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(54) Title: MIXTURES OF BIXLOZONE WITH PHOTOSYSTEM I ELECTRON DIVERTERS

(57) Abstract: This invention is directed to a mixture comprising bixlozone and at least one herbicide selected from photosystem I electron diverters and agriculturally acceptable salts and esters thereof. The invention is also directed to an agrochemical composition of the mixture and a method of using the mixture or composition.

MIXTURES OF BIXLOZONE WITH PHOTOSYSTEM I ELECTRON DIVERTERS

FIELD OF THE INVENTION

This invention relates to a herbicidal mixture of bixlozone with one or more photosystem I electron diverters and salts or esters thereof, and methods of their use for controlling undesirable vegetation.

BACKGROUND OF THE INVENTION

The control of undesired vegetation is extremely important in achieving high crop efficiency. Achievement of selective control of the growth of weeds especially in such useful crops as rice, soybean, sugar beet, maize, potato, wheat, barley, tomato and plantation crops, among others, is very desirable. Unchecked weed growth in such useful crops can cause significant reduction in productivity and thereby result in increased costs to the consumer. Many products are commercially available for these purposes, but the need continues for new mixtures that are more effective, less costly, less toxic, environmentally safer, have different sites of action, or can be applied in lower amounts because of synergy.

United States Patent 4,405,357 discloses certain 3-isoxazolidinones which exhibit desirable selective activity and are shown to be effective in controlling grassy and broadleaf weed species. Among the compounds disclosed in this patent is 2-[(2,4-dichlorophenyl)methyl]-4,4-dimethyl-3-isoxazolidinone (CA No. 81777-95-9). A mixture including 2-[(2,4-dichlorophenyl)methyl]-4,4-dimethyl-3-isoxazolidinone, along with several other active ingredients is taught in WO2015/127259. Cyperquat, diquat, morfenquat and paraquat are mentioned in this application publication, listed as possible secondary active components under the heading "Pyrimidinyloxybenzylamine herbicides". The specific mixtures of the present invention are not disclosed therein.

2-[(2,4-Dichlorophenyl)methyl]-4,4-dimethyl-3-isoxazolidinone is described in WO2019/243104 as controlling certain herbicide-resistant weed species. Specific combinations of the present invention are not disclosed therein. Formulations including various combinations of bixlozone with other herbicides are disclosed in WO2017025418. This application publication discloses general synergistic effect is particularly pronounced at certain concentration ratios, and that the weight ratios can be varied within relatively wide ranges. No synergy between bixlozone and photosystem I inhitors is disclosed therein.

SUMMARY OF THE INVENTION

This invention is directed to a mixture comprising bixlozone and at least one herbicide selected from photosystem I electron diverters and agriculturally acceptable salts and esters thereof. In particular, this invention is directed to an agrochemical composition comprising

bixlozone and at least one herbicide selected from photosystem I electron diverter wherein the bixlozone and photosystem I electron diverter are present in synergistically effective amounts. This invention is also directed to a method of controlling undesired vegetation comprising applying a herbicidally effective amount of a mixture comprising bixlozone and at least one herbicide selected from a photosystem I electron diverter to the locus of the undesired vegetation.

This invention also includes a herbicidal mixture comprising (a) a mixture as described above, and further comprising (b) at least one additional active ingredient selected from (b1) through (b15); and salts of compounds of (b1) through (b15), as described below.

DETAILS OF THE INVENTION

As used herein, the terms "comprises," "comprising," "includes," "including," "has," "having," "contains", "containing," "characterized by" or any other variation thereof, are intended to cover a non-exclusive inclusion, subject to any limitation explicitly indicated. For example, a mixture, composition, or method that comprises a list of elements is not necessarily limited to only those elements but may include other elements not expressly listed or inherent to such mixture, composition or method.

The transitional phrase "consisting of" excludes any element, step, or ingredient not specified. If in the claim, such would close the claim to the inclusion of materials other than those recited except for impurities ordinarily associated therewith. When the phrase "consisting of" appears in a clause of the body of a claim, rather than immediately following the preamble, it limits only the element set forth in that clause; other elements are not excluded from the claim as a whole.

The transitional phrase "consisting essentially of" is used to define a mixture, composition or method that includes materials, steps, features, components, or elements, in addition to those literally disclosed, provided that these additional materials, steps, features, components, or elements do not materially affect the basic and novel characteristic(s) of the claimed invention. The term "consisting essentially of" occupies a middle ground between "comprising" and "consisting of".

Where applicants have defined an invention or a portion thereof with an open-ended term such as "comprising," it should be readily understood that (unless otherwise stated) the description should be interpreted to also describe such an invention using the terms "consisting essentially of" or "consisting of." The term "about" when describing a ratio or a range of ratios means "plus or minus 10%" of the value.

Further, unless expressly stated to the contrary, "or" refers to an inclusive or and not to an exclusive or. For example, a condition A or B is satisfied by any one of the following: A

is true (or present) and B is false (or not present), A is false (or not present) and B is true (or present), and both A and B are true (or present).

