some embodiments, the compositions described herein further comprise one or more surface-active agents. In some embodiments, such surface-active agents are employed in both solid and liquid compositions, and in certain embodiments those designed to be diluted with carrier before application. The surface-active agents can be anionic, cationic or nonionic in character and can be employed as emulsifying agents, wetting agents, suspending 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 Corp., Ridgewood, New Jersey, 1998 and in "Encyclopedia of Surfactants," Vol. I-III, Chemical Publishing Co., 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-$C_{18}$ ethoxylate; alcohol-alkylene oxide addition products, such as tridecyl alcohol-$C_{16}$ ethoxylate; soaps, such as sodium stearate; alkyl-naphthalene-sulfonate salts, such as sodium dibutylnaphthalenesulfonate; 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.

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 embodiment's about 0.5 to 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 0.0006 to 10.0 weight percent active ingredient and in certain embodiments contain about 0.001 to 6.0 weight percent.

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

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.

Examples

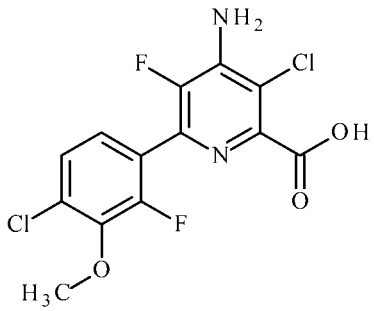
Results in Examples I, II, and III are greenhouse trial results.

Example I. Evaluation of Postemergence Foliar-Applied Herbicidal Mixtures for Weed Control in Direct Seeded Rice

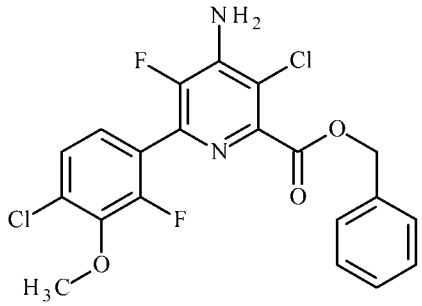
Seeds or nutlets of the desired test plant species were planted in a soil matrix prepared by mixing a loam or sandy loam soil (*e.g.*, 28.6 percent silt, 18.8 percent clay, and 52.6 percent sand, with a pH of about 5.8 and an organic matter content of about 1.8 percent) and calcareous grit in an 80 to 20 ratio. The soil matrix was contained in plastic pots with a volume of 1 quart and a surface area of 83.6 square centimeters ($cm^2$). When required to ensure good germination and healthy plants, a fungicide treatment and/or other chemical or physical treatment was applied. The plants were grown for 8-22 days in a greenhouse with an approximate 14 h photoperiod which was maintained at about 29° C during the day and 26° C during the night. Nutrients (Peters Excel® 15-5-15 5-Ca 2-Mg and iron chelate) were applied in the irrigation solution as needed and water was added on a regular basis. Supplemental lighting was provided with overhead metal halide 1000-Watt lamps as necessary. The plants were employed for testing when they reached the first through fourth true leaf stage.

Treatments consisted of the acid or esters of 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxy-phenyl) pyridine-2-carboxylic acid (Compound A), each formulated as an SC (suspension concentrate), and various herbicidal components alone and in combination. Forms of compound A were applied on an acid equivalent basis.

Forms of compound A (compound of formula I) tested include:




Compound A Acid



Compound A Benzyl Ester

Other herbicidal components were applied on an active ingredient basis and included cellulose biosynthesis-inhibiting (CBI) herbicides isoxaben formulated as Gallery® 75DF and indaziflam formulated as Specticle® 20WSP.

Treatment requirements were calculated based upon the rates being tested, the concentration of active ingredient or acid equivalent in the formulation, and a 12 mL application volume at a rate of 187 L/ha.

For treatments comprised of formulated compounds, measured amounts of compounds were placed individually in 25 mL glass vials and diluted in a volume of 1.25% (v/v) Agri-Dex® crop oil concentrated to obtain 12X stock solutions. If a test compound did not dissolve readily, the mixture was warmed and/or sonicated. Application solutions were prepared by adding an appropriate amount of each stock solution (*e.g.*, 1 mL) and diluted to the appropriate final concentrations with the addition of 10 mL of an aqueous mixture of 1.25% (v/v) crop oil concentrate so that the final spray solutions contained 1.25+/-0.05% (v/v) crop oil concentrate.

