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(54) Title: HERBICIDAL COMPOSITIONS COMPRISING ISOXABEN AND FLUFENACET

(57) Abstract: Herbicidal compositions and methods of controlling undesirable vegetation using a combination of (a) isoxaben, (b) flufenacet, and optionally (c) diflufenican provide control of broad-leaved weeds. 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.

HERBICIDAL COMPOSITIONS COMPRISING ISOXABEN AND FLUFENACET

Cross Reference to Related Applications

[0001] This application claims the benefit of U.S. Provisional Patent Application Serial No. 61/775,040 filed March 8, 2013, the disclosure of which is expressly incorporated herein by reference.

Background

[0002] 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.

[0003] Oilseed rape is a widely cultivated crop in, for example, Canada, Europe, the United States, Australia, China, India, and Chile. Increasingly, the oilseed rape varieties demanded by producers are either genetically modified or conventionally bred to be herbicide-tolerant. In some countries, herbicide-tolerant varieties have captured virtually the entire market. Imidazolinone-tolerant oilseed rape, offered by BASF under its Clearfield technology brand is now entering the market in Europe.

[0004] Volunteer oilseed rape is a serious weed problem for crops that follow oilseed rape. Significant seed is typically shed both before and during harvest, in extreme cases approaching 20%. The shed seed can remain viable in soil for years. Oilseed rape is typically rotated with a cereal crop, often winter wheat. Therefore, herbicides capable of controlling imidazolinone-tolerant oilseed rape are needed.

Summary

[0005] Provided herein are herbicidal compositions comprising (a) isoxaben and (b) flufenacet and optionally (c) diflufenican.

[0006] Also provided are methods of controlling broadleaved weeds comprising applying a combination of (a) isoxaben, (b) flufenacet, and optionally (c) diflufenican.

[0007] In certain embodiments the compositions and methods are used to control volunteer oilseed rape. In some embodiments the methods are used to control oilseed rape in cereals.

Detailed Description

DEFINITIONS

[0008] Isoxaben is the common name for *N*-[3-(1-ethyl-1-methylpropyl)isoxazol-5-yl]-2,6-dimethoxybenzamide. As described in Tomlin, C. D. S., Ed. *The Pesticide Manual: A World Compendium*, 15th ed.; BCPC: Alton, 2009 (hereafter “*The Pesticide Manual*”), isoxaben is a selective herbicide that inhibits cell wall biosynthesis. It is used, for example, pre-emergence in winter and spring cereals.

[0009] Flufenacet is the common name for *N*-(4-fluorophenyl)-*N*-(1-methylethyl)-2-[[5-(trifluoromethyl)-1,3,4-thiadiazol-2-yl]oxy]acetamide. As described in *The Pesticide Manual*, flufenacet is a systemic herbicide for which the target site may be fatty acid metabolism. It is used, for example, post-emergence in maize, wheat, and rice.

[0010] Diflufenican is the common name for *N*-(2,4-difluorophenyl)-2-[3-(trifluoromethyl)phenoxy]-3-pyridinecarboxamide. As described in *The Pesticide Manual*, diflufenican is a selective contact and residual herbicide that blocks carotenoid biosynthesis. It is used pre- and early post-emergence in autumn-sown wheat and barley to control grass and broad-leaved weeds. It is typically used in combination with other cereal herbicides, *e.g.* flufenacet.

[0011] As used herein, control of or controlling undesirable vegetation means killing or preventing the vegetation, or causing some other adversely modifying effect to the vegetation *e.g.*, deviations from natural growth or development, regulation, desiccation, retardation, and the like.

[0012] As used herein, herbicide and herbicidal active ingredient mean a compound that controls undesirable vegetation when applied in an appropriate amount.

[0013] As used herein, a herbicidally effective or vegetation controlling amount is an amount of herbicidal active ingredient the application of which controls the relevant undesirable vegetation.

[0014] As used herein, applying an herbicide or herbicidal composition means delivering it directly to the targeted vegetation or to the locus thereof or to the area where control of undesired vegetation is desired. Methods of application include, but are not limited to pre-emergence, post-emergence, foliar, soil, and in-water applications. Described herein are methods of controlling undesirable vegetation by applying certain herbicide combinations or compositions.

[0015] As used herein, plants and vegetation include, but are not limited to, dormant seeds, germinant seeds, emerging seedlings, plants emerging from vegetative propagules, immature vegetation, and established vegetation.