Also, the indefinite articles "a" and "an" preceding an element or component of the invention are intended to be nonrestrictive regarding the number of instances (i.e. occurrences) of the element or component. Therefore "a" or "an" should be read to include one or at least one, and the singular word form of the element or component also includes the plural unless the number is obviously meant to be singular.

As referred to herein, the term "seedling", used either alone or in a combination of words means a young plant developing from the embryo of a seed.

As referred to herein, the term "broadleaf" used either alone or in words such as "broadleaf weed" means dicot or dicotyledon, a term used to describe a group of angiosperms characterized by embryos having two cotyledons.

The common name "bixlozone" is synonymous with "2,4-DC" which describes 2--[(2,4-dichlorophenyl)methyl]-4,4-dimethyl-3-isoxazolidinone. Bixlozone is provided available under the tradename "Isoflex™ Active" and is found in some markets as a formulated product under the trade name "Overwatch®"."Photosystem I electron diverters" are chemical compounds that accept electrons from Photosystem I, and after several cycles, generate hydroxyl radicals. These radicals are extremely reactive and readily destroy unsaturated lipids, including membrane fatty acids and chlorophyll. This destroys cell membrane integrity, so that cells and organelles "leak", leading to rapid leaf wilting and desiccation, and eventually to plant death. Photosystem I electron diverters are classified in the HRAC Mode Of Action Group 22 and are typically used in non-selective foliar knock-down applications. Examples of photosystem I electron diverters include cyperquat, diquat, morfamquat and paraquat, and salts thereof. It has now been identified that field populations of *Lolium multiflorum* and *Urochloa decumbens* that are resistant photosystem I electon diverters are controlled by a mixture of bixlozone and at least one photosystem I electon diverter. In other words, a mixture of bixlozone with at least one photosystem I electon diverter is synergistic and able to overcome the resistance to the Group 22 herbicides. The unexpected element is that the activity of bixlozone is mainly by uptake via the roots and shoots (residual efficacy) and therefore less efficacy is expected on already established weeds. A mixture of diquat and paraquat is provided by Spray.Seed® 250 as a soluble concentrate (SL) liquid formulation containing the equivalent of 135 g/L paraquat and 115 g/L diquat.

One skilled in the art recognizes that because in the environment and under physiological conditions salts of photosystem I electron diverters can be found in equilibrium with their corresponding nonsalt forms, salts share the biological utility of the nonsalt forms. Thus a

wide variety of salts of a mixture of the invention are useful for control of undesired vegetation (i.e. are agriculturally suitable). The salts of a mixture of the invention include acid-addition salts with inorganic or organic acids such as hydrobromic, hydrochloric, nitric, phosphoric, sulfuric, acetic, butyric, fumaric, lactic, maleic, malonic, oxalic, propionic, salicylic, tartaric, 4-toluenesulfonic or valeric acids. Salts also include those formed with organic or inorganic bases such as pyridine, triethylamine or ammonia, or amides, hydrides, hydroxides or carbonates of sodium, potassium, lithium, calcium, magnesium or barium. Accordingly, the present invention comprises photosystem I electron diverters and agriculturally suitable salts thereof.

Embodiments of the present invention as described in the Summary of the Invention include

Embodiment A1. The mixture as described in the Summary of the Invention.

Embodiment A2. The mixture as descried in Embodiment A1 wherein the photosystem I electron diverter is selected from cyperquat, diquat, diquat dibromide, morfamquat and paraquat or combinations thereof.

Embodiment A3. The mixture as described in Embodiment A2 wherein the photosystem I electron diverter is selected from diquat and paraquat or combinations thereof.

Embodiment B1. The mixture of any of Embodiments A2 to A3 wherein the photosystem I electron diverter is a combination of diquat and paraquat.

Embodiment B2. The mixture of Embodiment B1 wherein the diquat is provided at 135 g/L and the paraquat is provided at 115 g/L.

Embodiment B3. The mixture of Embodiment B2 wherein the diquat is provided at 135 g/L and the paraquat is provided at 115 g/L in a soluble concentrate (SL) formulation.

Embodiment B4. The mixture of any one of Embodiments B1 through B3 wherein the diquat and paraquat are provided by Spray.Seed® 250 herbicide.

Embodiment C1. The mixture as described in any of Embodiments A1 through A3 wherein the mixture comprises bixlozone and diquat.

Embodiment C2. The mixture as described in Embodiment C1 wherein the mixture is synergistic.

Embodiment C3. The mixture of Embodiment C2 wherein the synergistic effect is observed on *Urocloa spp.* Or *Lolium spp.*.

Embodiment C4. The mixture as described in Embodiment C3 wherein the synergistic effect is observed on *Urochloa decumbens* (BRADC) or *Lolium multiflorum* (LOLMU).

Embodiment C5. The mixture as described in Embodiment C4 wherein the synergistic effect is observed on *Urochloa decumbens* (BRADC).