For treatments comprised of technical compounds, weighed amounts can be placed individually in 25 mL glass vials and dissolved in a volume of 97:3 v/v acetone/DMSO to obtain 12X stock solutions. If a test compound does not dissolve readily, the mixture can be warmed and/or sonicated. Application solutions can be prepared by adding an appropriate amount of each stock solution (*e.g.*, 1 mL) and diluted to the appropriate final concentrations with the addition of 10 mL of an aqueous mixture of 1.5% (v/v) crop oil concentrate so that the final spray solutions contain 1.25% (v/v) crop oil concentrate. When technical materials are used, the concentrated stock solutions can be added to the spray solutions so that the final acetone and DMSO concentrations of the application solutions are 16.2% and 0.5%, respectively.

For treatments comprised of formulated and technical compounds, weighed amounts of the technical materials can be placed individually in 25 mL glass vials and dissolved in a volume of 97:3 v/v acetone/DMSO to obtain 12X stock solutions, and measured amounts of the formulated compounds can be placed individually in 25 mL glass vials and diluted in a volume of 1.5% (v/v) crop oil concentrate or water to obtain 12X stock solutions. If a test compound does not dissolve readily, the mixture can be warmed and/or sonicated. Application solutions can be prepared by adding an appropriate amount of each stock solution (*e.g.*, 1 mL) and diluted to the appropriate final concentrations with the addition of an appropriate amount of an aqueous mixture of 1.5% (v/v) crop oil concentrate so that the final spray solutions contain 1.25% (v/v) crop oil concentrate. As required, additional water and/or 97:3 v/v acetone/DMSO can be added to individual application solutions so that the final acetone and DMSO concentrations of the application solutions being compared are 8.1% and 0.25%, respectively.

All stock solutions and applications solutions were visually inspected for compound compatibility prior to application. Spray solutions were applied to the plant material with an overhead Mandel track sprayer equipped with a 8002E nozzles calibrated to deliver 187 L/ha over an application area of 0.503 $m^2$ at a spray height of 18 to 20 inches (46 to 50 cm) above average plant canopy height. Control plants were sprayed in the same manner with the solvent blank.

The treated plants and control plants were placed in a greenhouse as described above and watered by sub-irrigation to prevent wash-off of the test compounds. After approximately 3 weeks, the condition of the test plants as compared with that of the untreated plants was determined visually and scored on a scale of 0 to 100 percent where 0 corresponds to no injury or growth inhibition and 100 corresponds to complete kill.

Colby's equation was used to determine the herbicidal effects expected from the mixtures (Colby, S.R. 1967. Calculation of the synergistic and antagonistic response of herbicide combinations. Weeds 15:20-22.) .

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

$$\text{Expected} = A + B - (A \times B/100)$$

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

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

The compounds tested, application rates employed, plant species tested, and results are given in Tables 1-4.

Table 1. Synergistic Activity of Foliar-Applied Compound A Acid and Isoxaben Herbicidal Compositions on Control of Weeds Common to Rice Cropping Systems.

| Compound A Acid | Isoxaben | Visual Weed Control (%) - 20 DAA | |
|---|---|---|---|
| | | BRAPP | |
| g ae/ha | g ai/ha | Obs | Exp |
| 4.38 | 0 | 75 | - |
| 8.75 | 0 | 80 | - |
| 0 | 140 | 0 | - |
| 0 | 280 | 0 | - |
| 0 | 560 | 20 | - |
| 4.38 | 140 | 90 | 75 |
| 8.75 | 140 | 95 | 80 |
| 4.38 | 280 | 85 | 75 |
| 8.75 | 280 | 100 | 80 |
| 4.38 | 560 | 95 | 80 |
| 8.75 | 560 | 90 | 84 |

| Compound A Acid | Isoxaben | Visual Weed Control (%) - 20 DAA | |
|---|---|---|---|
| | | DIGSA | |
| g ae/ha | g ai/ha | Obs | Exp |
| 8.75 | 0 | 45 | - |
| 17.5 | 0 | 50 | - |
| 0 | 280 | 10 | - |
| 0 | 560 | 20 | - |
| 8.75 | 280 | 70 | 51 |
| 17.5 | 280 | 75 | 55 |
| 8.75 | 560 | 85 | 56 |
| 17.5 | 560 | 90 | 60 |

| Compound A Acid | Isoxaben | Visual Weed Control (%) - 20 DAA |
|---|---|---|
| | | LEFCH |

| g ae/ha | g ai/ha | Obs | Exp |
|---|---|---|---|
| 4.38 | 0 | 15 | - |
| 0 | 140 | 0 | - |
| 0 | 280 | 0 | - |
| 4.38 | 140 | 35 | 15 |
| 4.38 | 280 | 30 | 15 |

Table 2. Synergistic Activity of Foliar-Applied Compound A Benzyl Ester and Isoxaben Herbicidal Compositions on Control of Weeds Common to Rice Cropping Systems.