COMPOSITIONS AND METHODS

[0016] In certain embodiments the herbicidal compositions provided herein comprise (a) isoxaben and (b) flufenacet wherein the weight ratio of active ingredients is in the range of about 20-80 of (a) to about 100-600 of (b). In certain embodiments the weight ratio of (a) to (b) is in the range of about 25-65 of (a) to about 125-400 of (b). In certain embodiments the weight ratio of (a) to (b) is in the range of about 30-50 of (a) to about 150-250 of (b). In certain embodiments the weight ratio of (a) to (b) is about 40 of (a) to about 200 of (b). In certain embodiments the weight ratio of (a) to (b) is in the range of 0.03 to 0.80. In certain embodiments the weight ratio of (a) to (b) is in the range of 0.06 to 0.52. In certain embodiments the weight ratio of (a) to (b) is in the range of 0.12 to 0.33. In certain embodiments the weight ratio of (a) to (b) is 0.2. In some embodiments the herbicidal active ingredients in the composition consist of isoxaben and flufenacet, *i.e.*, no other herbicidal active ingredient is present.

[0017] In certain embodiments the herbicidal composition comprises (a) isoxaben, (b) flufenacet, and (c) diflufenican, wherein the weight ratio of active ingredients is in the range of about 20-80 of (a) to about 100-600 of (b) to about 50-200 of (c). In certain embodiments the weight ratio of active ingredients is in the range of about 25-65 of (a) to about 125-400 of (b) to about 65-160 of (c). In certain embodiments the weight ratio of active ingredients is in the range of about 30-50 of (a) to about 150-250 of (b) to about 80-120 of (c). In certain embodiments the weight ratio of active ingredients is about 40 of (a) to about 200 of (b) to about 100 of (c). In certain embodiments the weight ratio of (a) to (b) is in the range of 0.03 to 0.80 and the weight ratio of (a) to (c) is in the range of 0.1 to 1.6. In certain embodiments the weight ratio of (a) to (b) is in the range of 0.06 to 0.52 and the weight ratio of (a) to (c) is in the range of 0.16 to 1. In certain embodiments the weight ratio of (a) to (b) is in the range of 0.12 to 0.33 and the weight ratio of (a) to (c) is in the range of 0.25 to 0.63. In certain embodiments the weight ratio of (a) to (b) is 0.2 and the weight ratio of (a) to (c) is 0.4. In some embodiments the herbicidal active ingredients in the composition consist of isoxaben, flufenacet, and diflufenican.

[0018] The compositions may also contain an agriculturally acceptable adjuvant or carrier.

[0019] Also provided are methods of controlling broadleaved weeds comprising applying one of the above described compositions to the locus where control is desired.

[0020] Furthermore, in some embodiments, the combination of (a) isoxaben and (b) flufenacet, or the combination of (a) isoxaben, (b) flufenacet, and (c) diflufenican exhibits synergism, *i.e.*, the herbicidal active ingredients are more effective in combination than when applied individually. The *Herbicide Handbook* of the Weed Science Society of America, Ninth Edition, 2007, p. 429 notes that “‘synergism’ [is] 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.” In certain embodiments, the compositions exhibit synergy as determined by Colby’s equation. Colby, S. R. Calculation of the synergistic and antagonistic response of herbicide combinations. *Weeds* **1967**, *15*, 20-22.

[0021] Herbicidal activity (control of undesirable vegetation) is exhibited by the compositions 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 to relatively immature undesirable vegetation to achieve the maximum control of weeds.

[0022] In some embodiments, the compositions and methods provided herein are utilized to control weeds in cereal crops, including but not limited to rice, wheat, barley, triticale, oats, rye, sorghum, corn/maize, and also in cereal crops that are tolerant to glyphosate, glufosinate, dicamba, imidazolinones, phenoxy auxins, pyridyloxy auxins, aryloxyphenoxypropionates, acetyl CoA carboxylase (ACCase) inhibitors, acetolactate synthase (ALS) inhibitors, 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitors, protoporphyrinogen oxidase (PPO) inhibitors, triazines, or bromoxynil.

[0023] In some embodiments, the compositions and methods provided herein are utilized to control undesirable vegetation consisting of broadleaf weeds.