Embodiment C6. The mixture as described in Embodiment C5 wherein the synergistic effect is observed on *Lolium multiflorum* (LOLMU).

Embodiment C7. The mixture as described in Embodiment C4 wherein the synergistic effect is observed on *Lolium rigidum* (LOLRI).

Embodiment C8. The mixture as described in any one of Embodiments C1 through C7 wherein the ratio of bixlozone to diquat is from about 1.5 : 1 to about 3 : 2.

Embodiment C9. The mixture as described in Embodiment C8 wherein the ratio of bixlozone to diquat is about 1.5 : 1.

Embodiment C10. The mixture as described in Embodiment C8 wherein the ratio of bixlozone to diquat is about 3 : 2.

Embodiment C11. The mixture as described in any one of Embodiment C1 through C7 wherein the ratio of bixlozone to diquat is from about 3 : 2 to about 7.2 : 5.

Embodiment C12. The mixture as described in Embodiment C11 wherein the ratio of bixlozone to diquat is about 3 : 2.

Embodiment C13. The mixture as described in Embodiment C12 wherein the ratio of bixlozone to diquat is about 7.2 : 5.

Embodiment C14. The mixture as described in any of Embodiments C1 to C13 wherein the application rate of bixlozone is from about 100 to about 700 g/ha (grams per hectare).

Embodiment C15. The mixture as described in Embodiment C14 wherein the application rate of bixlozone is from about 125 to about 650 g/ha.

Embodiment C16. The mixture of Embodiment C15 wherein the application rate of bixlozone is from about 150 to about 600 g/ha.

Embodiment C17. The mixture of Embodiment C16 wherein the application rate of bixlozone is from about 150 to about 400 g/ha.

Embodiment C18. The mixture of Embodiment C17 wherein the application rate of bixlozone is from about 150 to about 300 g/ha.

Embodiment C19. The mixture of Embodiment C18 wherein the application rate of bixlozone is from about 150 to about 200 g/ha.

Embodiment C20. The mixture of any one of Embodiments C1 through C19 wherein the mixture further comprises mineral oil.

Embodiment D1. The mixture as described in any of Embodiments A1 through A3 wherein the mixture comprises bixlozone and paraquat.

Embodiment D2. The mixture as described in Embodiment D1 wherein the mixture is synergistic.

Embodiment D3. The mixture as described in Embodiment D1 or D2 wherein the synergistic effect is observed on ryegrass (3RYGC).

Embodiment D4. The mixture as described in Embodiment D3 wherein the synergistic effect is observed on wild-type ryegrass or paraquat-resistant ryegrass.

Embodiment D5. The mixture as described in any one of Embodiments D1 through D5 wherein the ratio of bixlozone to paraquat is from about 2.5 : 1 to about 1 : 1.

Embodiment D6. The mixture as described in Embodiment D5 wherein the ratio of bixlozone to paraquat is about 2 : 1.

Embodiment D7. The mixture as described in any one of Embodiments D1 through D6 wherein the application rate of bixlozone in from about 100 to about 700 g/ha.

Embodiment D8. The mixture of Embodiment D7 wherein the application rate of bixlozone is from about 250 to about 600 g/ha.

Embodiment D9. The mixture of Embodiment D8 wherein the application rate of bixlozone is from about 350 to about 550 g/ha.

Embodiment D10. The mixture of Embodiment 26B wherein the application rate of bixlozone is from about 450 to about 550 g/ha.

Embodiment D11. The mixture of Embodiment 26B wherein the application rate of bixlozone is about 500 g/ha.

Embodiment E1. The mixture of any one of Embodiments A1 through A3 or B1 through B5 or C1 through C20 or D1 through D11 wherein the mixture further comprises a third active ingredient.

Embodiment E2. The mixture of any one of Embodiments A1 through A3 or B1 through B5 or C1 through C20 or D1 through D11 wherein the mixture is in a form selected from a suspension concentrate, a capsule suspension, an emulsifiable concentrate, granules and wettable granules, and combinations thereof.

Embodiment F1. A method of making the mixture as described in any one of Embodiments A1 through A3, or B1 through B5, or C1 through C20, or D1 through D11, or E1 through E2.

Embodiment G1. A method of using the mixture as described in any of one of Embodiments A1 through A3, or B1 through B5, or C1 through C20, or D1 through D11, or prepared as described in Embodiment F1 comprising the steps of applying a herbicidally effective amount of the mixture to the locus of an undesirable plant.

Embodiment G2. The method of Embodiment G1 wherein the method comprises applying an agrochemical composition of bixlozone, paraquat and diquat for pre-plant burndown.

Embodiment G3. The method of Embodiment G1 wherein the method comprises applying an agrochemical composition of i) bixlozone and paraquat; or ii) bixlozone and diquat for pre-plant burndown.