| Compound A Benzyl Ester | Isoxaben | Visual Weed Control (%) - 20 DAA | |
|---|---|---|---|
| | | BRAPP | |
| g ae/ha | g ai/ha | Obs | Exp |
| 4.38 | 0 | 70 | - |
| 8.75 | 0 | 80 | - |
| 17.5 | 0 | 90 | - |
| 0 | 280 | 0 | - |
| 0 | 560 | 20 | - |
| 4.38 | 280 | 80 | 70 |
| 8.75 | 280 | 95 | 80 |
| 17.5 | 280 | 99 | 90 |
| 4.38 | 560 | 95 | 76 |
| 8.75 | 560 | 90 | 84 |
| 17.5 | 560 | 95 | 92 |

| Compound A Benzyl Ester | Isoxaben | Visual Weed Control (%) - 20 DAA | |
|---|---|---|---|
| | | DIGSA | |
| g ae/ha | g ai/ha | Obs | Exp |
| 8.75 | 0 | 30 | - |
| 17.5 | 0 | 30 | - |
| 0 | 280 | 10 | - |
| 0 | 560 | 20 | - |
| 8.75 | 280 | 50 | 37 |
| 17.5 | 280 | 30 | 37 |
| 8.75 | 560 | 60 | 44 |
| 17.5 | 560 | 85 | 44 |

| Compound A Benzyl Ester | Isoxaben | Visual Weed Control (%) - 20 DAA |
|---|---|---|
| | | IPOHE |

| g ae/ha | g ai/ha | Obs | Exp |
|---|---|---|---|
| 4.38 | 0 | 10 | - |
| 8.75 | 0 | 10 | - |
| 17.5 | 0 | 15 | - |
| 0 | 140 | 15 | - |
| 0 | 280 | 25 | - |
| 4.38 | 140 | 30 | 24 |
| 8.75 | 140 | 35 | 24 |
| 17.5 | 140 | 45 | 28 |
| 4.38 | 280 | 45 | 33 |
| 8.75 | 280 | 35 | 33 |
| 17.5 | 280 | 35 | 36 |

| Compound A Benzyl Ester | Isoxaben | Visual Weed Control (%) - 20 DAA | |
|---|---|---|---|
| | | CYPIR | |
| g ae/ha | g ai/ha | Obs | Exp |
| 4.38 | 0 | 70 | - |
| 0 | 140 | 10 | - |
| 0 | 280 | 60 | - |
| 0 | 560 | 50 | - |
| 4.38 | 140 | 90 | 73 |
| 4.38 | 280 | 100 | 88 |
| 4.38 | 560 | 100 | 85 |

Table 3. Synergistic Activity of Foliar-Applied Compound A Acid and Indaziflam Herbicidal Compositions on Control of Weeds Common to Rice Cropping Systems.

| Compound A Acid | Indaziflam | Visual Weed Control (%) - 21 DAA | |
|---|---|---|---|
| | | BRAPP | |
| g ae/ha | g ai/ha | Obs | Exp |
| 5.3 | 0 | 60 | - |
| 10.6 | 0 | 85 | - |
| 0 | 21 | 0 | - |
| 0 | 42 | 15 | - |
| 5.3 | 21 | 85 | 60 |
| 10.6 | 21 | 100 | 85 |
| 5.3 | 42 | 100 | 66 |
| 10.6 | 42 | 95 | 87 |

5

| Compound A Acid | Indaziflam | Visual Weed Control (%) - 21 DAA | |
|---|---|---|---|
| | | DIGSA | |
| g ae/ha | g ai/ha | Obs | Exp |
| 5.3 | 0 | 20 | - |
| 10.6 | 0 | 30 | - |
| 21.2 | 0 | 35 | - |
| 0 | 21 | 50 | - |
| 0 | 42 | 45 | - |
| 5.3 | 21 | 85 | 60 |
| 10.6 | 21 | 95 | 65 |
| 21.2 | 21 | 80 | 68 |
| 5.3 | 42 | 99 | 56 |
| 10.6 | 42 | 99 | 62 |
| 21.2 | 42 | 95 | 64 |

Table 4. Synergistic Activity of Foliar-Applied Compound A Benzyl Ester and Indaziflam Herbicidal Compositions on Control of Weeds Common to Rice Cropping Systems.