[0024] In some embodiments, the undesirable vegetation is *Brassica*, *Stellaria*, or *Geranium*. In some embodiments, the compositions and methods provided herein are utilized to control undesirable vegetation such as oilseed rape (*Brassica napus* (winter), BRSNW), common chickweed (*Stellaria media* (L.) Vill, STEME), and cutleaf geranium (*Geranium dissectum* L., GERDI).

[0025] 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 120 grams active ingredient per hectare (g ai/ha) to about 800 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 180 g ai/ha to about 425 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 200 g ai/ha to about 300 g ai/ha based on the total amount of the isoxaben and the flufenacet in the composition. In certain embodiments, the composition is applied at an application rate of from about 300 g ai/ha to about 400 g ai/ha based on the total amount of the isoxaben, the flufenacet, and the diflufenican in the composition.

[0026] In some embodiments, the isoxaben is applied at a rate from about 20 g ai/ha to about 80 g ai/ha and flufenacet is applied at a rate from about 100 g ai/ha to about 600 g ai/ha. In some embodiments, the isoxaben is applied at a rate from about 25 g ai/ha to about 65 g ai/ha and flufenacet is applied at a rate from about 125 g ai/ha to about 400 g ai/ha. In some embodiments, the isoxaben is applied at a rate from about 30 g ai/ha to about 50 g ai/ha and flufenacet is applied at a rate from about 150 g ai/ha to about 250 g ai/ha. In some embodiments, the isoxaben is applied at a rate of about 40 g ai/ha and flufenacet is applied at a rate of about 200 g ai/ha. In some embodiments, the isoxaben is applied at a rate from about 20 g ai/ha to about 80 g ai/ha, the flufenacet is applied at a rate from about 100 g ai/ha to about 600 g ai/ha, and the diflufenican is applied at a rate of about 50 g ai/ha to about 200 g ai/ha. In some embodiments, the isoxaben is applied at a rate from about 25 g ai/ha to about 65 g ai/ha, the flufenacet is applied at a rate from about 125 g ai/ha to about 400 g ai/ha, and the diflufenican is applied at a rate of about 65 g ai/ha to about 160 g ai/ha. In some embodiments, the isoxaben is applied at a rate from about 30 g ai/ha to about 50 g ai/ha, the flufenacet is applied at a rate from about 150 g ai/ha to about 250 g ai/ha, and the diflufenican is applied at a rate of about 80 g ai/ha to about 120 g ai/ha. In some

embodiments, the isoxaben is applied at a rate of about 40 g ai/ha, the flufenacet is applied at a rate of about 200 g ai/ha, and the diflufenican is applied at a rate of about 100 g ai/ha.

[0027] In some embodiments, the isoxaben is applied at a rate from about 20 g ai/ha to about 125 g ai/ha and the flufenacet is applied at a rate from about 100 g ai/ha to about 1000 g ai/ha. In some embodiments, the isoxaben is applied at a rate from about 20 g ai/ha to about 125 g ai/ha, the flufenacet is applied at a rate from about 100 g ai/ha to about 1000 g ai/ha, and the diflufenican is applied at a rate of about 50 g ai/ha to about 250 g ai/ha.

[0028] The components of the mixtures described herein can be applied either separately or as part of a multipart herbicidal system. In some embodiments of the methods described herein, the active ingredients are applied simultaneously, including, *e.g.*, in the form of a composition. In some embodiments, the active ingredients are applied sequentially, *e.g.*, within 5, 10, 15, or 30 minutes of each other; 1, 2, 3, 4, 5, 10, 12, 24, 48 hour(s) of each other, or 1 week of each other.