Embodiments of this invention, including Embodiments A1 through A3, or B1 through B5, or C1 through C20, or D1 through D11, or prepared as described in Embodiment F1, or used as described in Embodiments G1 through G3 above as well as any other embodiments described herein, can be combined in any manner, and the descriptions of variables in the embodiments pertain not only to the mixtures but also the methods of using the mixtures. In addition, embodiments of this invention, including Embodiments A1 through A3, or B1 through B5, or C1 through C20, or D1 through D11, or prepared as described in Embodiment F1, or used as described in Embodiments G1 through G3 above as well as any other embodiments described herein, and any combination thereof, pertain to the compositions of the mixtures and methods of using the compositions of the present invention.

This invention also relates to a method for controlling undesired vegetation comprising applying to the locus of the vegetation herbicidally effective amounts of the mixtures of the invention (e.g., as a composition described herein). Of note as embodiments relating to methods of use are those involving the mixtures of embodiments described above. Mixtures of the invention are particularly useful for selective control of weeds selected from the group consisting of annual blue grass, annual ryegrass (*Lolium rigidum*), ball medic (*Medicago* spp.), barley grass (*Hordeum murinum*), bedstraw (*Galium tricornutum*), Benghal dayflower, bifora (*Bifora testiculata*), black grass, black night shade, broadleaf signal grass, brome grass (*Bromus* spp.), Canada thistle, capeweed (*Arctotheca calendula*), cheat, chickweed (*Stellaria media*), common cocklebur (Xanthium pensylvanicum), common ragweed, corn poppies,

doublegee (*Emex australis*), field violet, fleabane (*Conyza bonariensis*) giant foxtail, fumitory (*Fumaria* spp), goose grass, green fox tail, guinea grass, hairy beggarticks, herbicide-resistant black grass, horseweed, Indian hedge mustard (*Sisymbrium orientale*), Italian rye grass, Jersey cudweed (*Gnaphalium luteoalbum*), jimsonweed, johnsongrass (Sorghum halepense), large crabgrass, lesser loosestrife (*Lythrum hyssopifolia*), little seed cany grass, morning glory, Patterson's Curse (*Echium plantagineum*), Pennsylvania smartweed, hood canarygrass (*Phalaris paradoxa*), pitted morningglory, prickly lettuce (*Lactuca serriola*), prickly sida, quack grass, redflowered mallow (*Modiola caroliniana*), redroot pigweed, rough poppy (*Papaver hybridum*), serradella, shatter cane, shepherd's purse, silky windgrass, silvergrass (*Vulpia bromoides*), sowthistle (*Sonchus oleraceus*), sub-clover (*Trifolium* spp.), sunflower (as weed in potato), volunteer chickpea, faba beans, field peas, lentils, lupins and vetch, wild buckwheat (Polygonum convolvulus), wild mustard (Brassica kaber), wild oat (Avena fatua), wild pointsettia, wild radish (*Raphanus raphanistrum*), wild turnip (*Rapistrum rugosum, Brassica tournefortii*), wireweed (*Polygonum aviculare*), yellow foxtail, yellow nutsedge (Cyperus esculentus) in crops such as bananas, barley, beans, beets, cassava, cereals, citrus, cocoas, coconuts, coffee, corn, grapes, groundnuts, hops, oil palm, oilseed rape, peas, peanuts, potato, rice, sugar cane, sunflower, tea, tobacco, turf and wheat.

Also noteworthy as embodiments are herbicidal compositions of the present invention comprising the mixtures of embodiments described above.

The mixtures the invention can be prepared by general methods known in the art.

Without further elaboration, it is believed that one skilled in the art using the preceding description can utilize the present invention to its fullest extent. The following non-limiting Examples are illustrative of the invention. Steps in the following Examples illustrate a procedure for each step in an overall synthetic transformation, and the starting material for each step may not have necessarily been prepared by a particular preparative run whose procedure is described in other Examples or Steps. Percentages are by weight except for chromatographic solvent mixtures or where otherwise indicated.

A compound of this invention will generally be used as a herbicidal active ingredient in a composition, i.e. formulation, with at least one additional component selected from the group consisting of surfactants, solid diluents and liquid diluents, which serves as a carrier. The formulation or composition ingredients are selected to be consistent with the physical properties of the active ingredient, mode of application and environmental factors such as soil type, moisture and temperature.

Useful formulations include both liquid and solid compositions. Liquid compositions include solutions (including emulsifiable concentrates), suspensions, emulsions (including

microemulsions, oil-in -water emulsions, flowable concentrates and/or suspoemulsions) and the like, which optionally can be thickened into gels. The general types of aqueous liquid compositions are soluble concentrate, suspension concentrate, capsule suspension, concentrated emulsion, microemulsion, oil-in-water emulsion, flowable concentrate and suspo-emulsion. The general types of nonaqueous liquid compositions are emulsifiable concentrate, microemulsifiable concentrate, dispersible concentrate and oil dispersion.