| Compound A Benzyl Ester | Indaziflam | Visual Weed Control (%) - 21 DAA | |
|---|---|---|---|
| | | DIGSA | |
| g ae/ha | g ai/ha | Obs | Exp |
| 4.38 | 0 | 10 | - |
| 8.75 | 0 | 45 | - |
| 17.5 | 0 | 70 | - |
| 0 | 21 | 50 | - |
| 0 | 42 | 45 | - |
| 4.38 | 21 | 95 | 55 |
| 8.75 | 21 | 90 | 73 |
| 17.5 | 21 | 65 | 85 |
| 4.38 | 42 | 65 | 51 |
| 8.75 | 42 | 85 | 70 |
| 17.5 | 42 | 99 | 84 |

5

| Compound A Benzyl Ester | Indaziflam | Visual Weed Control (%) - 21 DAA | |
|---|---|---|---|
| | | LEFCH | |
| g ae/ha | g ai/ha | Obs | Exp |
| 4.38 | 0 | 30 | - |
| 8.75 | 0 | 35 | - |
| 17.5 | 0 | 35 | - |
| 0 | 42 | 70 | - |
| 4.38 | 42 | 99 | 79 |
| 8.75 | 42 | 100 | 81 |
| 17.5 | 42 | 100 | 81 |

| | | |
|---|---|---|
| BRAPP | *Brachiaria platyphylla* (Griseb.) Nash or *Urochloa platyphylla* (Nash) R.D. Webster | signalgrass, broadleaf |
| CYPIR | *Cyperus iria* L. | flatsedge, rice |
| DIGSA | *Digitaria sanguinalis* (L.) Scop. | crabgrass, large |
| IPOHE | *Ipomoea hederacea* Jacq. | morningglory, ivyleaf |
| LEFCH | *Leptochloa chinensis* (L.) Nees | sprangletop, Chinese |

g ae/ha = grams acid equivalent per hectare

g ai/ha = grams active ingredient per hectare

Obs = observed value

Exp = expected value as calculated by Colby's equation

DAA = days after application

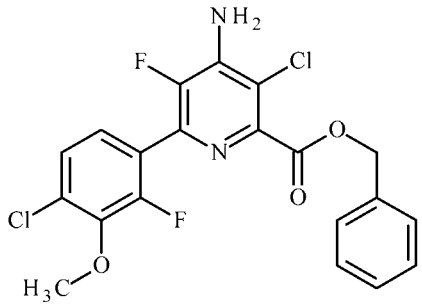
Example II. Evaluation of Postemergence Herbicidal Activity of Mixtures in Cereal Crops in the Greenhouse.

Seeds of the desired test plant species were planted in Sun Gro MetroMix® 306 planting mixture, which typically has a pH of 6.0 to 6.8 and an organic matter content of about 30 percent, in plastic pots with a surface area of 103.2 square centimeters ($cm^2$). When required to ensure good germination and healthy plants, a fungicide treatment and/or other chemical or physical treatment was applied. The plants were grown for 7-36 days in a greenhouse with an approximate 14 hour photoperiod which was maintained at about 18° C during the day and about 17° C during the night. Nutrients and water were added on a regular basis and supplemental lighting was provided with overhead metal halide 1000-Watt

lamps as necessary. The plants were employed for testing when they reached the second or third true leaf stage.

Treatments consisted of the benzyl ester of 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxy-phenyl)pyridine-2-carboxylic acid (Compound A), formulated as an SC, a second cereal herbicide alone and then both in combination.

Forms of compound A (compound of formula I) tested include:




Compound A Benzyl Ester

Other herbicidal components were applied on an active ingredient basis and included cellulose biosynthesis inhibiting herbicides.

Measured aliquots of benzyl ester of 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxy-phenyl)pyridine-2-carboxylic acid (Compound A) were placed in 25 milliliter (mL) glass vials and diluted in a volume of 1.25% (v/v) Agri-Dex® crop oil concentrate to obtain stock solutions. Compound requirements are based upon a 12 mL application volume at a rate of 187 liters per hectare (L/ha). Spray solutions of the second cereal herbicide and experimental compound mixtures were prepared by adding the stock solutions to the appropriate amount of dilution solution to form 12 mL spray solution with active ingredients in two- and three-way combinations. Formulated compounds were applied to the plant material with an overhead Mandel track sprayer equipped with an 8002E nozzle calibrated to deliver 187 L/ha over an application area of 0.503 square meters ($m^2$) at a spray height of 18 inches (46 cm) above average plant canopy. Control plants were sprayed in the same manner with the solvent blank.

The treated plants and control plants were placed in a greenhouse as described above and watered by sub-irrigation to prevent wash-off of the test compounds. After 20-22 days, the condition of the test plants as compared with that of the control plants was determined

visually and scored on a scale of 0 to 100 percent where 0 corresponds to no injury and 100 corresponds to complete kill.