[0029] 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, ametrudione, ametryn, amibuzin, amicarbazone, amidosulfuron, aminocyclopyrachlor, aminopyralid, amiprofos-methyl, amitrole, ammonium sulfamate, anilofos, anisuron, asulam, atraton, atrazine, azafenidin, azimsulfuron, aziprotryne, barban, BCPC, beflubutamid, benazolin, bencarbazon, benfluralin, benfuresate, bensulfuron-methyl, bensulide, benthio carb, bentazon-sodium, benzadox, benzfendizone, benzipram, benzobicyclon, benzofenap, benzofluor, benzoylprop, benzthiazuron, bicyclopiron, 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, 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, diethyl, difenopenten, difenoxuron, difenzoquat, diflufenzopyr, dimefuron, dimepiperate, dimethachlor, dimethametryn, dimethenamid, dimethenamid-P, dimexano, dimidazon, dinitramine, dinofenate, dinoprop, dinosam, dinoseb, dinoterb, diphenamid, dipropetryn, diquat, disul, dithiopyr, diuron, DMPA, DNOC, DSMA, EBEP, eglinazine, endothal, epronaz, EPTC, erbon, esprocarb, ethalfluralin, ethametsulfuron, ethidimuron, ethiolate, ethobenzanid, ethofumesate, ethoxyfen, ethoxysulfuron, etinofen, etnipromid, 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, flufenican, flufenpyr-ethyl, flumetsulam, flumezin, flumiclorac-pentyl, flumioxazin, flumipropyn, fluometuron, fluorodifen, fluoroglycofen, fluoromidine, fluoronitrofen, fluothiuron, flupoxam, flupropacil, flupropanate, flupyrsulfuron, fluridone, flurochloridone, fluroxypyr, flurtamone, fluthiacet, fomesafen, foramsulfuron, fosamine, fumiclorac, furyloxyfen, glufosinate, glufosinate-ammonium, glufosinate-P-ammonium, glyphosate, halosafen, halosulfuron-methyl, haloxydine, haloxyfop-methyl, haloxyfop-P-methyl, hexachloroacetone, hexaflurate, hexazinone, imazamethabenz, imazamox, imazapic, imazapyr, imazaquin, imazethapyr, imazosulfuron, indanofan, indaziflam, iodobonil, iodomethane, iodosulfuron, iodosulfuron-ethyl-sodium, iofensulfuron, ioxynil, ipazine, ipfencarbazone, iprymidam, isocarbamid, isocil, isomethiozin, isonoruron, isopollinate, isopropalin, isoproturon, isouron, isoxachlortole, isoxaflutole, isoxapyrifop, karbutilate, ketospiradox, lactofen, lenacil, linuron, MAA, MAMA, 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, methyl dymron, metobenzuron, metobromuron, metolachlor, metosulam, metoxuron, metribuzin, metsulfuron, metsulfuron-methyl, molinate, monalide, monisouron, monochloroacetic acid, monolinuron, monuron, morfamquat, MSMA, naproanilide, napropamide, napropamide-M, naptalam, neburon, nicosulfuron, nipyraclufen, nitralin, nitrofen, nitrofluorfen, norflurazon, noruron, OCH, orbencarb, *ortho*-dichlorobenzene, orthosulfamuron, oryzalin, oxadiargyl, oxadiazon, oxapyrazon, oxasulfuron, oxaziclomefone, oxyfluorfen, paraflufen-ethyl, parafluron, paraquat, pebulate, pelargonic acid, pendimethalin, penoxsulam, pentachlorophenol, pentanochlor, pentoxazone, perfluidone, pethoxamid, phenisopham, phenmedipham, phenmedipham-ethyl, phenobenzuron, phenylmercury acetate, picloram, picolinafen, pinoxaden, piperophos, potassium arsenite, potassium azide, potassium cyanate, pretilachlor, primisulfuron-methyl, procyazine, prodiamine, profluzol, 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, pyriothiobac-sodium, pyroxasulfone, pyroxsulam, quinclorac, quinmerac, quinochloramine, quinonamid, quizalofop, quizalofop-P-ethyl, rhodethanil, rimsulfuron, saflufenacil, S-metolachlor, sebuthylazine, sebumeton, sethoxydim, siduron, simazine, simeton, simetryn, SMA, sodium arsenite, sodium azide, sodium chlorate, sulcotrione, sulfallate, sulfentrazone, sulfometuron, sulfosate, sulfosulfuron, sulfuric acid, sulglycapin, swep, TCA, tebutam, tebuthiuron, tefuryltrione, tembotrione, tepraloxydim, terbacil, terbucarb, terbuchlor, terbumeton, terbuthylazine, terbutryn, tetrafluron, thenylchlor, thiazafluron, thiazopyr, thidiazimin, thidiazuron, thiencarbazone-methyl, thifensulfuron, thifensulfuron-methyl, thiobencarb, tiocarbamil, 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.