The general types of solid compositions are dusts, powders, granules, pellets, prills, pastilles, tablets, filled films (including seed coatings) and the like, which can be water-dispersible ("wettable") or water-soluble. Films and coatings formed from film-forming solutions or flowable suspensions are particularly useful for seed treatment. Active ingredient can be (micro)encapsulated and further formed into a suspension or solid formulation; alternatively the entire formulation of active ingredient can be encapsulated (or "overcoated"). Encapsulation can control or delay release of the active ingredient. An emulsifiable granule combines the advantages of both an emulsifiable concentrate formulation and a dry granular formulation. High-strength compositions are primarily used as intermediates for further formulation.

Sprayable formulations are typically extended in a suitable medium before spraying. Such liquid and solid formulations are formulated to be readily diluted in the spray medium, usually water, but occasionally another suitable medium like an aromatic or paraffinic hydrocarbon or vegetable oil. Spray volumes can range from about from about one to several thousand liters per hectare, but more typically are in the range from about ten to several hundred liters per hectare. Sprayable formulations can be tank mixed with water or another suitable medium for foliar treatment by aerial or ground application, or for application to the growing medium of the plant. Liquid and dry formulations can be metered directly into drip irrigation systems or metered into the furrow during planting.

The formulations will typically contain effective amounts of active ingredient, diluent and surfactant within the following approximate ranges which add up to 100 percent by weight.

	Weight Percent		
	Active Ingredient	Diluent	Surfactant
Water-Dispersible and Water-soluble Granules, Tablets and Powders	0.001–90	0–99.999	0–15
Oil Dispersions, Suspensions, Emulsions, Solutions (including Emulsifiable Concentrates)	1–50	40–99	0–50
Dusts	1–25	70–99	0–5
Granules and Pellets	0.001–99	5–99.999	0–15
High Strength Compositions	90–99	0–10	0–2

Solid diluents include, for example, clays such as bentonite, montmorillonite, attapulgite and kaolin, gypsum, cellulose, titanium dioxide, zinc oxide, starch, dextrin, sugars (e.g., lactose, sucrose), silica, talc, mica, diatomaceous earth, urea, calcium carbonate, sodium carbonate and bicarbonate, and sodium sulfate. Typical solid diluents are described in Watkins et al., *Handbook of Insecticide Dust Diluents and Carriers*, 2nd Ed., Dorland Books, Caldwell, New Jersey.

Liquid diluents include, for example, water, *N*,*N*-dimethylalkanamides (e.g., *N*,*N*-dimethylformamide), limonene, dimethyl sulfoxide, *N*-alkylpyrrolidones (e.g., *N*-methylpyrrolidinone), alkyl phosphates (e.g., triethyl phosphate), ethylene glycol, triethylene glycol, propylene glycol, dipropylene glycol, polypropylene glycol, propylene carbonate, butylene carbonate, paraffins (e.g., white mineral oils, normal paraffins, isoparaffins), alkylbenzenes, alkylnaphthalenes, glycerine, glycerol triacetate, sorbitol, aromatic hydrocarbons, dearomatized aliphatics, alkylbenzenes, alkylnaphthalenes, ketones such as cyclohexanone, 2-heptanone, isophorone and 4-hydroxy-4-methyl-2-pentanone, acetates such as isoamyl acetate, hexyl acetate, heptyl acetate, octyl acetate, nonyl acetate, tridecyl acetate and isobornyl acetate, other esters such as alkylated lactate esters, dibasic esters, alkyl and aryl benzoates and γ-butyrolactone, and alcohols, which can be linear, branched, saturated or unsaturated, such as methanol, ethanol, *n*-propanol, isopropyl alcohol, *n*-butanol, isobutyl alcohol, *n*-hexanol, 2-ethylhexanol, *n*-octanol, decanol, isodecyl alcohol, isooctadecanol, cetyl alcohol, lauryl alcohol, tridecyl alcohol, oleyl alcohol, cyclohexanol, tetrahydrofurfuryl alcohol, diacetone alcohol, cresol and benzyl alcohol. Liquid diluents also include glycerol esters of saturated and unsaturated fatty acids (typically C_6–C_{22}), such as plant seed and fruit oils (e.g., oils of olive, castor, linseed, sesame, corn

(maize), peanut, sunflower, grapeseed, safflower, cottonseed, soybean, rapeseed, coconut and palm kernel), animal-sourced fats (e.g., beef tallow, pork tallow, lard, cod liver oil, fish oil), and mixtures thereof. Liquid diluents also include alkylated fatty acids (e.g., methylated, ethylated, butylated) wherein the fatty acids may be obtained by hydrolysis of glycerol esters from plant and animal sources, and can be purified by distillation. Typical liquid diluents are described in Marsden, *Solvents Guide*, 2nd Ed., Interscience, New York, 1950.

The solid and liquid compositions of the present invention often include one or more surfactants. When added to a liquid, surfactants (also known as "surface-active agents") generally modify, most often reduce, the surface tension of the liquid. Depending on the nature of the hydrophilic and lipophilic groups in a surfactant molecule, surfactants can be useful as wetting agents, dispersants, emulsifiers or defoaming agents.