Colby's equation was used to determine the herbicidal effects expected from the mixtures (Colby, S.R. 1967. Calculation of the synergistic and antagonistic response of herbicide combinations. Weeds 15:20-22.) .

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

$$\text{Expected} = A + B - (A \times B/100)$$

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

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

The compounds tested, application rates employed, plant species tested, and results are given in Table 5.

Table 5. Synergistic Activity of Foliar-Applied Compound A Benzyl Ester and Isoxaben Herbicidal Compositions on Weed Control in a Cereals Cropping System.

| Compound A Benzyl Ester | Isoxaben | Visual Weed Control (%) - 21 DAA | | | | | |
|---|---|---|---|---|---|---|---|
| | | AMARE | | CHEAL | | SINAR | |
| g ai/ha | g ai/ha | Obs | Exp | Obs | Exp | Obs | Exp |
| 2.5 | 0 | 20 | - | 50 | - | 70 | - |
| 5 | 0 | 38 | - | 58 | - | 73 | - |
| 0 | 31.25 | 0 | - | 5 | - | 13 | - |
| 0 | 62.5 | 8 | - | 5 | - | 13 | - |
| 2.5 | 31.25 | 23 | 20 | 70 | 53 | 88 | 74 |
| 2.5 | 62.5 | 45 | 26 | 73 | 53 | 85 | 74 |
| 5 | 31.25 | 53 | 38 | 80 | 60 | 95 | 76 |
| 5 | 62.5 | 55 | 42 | 83 | 60 | 93 | 76 |

| Compound A Benzyl Ester | Isoxaben | Visual Weed Control (%) - 21 DAA | | | |
|---|---|---|---|---|---|
| | | GALAP | | BRSNW | |
| g ai/ha | g ai/ha | Obs | Exp | Obs | Exp |
| 2.5 | 0 | 55 | - | 18 | - |
| 5 | 0 | 66 | - | 13 | - |
| 10 | 0 | 77 | - | 13 | - |

| | | | | | |
|---|---|---|---|---|---|
| 0 | 31.25 | 0 | - | 35 | - |
| 0 | 62.5 | 8 | - | 45 | - |
| 0 | 125 | 12 | - | 80 | - |
| 2.5 | 31.25 | 58 | 55 | 69 | 46 |
| 2.5 | 62.5 | 60 | 58 | 68 | 55 |
| 5 | 31.25 | 63 | 66 | 78 | 43 |
| 5 | 62.5 | 73 | 69 | 88 | 52 |
| 5 | 125 | 83 | 70 | 95 | 83 |
| 10 | 125 | 95 | 79 | 95 | 83 |

| Compound A Benzyl Ester | Isoxaben | Visual Weed Control (%) - 21 DAA | |
|---|---|---|---|
| | | CIRAR | |
| g ai/ha | g ai/ha | Obs | Exp |
| 5 | 0 | 39 | - |
| 10 | 0 | 60 | - |
| 0 | 31.25 | 3 | - |
| 0 | 62.5 | 13 | - |
| 0 | 125 | 17 | - |
| 5 | 31.25 | 48 | 41 |
| 5 | 62.5 | 68 | 47 |
| 5 | 125 | 82 | 49 |
| 10 | 125 | 89 | 67 |

| Compound A Benzyl Ester | Isoxaben | Visual Weed Control (%) - 21 DAA | |
|---|---|---|---|
| | | STEME | |
| g ai/ha | g ai/ha | Obs | Exp |
| 2.5 | 0 | 25 | - |
| 5 | 0 | 25 | - |
| 10 | 0 | 27 | - |
| 0 | 31.25 | 5 | - |
| 0 | 62.5 | 5 | - |
| 2.5 | 31.25 | 35 | 29 |
| 2.5 | 62.5 | 61 | 29 |
| 5 | 31.25 | 50 | 29 |
| 5 | 62.5 | 83 | 29 |

| | | |
|---|---|---|
| AMARE | *Amaranthus retroflexus* L. | pigweed, redroot |
| BRSNW | *Brassica napus* L. | rape, oilseed (winter) |

| | | |
|---|---|---|
| CHEAL | *Chenopodium album* L. | lambsquarters, common |
| CIRAR | *Cirsium arvense* (L.) Scop. | thistle, Canada |
| GALAP | *Galium aparine* L. | bedstraw, catchweed |
| SINAR | *Sinapis arvensis* L. | mustard, wild |
| STEME | *Stellaria media* (L.) Vill. | chickweed, common |

g ae/ha = grams acid equivalent per hectare

g ai/ha = grams active ingredient per hectare

Obs = observed value

Exp = expected value as calculated by Colby's equation

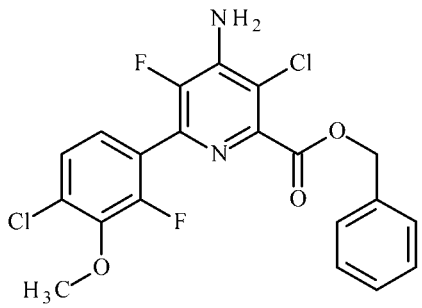
DAA = days after application

Example III. Evaluation of Pre-emergence Soil-Applied Herbicidal Mixtures for Weed Control