[0030] The compositions and methods described herein, can, further, be used in conjunction with glyphosate, glufosinate, dicamba, phenoxy auxins, pyridyloxy auxins, aryloxyphenoxypropionates, acetyl CoA carboxylase (ACCase) inhibitors, imidazolinones, acetolactate synthase (ALS) inhibitors, 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitors, protoporphyrinogen oxidase (PPO) inhibitors, triazines, and bromoxynil on crops that are tolerant thereto, and on crops possessing multiple or stacked traits conferring tolerance to multiple chemistries and/or multiple modes-of-action.

[0031] 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.

[0032] Suitable agricultural adjuvants and carriers include, but are not limited to, crop oil concentrate; nonylphenol ethoxylate; benzylcocoalkyldimethyl quaternary ammonium salt; blend of petroleum hydrocarbon, alkyl esters, organic acid, and anionic surfactant; C₉-C₁₁ alkylpolyglycoside; phosphated alcohol ethoxylate; natural primary alcohol (C₁₂-C₁₆) ethoxylate; di-*sec*-butylphenol EO-PO block copolymer; polysiloxane-methyl cap; nonylphenol ethoxylate + urea ammonium nitrate; emulsified methylated seed oil; tridecyl alcohol (synthetic) ethoxylate (8EO); tallow amine ethoxylate (15 EO); PEG(400) dioleate-99.

[0033] 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.

[0034] 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.

[0035] 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-C₁₈ ethoxylate; alcohol-alkylene oxide addition products, such as tridecyl alcohol-C₁₆ ethoxylate; soaps, such as sodium stearate; alkyl-naphthalene-sulfonate salts, such as sodium dibutyl-naphthalenesulfonate; dialkyl esters of sulfosuccinate salts, such as sodium di(2-ethylhexyl) sulfosuccinate; sorbitol esters, such as sorbitol oleate; quaternary amines, such as lauryl trimethylammonium chloride; polyethylene glycol esters of fatty acids, such as polyethylene glycol stearate; block copolymers of ethylene oxide and propylene oxide; salts of mono and dialkyl phosphate esters; vegetable or seed oils such as soybean oil, rapeseed/canola oil, olive oil, castor oil, sunflower seed oil, coconut oil, corn oil, cottonseed oil, linseed oil, palm oil, peanut oil, safflower oil, sesame oil,

tung oil and the like; and esters of the above vegetable oils, and in certain embodiments, methyl esters.

[0036] 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.

[0037] 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.

[0038] In some embodiments, the concentration of the active ingredients in the compositions described herein is from 0.0005 to 98 percent by weight. In some embodiments, the concentration is from 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 0.1 to 98 weight percent, and in certain embodiments, 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, 0.0006 to 3.0 weight percent active ingredient and in certain embodiments contain 0.01 to 0.3 weight percent.

[0039] 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.

[0040] 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

[0041] Results in Tables 1 and 2 are for foliar applied compositions in small plot research experiments to evaluate the efficacy of the compositions in winter wheat. Application water volume was 200 liters per hectare (L/ha). Crop stage at time of application was 12-13. Control of BRSNW, GERDI, and STEME was evaluated visually (as percent (%) injury) at intervals indicated in the tables. The values reported are means. Means followed by the same letter in the tables do not significantly differ ($P=0.5$, Duncan's New MRT). Colby's equation was used to determine the herbicidal effects expected from the mixtures (Colby, S. R. Calculation of the synergistic and antagonistic response of herbicide combinations. *Weeds* **1967**, *15*, 20-22.). More specifically, 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 (or combination B) at the same concentration as used in the mixture.

The compositions tested, application rates employed, plant species tested, and results are given in Tables 1 and 2.

The following abbreviations are used in Tables 1 and 2:

BRSNW = *Brassica napus* (winter oilseed rape)

GERDI = *Geranium dissectum* (cutleaf geranium)

STEME = *Stellaria media* (L.) Vill. (common chickweed)

g ai/ha = grams active ingredient per hectare

Ob = observed value of percent (%) control rated visually

Ex = expected value of percent (%) control as calculated by Colby's equation

DAT = day after treatment

Table 1. Trial 1

Treatment				VISUAL % CONTROL OF STEME 28 DAT		VISUAL % CONTROL OF BRSNW 28 DAT		VISUAL % CONTROL OF GERDI 28DAT	
Ingredient A		Ingredient B		Ob	Ex	Ob	Ex	Ob	Ex
UNTREATED				0 e		0 d		0 d	
isoxaben	40 g ai/ha			0 e		0 d		0 d	
flufenacet	200 g ai/ha			0 e		0 d		0 d	
flufenacet	200 g ai/ha	diflufenican	100 g ai/ha	50 c		53 b		65 bc	
isoxaben	40 g ai/ha	flufenacet	200 g ai/ha	55 bc	0	80 a	0	88 a	0
isoxaben	40 g ai/ha	flufenacet plus diflufenican	200 g ai/ha 100 g ai/ha	60 bc	50	73 ab	53	78 ab	65

Table 2. Trial 2.