Surfactants can be classified as nonionic, anionic or cationic. Nonionic surfactants useful for the present compositions include, but are not limited to: alcohol alkoxylates such as alcohol alkoxylates based on natural and synthetic alcohols (which may be branched or linear) and prepared from the alcohols and ethylene oxide, propylene oxide, butylene oxide or mixtures thereof; amine ethoxylates, alkanolamides and ethoxylated alkanolamides; alkoxylated triglycerides such as ethoxylated soybean, castor and rapeseed oils; alkylphenol alkoxylates such as octylphenol ethoxylates, nonylphenol ethoxylates, dinonyl phenol ethoxylates and dodecyl phenol ethoxylates (prepared from the phenols and ethylene oxide, propylene oxide, butylene oxide or mixtures thereof); block polymers prepared from ethylene oxide or propylene oxide and reverse block polymers where the terminal blocks are prepared from propylene oxide; ethoxylated fatty acids; ethoxylated fatty esters and oils; ethoxylated methyl esters; ethoxylated tristyrylphenol (including those prepared from ethylene oxide, propylene oxide, butylene oxide or mixtures thereof); fatty acid esters, glycerol esters, lanolin-based derivatives, polyethoxylated esters such as polyethoxylated sorbitan fatty acid esters, polyethoxylated sorbitol fatty acid esters and polyethoxylated glycerol fatty acid esters; other sorbitan derivatives such as sorbitan esters; polymeric surfactants such as random copolymers, block copolymers, alkyd peg (polyethylene glycol) resins, graft or comb polymers and star polymers; polyethylene glycols (pegs); polyethylene glycol fatty acid esters; silicone-based surfactants; and sugar-derivatives such as sucrose esters, alkyl polyglycosides and alkyl polysaccharides.

Useful anionic surfactants include, but are not limited to: alkylaryl sulfonic acids and their salts; carboxylated alcohol or alkylphenol ethoxylates; diphenyl sulfonate derivatives; lignin and lignin derivatives such as lignosulfonates; maleic or succinic acids or their anhydrides; olefin sulfonates; phosphate esters such as phosphate esters of alcohol alkoxylates,

phosphate esters of alkylphenol alkoxylates and phosphate esters of styryl phenol ethoxylates; protein-based surfactants; sarcosine derivatives; styryl phenol ether sulfate; sulfates and sulfonates of oils and fatty acids; sulfates and sulfonates of ethoxylated alkylphenols; sulfates of alcohols; sulfates of ethoxylated alcohols; sulfonates of amines and amides such as *N,N*-alkyltaurates; sulfonates of benzene, cumene, toluene, xylene, and dodecyl and tridecylbenzenes; sulfonates of condensed naphthalenes; sulfonates of naphthalene and alkyl naphthalene; sulfonates of fractionated petroleum; sulfosuccinamates; and sulfosuccinates and their derivatives such as dialkyl sulfosuccinate salts.

Useful cationic surfactants include, but are not limited to: amides and ethoxylated amides; amines such as *N*-alkyl propanediamines, tripropylenetriamines and dipropylenetetramines, and ethoxylated amines, ethoxylated diamines and propoxylated amines (prepared from the amines and ethylene oxide, propylene oxide, butylene oxide or mixtures thereof); amine salts such as amine acetates and diamine salts; quaternary ammonium salts such as quaternary salts, ethoxylated quaternary salts and diquaternary salts; and amine oxides such as alkyldimethylamine oxides and bis-(2-hydroxyethyl)-alkylamine oxides.

Also useful for the present mixtures are compositions with nonionic and anionic surfactants or mixtures of nonionic and cationic surfactants. Nonionic, anionic and cationic surfactants and their recommended uses are disclosed in a variety of published references including *McCutcheon's Emulsifiers and Detergents*, annual American and International Editions published by McCutcheon's Division, The Manufacturing Confectioner Publishing Co.; Sisely and Wood, *Encyclopedia of Surface Active Agents*, Chemical Publ. Co., Inc., New York, 1964; and A. S. Davidson and B. Milwidsky, *Synthetic Detergents*, Seventh Edition, John Wiley and Sons, New York, 1987.

Compositions of this invention may also contain formulation auxiliaries and additives, known to those skilled in the art as formulation aids (some of which may be considered to also function as solid diluents, liquid diluents or surfactants). Such formulation auxiliaries and additives may control: pH (buffers), foaming during processing (antifoams such polyorganosiloxanes), sedimentation of active ingredients (suspending agents), viscosity (thixotropic thickeners), in-container microbial growth (antimicrobials), product freezing (antifreezes), color (dyes/pigment dispersions), wash-off (film formers or stickers), evaporation (evaporation retardants), and other formulation attributes. Film formers include, for example, polyvinyl acetates, polyvinyl acetate copolymers, polyvinylpyrrolidone-vinyl acetate copolymer, polyvinyl alcohols, polyvinyl alcohol copolymers and waxes. Examples of formulation auxiliaries and additives include those listed in *McCutcheon's Volume 2: Functional Materials*, annual International and North American editions published by

McCutcheon's Division, The Manufacturing Confectioner Publishing Co.; and PCT Publication WO 03/024222.