Seeds or nutlets of the desired test plant species were planted in a soil matrix prepared by mixing a loam soil (*e.g.*, 32 percent silt, 23 percent clay, and 45 percent sand, with a pH of about 6.5 and an organic matter content of about 1.9 percent) and calcareous grit in an 80 to 20 ratio. The soil matrix was contained in plastic pots with a volume of 1 quart and a surface area of 83.6 square centimeters ($cm^2$).

Treatments consisted of the benzyl ester of 4-amino-3-chloro-5-fluoro-6-(4-chloro-2-fluoro-3-methoxy-phenyl)pyridine-2-carboxylic acid (compound A) formulated as an SC (suspension concentrate) and various herbicidal components alone and in combination. Forms of compound A were applied on an acid equivalent basis.

Forms of compound A (compound of formula I) tested include:




Compound A Benzyl Ester

Other herbicidal components were applied on an acid equivalent or active ingredient basis and included the cellulose biosynthesis inhibiting herbicides, isoxaben formulated as Gallery® 75DF and indaziflam formulated as Specticle® 20WSP.

Treatment requirements were calculated based upon the rates being tested, the concentration of active ingredient or acid equivalent in the formulation, and a 12 mL application volume at a rate of 187 L/ha.

For treatments comprised of formulated compounds, measured amounts of compounds were placed individually in 25 mL glass vials and diluted in a volume of 1.25% (v/v) Agri-Dex® crop oil concentrate (COC) to obtain 12X stock solutions. If a test compound did not dissolve readily, the mixture was warmed and/or sonicated. Application solutions were prepared by adding an appropriate amount of each stock solution (*e.g.*, 1 mL) and diluted to the appropriate final concentrations with the addition of 10 mL of an aqueous mixture of 1.25% (v/v) COC so that the final spray solutions contained 1.25% (v/v) COC.

For treatments comprised of technical compounds, weighed amounts can be placed individually in 25 mL glass vials and dissolved in a volume of 97:3 (v/v) acetone/DMSO to obtain 12X stock solutions. If a test compound does not dissolve readily, the mixture can be warmed and/or sonicated. Application solutions can be prepared by adding an appropriate amount of each stock solution (*e.g.*, 1 mL) and diluted to the appropriate final concentrations with the addition of 10 mL of an aqueous mixture of 1.5% (v/v) COC so that the final spray solutions contain 1.25% (v/v) COC. When technical materials are used, the concentrated stock solutions can be added to the spray solutions so that the final acetone and DMSO concentrations of the application solutions are 16.2% and 0.5%, respectively.

For treatments comprised of formulated and technical compounds, weighed amounts of the technical materials can be placed individually in 25 mL glass vials and dissolved in a volume of 97:3 (v/v) acetone/DMSO to obtain 12X stock solutions, and measured amounts of the formulated compounds can be placed individually in 25 mL glass vials and diluted in a volume of 1.5% (v/v) COC or water to obtain 12X stock solutions. If a test compound does not dissolve readily, the mixture can be warmed and/or sonicated. Application solutions can be prepared by adding an appropriate amount of each stock solution (*e.g.*, 1 mL) and diluted to the appropriate final concentrations with the addition of an appropriate amount of an aqueous mixture of 1.5% (v/v) COC so that the final spray solutions contain 1.25% (v/v)

COC. As required, additional water and/or 97:3 (v/v) acetone/DMSO can be added to individual application solutions so that the final acetone and DMSO concentrations of the application solutions being compared are 8.1% and 0.25%, respectively.

All stock solutions and applications solutions were visually inspected for compound compatibility prior to application. Spray solutions were applied to the soil with an overhead Mandel track sprayer equipped with a 8002E nozzles calibrated to deliver 187 L/ha over an application area of 0.503 $m^2$ at a spray height of 18 inches (46 cm) above average pot height. Control pots were sprayed in the same manner with the solvent blank.