Treatment				VISUAL % CONTROL OF BRSNW 13 DAT		VISUAL % CONTROL OF BRSNW 25 DAT	
Ingredient A		Ingredient B		Ob	Ex	Ob	Ex
UNTREATED				0 e		0 d	
isoxaben	40 g ai/ha			22 de		23 cd	
flufenacet	200 g ai/ha			43 cd		55 b	
flufenacet	200 g ai/ha	diflufenican	100 g ai/ha	42 cd		48 bc	
isoxaben	40 g ai/ha	flufenacet	200 g ai/ha	85 ab	55.5	87 a	65.4
isoxaben	40 g ai/ha	flufenacet plus diflufenican	200 g ai/ha 100 g ai/ha	85 ab	54.8	87 a	60.0

WHAT IS CLAIMED IS:

1. An herbicidal composition comprising (a) isoxaben and (b) flufenacet, wherein the weight ratio of (a) to (b) is from 20-80 of (a) to 100-600 of (b).
2. The herbicidal composition of claim 1 wherein isoxaben and flufenacet are the only herbicidally active ingredients.
3. The herbicidal composition of claim 1 or 2 wherein the weight ratio of (a) to (b) is from 0.06 to 0.52.
4. The herbicidal composition of claim 1 additionally comprising (c) diflufenican, wherein the weight ratio of (a) to (b) to (c) is from 20-80 of (a) to 100-600 of (b) to 50-200 of (c).
5. The herbicidal composition of claim 4 wherein isoxaben, flufenacet, and diflufenican are the only herbicidally active ingredients.
6. The herbicidal composition of claim 4 or 5 wherein the weight ratio of (a) to (b) is from 0.06 to 0.52 and the weight ratio of (a) to (c) is from 0.16 to 1.
7. The composition of any of claims 1-6, which is synergistic in the control of *Brassica napus* (winter), *Stellaria media* (L.) Vill, or *Geranium dissectum* L. as determined by the Colby equation.
8. A method of controlling undesirable vegetation which comprises applying the composition of any one of claims 1-7.
9. A method of controlling undesirable vegetation which comprises applying an herbicidally effective amount of (a) isoxaben and (b) flufenacet, wherein the weight ratio of (a) to (b) is from 20-80 of (a) to 100-600 of (b).
10. The method of claim 9 which further comprises applying a herbicidally effective amount of (c) diflufenican, wherein the weight ratio of (a) to (b) to (c) is from 20-80 of (a) to 100-600 of (b) to 50-200 of (c).

11. The method of any one of claims 8-10 wherein the application rate of (a) isoxaben is from 20 to 80 g ai/ha, and the application rate of flufenacet is from 100 to 600 g ai/ha.
12. The method of claim 10 wherein the application rate of (a) isoxaben is 20 to 80 g ai/ha, the application rate of flufenacet is from 100 to 600 g ai/ha and the application rate of diflufenican is from 50 to 200 g ai/ha..
13. The method of any one of claim 8-12, which is carried out in the presence of a cereal crop, wherein the cereal crop is rice, wheat, barley, triticale, oats, rye, sorghum, or maize.
14. The method of any one of claims 8-13 wherein the undesirable vegetation is volunteer oilseed rape.
15. The method of claim 13 or 14 wherein the cereal crop is tolerant to glyphosate, glufosinate, dicamba, imidazolinones, phenoxy auxins, pyridyloxy auxins, aryloxyphenoxypropionates, acetyl CoA carboxylase (ACCase) inhibitors, acetolactate synthase (ALS) inhibitors, 4-hydroxyphenyl-pyruvate dioxygenase (HPPD) inhibitors, protoporphyrinogen oxidase (PPO) inhibitors, triazines, or bromoxynil.