The mixture of the invention and any other active ingredients are typically incorporated into the present compositions by dissolving the active ingredient in a solvent or by grinding in a liquid or dry diluent. Solutions, including emulsifiable concentrates, can be prepared by simply mixing the ingredients. If the solvent of a liquid composition intended for use as an emulsifiable concentrate is water-immiscible, an emulsifier is typically added to emulsify the active-containing solvent upon dilution with water. Active ingredient slurries, with particle diameters of up to 2,000 μm can be wet milled using media mills to obtain particles with average diameters below 3 μm. Aqueous slurries can be made into finished suspension concentrates (see, for example, U.S. 3,060,084) or further processed by spray drying to form water-dispersible granules. Dry formulations usually require dry milling processes, which produce average particle diameters in the 2 to 10 μm range. Dusts and powders can be prepared by blending and usually grinding (such as with a hammer mill or fluid-energy mill). Granules and pellets can be prepared by spraying the active material upon preformed granular carriers or by agglomeration techniques. See Browning, "Agglomeration", *Chemical Engineering*, December 4, 1967, pp 147–48, *Perry's Chemical Engineer's Handbook*, 4th Ed., McGraw-Hill, New York, 1963, pages 8–57 and following, and WO 91/13546. Pellets can be prepared as described in U.S. 4,172,714. Water-dispersible and water-soluble granules can be prepared as taught in U.S. 4,144,050, U.S. 3,920,442 and DE 3,246,493. Tablets can be prepared as taught in U.S. 5,180,587, U.S. 5,232,701 and U.S. 5,208,030. Films can be prepared as taught in GB 2,095,558 and U.S. 3,299,566.

For further information regarding the art of formulation, see T. S. Woods, "The Formulator's Toolbox – Product Forms for Modern Agriculture" in *Pesticide Chemistry and Bioscience, The Food–Environment Challenge*, T. Brooks and T. R. Roberts, Eds., Proceedings of the 9th International Congress on Pesticide Chemistry, The Royal Society of Chemistry, Cambridge, 1999, pp. 120–133. See also U.S. 3,235,361, Col. 6, line 16 through Col. 7, line 19 and Examples 10–41; U.S. 3,309,192, Col. 5, line 43 through Col. 7, line 62 and Examples 8, 12, 15, 39, 41, 52, 53, 58, 132, 138–140, 162–164, 166, 167 and 169–182; U.S. 2,891,855, Col. 3, line 66 through Col. 5, line 17 and Examples 1–4; Klingman, *Weed Control as a Science*, John Wiley and Sons, Inc., New York, 1961, pp 81–96; Hance et al., *Weed Control Handbook*, 8th Ed., Blackwell Scientific Publications, Oxford, 1989; and *Developments in formulation technology*, PJB Publications, Richmond, UK, 2000.

In the following Examples, all percentages are by weight and all formulations are prepared in conventional ways. Mixture numbers refer to the following mixtures: A =

bixlozone + paraquat + diquat; B = bixlozone + paraquat; and C = bixlozone + diquat. The individual components of the mixture can be formulated separately, then combined as formulated materials. Accordingly, the following are exemplary formulations: D = bixlozone; E = paraquat; and F = diquat. Without further elaboration, it is believed that one skilled in the art using the preceding description can utilize the present invention to its fullest extent. The following Examples are, therefore, to be construed as merely illustrative, and not limiting of the disclosure in any way whatsoever. Percentages are by weight except where otherwise indicated.

Example A

High Strength Concentrate

Mixture A, B, C, D, E or F	98.5%
silica aerogel	0.5%
synthetic amorphous fine silica	1.0%

Example B

Wettable Powder

Mixture A, B, C, D, E or F	65.0%
dodecylphenol polyethylene glycol ether	2.0%
sodium ligninsulfonate	4.0%
sodium silicoaluminate	6.0%
montmorillonite (calcined)	23.0%

Example C

Granule

Mixture A, B, C, D, E or F	10.0%
attapulgite granules (low volatile matter, 0.71/0.30 mm; U.S.S. No. 25–50 sieves)	90.0%

Example D

Extruded Pellet

Mixture A, B, C, D, E or F	25.0%
anhydrous sodium sulfate	10.0%
crude calcium ligninsulfonate	5.0%
sodium alkylnaphthalenesulfonate	1.0%
calcium/magnesium bentonite	59.0%

Example E

Emulsifiable Concentrate

Mixture A, B, C, D, E or F	10.0%

polyoxyethylene sorbitol hexoleate	20.0%
C_6–C_{10} fatty acid methyl ester	70.0%