The treated and control pots were placed in a greenhouse and top watered as needed. When required to ensure good germination and healthy plants, a fungicide treatment and/or other chemical or physical treatment was applied. The pots were maintained in a greenhouse with an approximate 14 hr, photoperiod which was maintained at about 29° C during the day and 26° C during the night. Nutrients (Peters® Excel 15-5-15 5-Ca 2-Mg) were applied in the irrigation solution as needed and water was added on a regular basis. Supplemental lighting was provided with overhead metal halide 1000-Watt lamps as necessary. After approximately 4 weeks, the condition of the test plants as compared with that of the untreated plants was determined visually and scored on a scale of 0 to 100 percent where 0 corresponds to no injury or growth inhibition and 100 corresponds to complete kill.

Colby's equation was used to determine the herbicidal effects expected from the mixtures (Colby, S.R. 1967. Calculation of the synergistic and antagonistic response of herbicide combinations. Weeds 15:20-22.) .

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

$$\text{Expected} = A + B - (A \times B/100)$$

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

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

Some of the compounds tested, application rates employed, plant species tested, and results are given in Tables 6-7.

Table 6. Synergistic Activity of Soil-applied, Pre-emergence Applications of Compound A Benzyl Ester and Isoxaben Herbicidal Compositions on Weed Control.

| Compound A Benzyl Ester | Isoxaben | Visual Weed Control (%) - 27 DAA | |
|---|---|---|---|
| | | ABUTH | |
| g ae/ha | g ai/ha | Obs | Exp |
| 16 | 0 | 48 | - |
| 32 | 0 | 87 | - |
| 0 | 560 | 77 | - |
| 0 | 1120 | 67 | - |
| 16 | 560 | 93 | 88 |
| 32 | 560 | 100 | 97 |
| 16 | 1120 | 100 | 83 |
| 32 | 1120 | 100 | 96 |

Table 7. Synergistic Activity of Soil-applied, Pre-emergence Applications of Compound A Benzyl Ester and Indaziflam Herbicidal Compositions on Weed Control.

| Compound A Benzyl Ester | Indaziflam | Visual Weed Control (%) - 27 DAA | |
|---|---|---|---|
| | | SETFA | |
| g ae/ha | g ai/ha | Obs | Exp |
| 16 | 0 | 8 | - |
| 32 | 0 | 15 | - |
| 0 | 95 | 70 | - |
| 16 | 95 | 100 | 73 |
| 32 | 95 | 100 | 75 |

| Compound A Benzyl Ester | Indaziflam | Visual Weed Control (%) - 28 DAA | | | |
|---|---|---|---|---|---|
| | | IPOHE | | XANST | |
| g ae/ha | g ai/ha | Obs | Exp | Obs | Exp |
| 16 | 0 | 13 | - | 0 | - |
| 32 | 0 | 23 | - | 5 | - |
| 0 | 17.5 | 40 | - | 25 | - |
| 0 | 70 | 40 | - | 45 | - |
| 16 | 17.5 | 73 | 48 | 38 | 25 |
| 32 | 17.5 | 55 | 54 | 50 | 29 |
| 16 | 70 | 80 | 48 | 68 | 45 |
| 32 | 70 | 68 | 54 | 80 | 48 |

5

ABUTH *Abutilon theophrasti* Medik. velvetleaf

| | | |
|---|---|---|
| IPOHE | *Ipomoea hederacea* (L.) Jacq. | morningglory, ivyleaf |
| SETFA | *Setaria faberi* Herrm. | foxtail, giant |
| XANST | *Xanthium strumarium* L. | cocklebur, common |

g ae/ha = grams acid equivalent per hectare

g ai/ha = grams active ingredient per hectare

Obs = observed value

Exp = expected value as calculated by Colby's equation

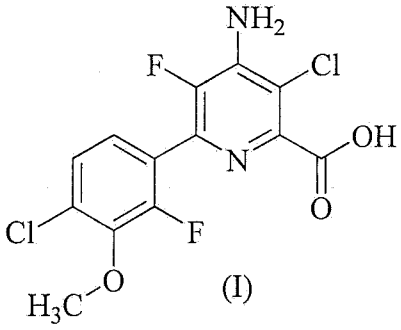
DAA = days after application

As used herein, except where the context requires otherwise, the term "comprise" and variations of the term, such as "comprising", "comprises" and "comprised", are not intended to exclude other additives, components, integers or steps.

Reference to any prior art in the specification is not, and should not be taken as, an acknowledgment, or any form of suggestion, that this prior art forms part of the common general knowledge in Australia or any other jurisdiction or that this prior art could reasonably be expected to be ascertained, understood and regarded as relevant by a person skilled in the art.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

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



(I)

or an agriculturally acceptable salt or ester thereof and (b) a cellulose biosynthesis inhibitor, wherein (a) and (b) are present in the composition in a ratio such that the composition exhibits herbicidal synergy, and wherein the ratio between (a) and (b) is from about 1.8:1 to about 1:127.9.

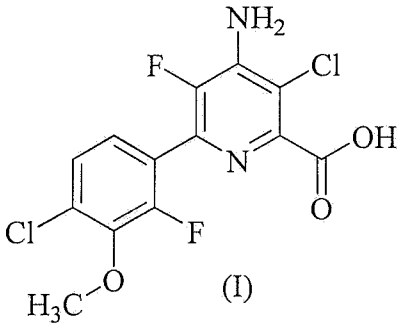
2. The composition of claim 1, wherein (a) is the compound of formula (I), a $C_{1-4}$ alkyl ester of the compound of formula (I), or a benzyl ester of the compound of formula (I).

3. The composition of any one of claims 1-2, wherein (b) is at least one compound, or an agriculturally acceptable salt, carboxylic acid, carboxylate salt, or ester thereof, selected from the group consisting of: indaziflam and isoxaben.

4. The composition of any one of claims 1-3, further comprising an agriculturally acceptable adjuvant or carrier.

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

6. A method of controlling undesirable vegetation, comprising the steps of: contacting a plant, wherein the plant is undesirable vegetation or the locus thereof, soil or water, wherein the soil or the water allows for the growth of the undesirable vegetation, with a herbicidally effective amount of a combination comprising (a) a compound of the formula (I):



(I)

or an agriculturally acceptable salt or ester thereof and (b) a cellulose biosynthesis inhibitor, wherein (a) and (b) are present in the composition in a ratio such that the composition exhibits herbicidal synergy, and wherein the ratio between (a) and (b) is from about 1.8:1 to about 1:127.9.

7. The method of claim 6, wherein (a) is the compound of formula (I), a $C_{1-4}$ alkyl ester of the compound of formula (I), or a benzyl ester of the compound of formula (I).

8. The method of any one of claims 6-7, wherein (b) is at least one compound, selected from the group consisting of: indaziflam and isoxaben.

9. The method of any one of claims 6-8, wherein the undesirable vegetation is controlled in direct-seeded, water-seeded and transplanted rice, cereals, wheat, barley, oats, rye, sorghum, corn/maize, sugarcane, sunflower, oilseed rape, canola, sugar beet, soybean, cotton, pineapple, pastures, grasslands, rangelands, fallowland, turf, tree and vine orchards, aquatics, industrial vegetation management (IVM) or rights of way (ROW).

10. The method of any one of claims 6-9, wherein the (a) and (b) are applied pre-emergently to the plant or the crop.

11. The method of any one of claims 6-10, wherein the undesirable vegetation is controlled in glyphosate-, 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase inhibitor-, glufosinate-, glutamine synthetase inhibitor-, dicamba-, phenoxy auxin-, pyridyloxy auxin-, synthetic auxin-, auxin transport inhibitor-, aryloxyphenoxypropionate-, cyclohexanedione-, phenylpyrazoline-, acetyl CoA carboxylase (ACCase) inhibitor-, imidazolinone-, sulfonylurea-, pyrimidinylthiobenzoate-, triazolopyrimidine-, sulfonylaminocarbonyltriazolinone-, acetolactate synthase (ALS) or acetohydroxy acid synthase (AHAS) inhibitors-, 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitor-, phytoene desaturase inhibitor-, carotenoid biosynthesis inhibitor-, protoporphyrinogen oxidase (PPO) inhibitor-, cellulose biosynthesis inhibitor-, mitosis inhibitor-, microtubule inhibitor-, very long chain fatty acid inhibitor-, fatty acid and lipid biosynthesis inhibitor-, photosystem I inhibitor-, photosystem II inhibitor-, triazine-, or bromoxynil- tolerant crops.

12. The method of claim 11, wherein the tolerant crop possesses multiple or stacked traits conferring tolerance to multiple herbicides or multiple modes of action.

13. The method of any one of claims 6-12, wherein the undesirable vegetation comprises a herbicide resistant or tolerant plant.

14. The composition of any one of claims 1-5, wherein (b) is indaziflam, and the weight ratio of (a) to (b) is from about 1.8:1 to about 1:9.6.

15. The composition of any one of claims 1-5, wherein (b) is isoxaben, and the weight ratio of (a) to (b) is from about 1:6.3 to about 1:127.9.

16. The method of any one of claims 6-13, wherein (b) is indaziflam, and the weight ratio of (a) to (b) is from about 1.8:1 to about 1:9.6.

17. The method of any one of claims 6-13, wherein (b) is isoxaben, and the weight ratio of (a) to (b) is from about 1:6.3 to about 1:127.9.