Example F

Microemulsion

Mixture A, B, C, D, E or F	5.0%
polyvinylpyrrolidone-vinyl acetate copolymer	30.0%
alkylpolyglycoside	30.0%
glyceryl monooleate	15.0%
Water	20.0%

Example G

Suspension Concentrate

Mixture A, B, C, D, E or F	35%
butyl polyoxyethylene/polypropylene block copolymer	4.0%
stearic acid/polyethylene glycol copolymer	1.0%
styrene acrylic polymer	1.0%
xanthan gum	0.1%
propylene glycol	5.0%
silicone based defoamer	0.1%
1,2-benzisothiazolin-3-one	0.1%
Water	53.7%

Example H

Emulsion in Water

Mixture A, B, C, D, E or F	10.0%
butyl polyoxyethylene/polypropylene block copolymer	4.0%
stearic acid/polyethylene glycol copolymer	1.0%
styrene acrylic polymer	1.0%
xanthan gum	0.1%
propylene glycol	5.0%
silicone based defoamer	0.1%
1,2-benzisothiazolin-3-one	0.1%
aromatic petroleum based hydrocarbon	20.0
Water	58.7%

Example I

Oil Dispersion

Mixture A, B, C, D, E or F	25%

polyoxyethylene sorbitol hexaoleate	15%
organically modified bentonite clay	2.5%
fatty acid methyl ester	57.5%

Test results indicate that the mixtures of the present invention are highly active synergistically as preemergent and/or postemergent herbicides . The mixtures of the inention generally show highest activity for postemergence weed control (i.e. applied after weed seedlings emerge from the soil) and preemergence weed control (i.e. applied before weed seedlings emerge from the soil). Many of them have utility for broad-spectrum pre- and/or postemergence weed control in areas where complete control of all vegetation is desired such as around fuel storage tanks, industrial storage areas, parking lots, drive-in theaters, air fields, river banks, irrigation and other waterways, around billboards and highway and railroad structures. Mixtures of this invention, by virtue of selective metabolism in crops versus weeds, or by selective activity at the locus of physiological inhibition in crops and weeds, or by selective placement on or within the environment of a mixture of crops and weeds, are useful for the selective control of grass and broadleaf weeds within a crop/weed mixture. One skilled in the art will recognize that the preferred combination of these selectivity factors within a mixture or group of mixtures can readily be determined by performing routine biological and/or biochemical assays. Mixtures of this invention may show tolerance to important agronomic crops including, but is not limited to, alfalfa, barley, cotton, wheat, rape, sugar beets, corn (maize), sorghum, soybeans, rice, oats, peanuts, vegetables, tomato, potato, perennial plantation crops including coffee, cocoa, oil palm, rubber, sugarcane, citrus, grapes, fruit trees, nut trees, banana, plantain, pineapple, hops, tea and forests such as eucalyptus and conifers (e.g., loblolly pine), and turf species (e.g., Kentucky bluegrass, St. Augustine grass, Kentucky fescue and Bermuda grass). Mixtures of this invention can be used in crops genetically transformed or bred to incorporate resistance to herbicides, express proteins toxic to invertebrate pests (such as *Bacillus thuringiensis* toxin), and/or express other useful traits. Those skilled in the art will appreciate that not all mixtures are equally effective against all weeds.

As the mixtures of the invention have both preemergent and postemergent herbicidal activity, to control undesired vegetation by killing or injuring the vegetation or reducing its growth, the mixtures can be usefully applied by a variety of methods involving contacting a herbicidally effective amount of a mixture of the invention, or a composition comprising said mixture and at least one of a surfactant, a solid diluent or a liquid diluent, to the foliage or other part of the undesired vegetation or to the environment of the undesired vegetation such

as the soil or water in which the undesired vegetation is growing or which surrounds the seed or other propagule of the undesired vegetation.

A herbicidally effective amount of the mixtures of this invention is determined by a number of factors. These factors include: formulation selected, method of application, amount and type of vegetation present, growing conditions, etc. In general, a herbicidally effective amount of mixtures of this invention is about 0.001 to 20 kg/ha with a preferred range of about 0.004 to 1 kg/ha. One skilled in the art can easily determine the herbicidally effective amount necessary for the desired level of weed control.

In one common embodiment, a mixture of the invention is applied, typically in a formulated composition, to a locus comprising desired vegetation (e.g., crops) and undesired vegetation (i.e. weeds), both of which may be seeds, seedlings and/or larger plants, in contact with a growth medium (e.g., soil). In this locus, a composition comprising a mixture of the invention can be directly applied to a plant or a part thereof, particularly of the undesired vegetation, and/or to the growth medium in contact with the plant.

Plant varieties and cultivars of the desired vegetation in the locus treated with a mixture of the invention can be obtained by conventional propagation and breeding methods or by genetic engineering methods. Genetically modified plants (transgenic plants) are those in which a heterologous gene (transgene) has been stably integrated into the plant's genome. A transgene that is defined by its particular location in the plant genome is called a transformation or transgenic event.

Although most typically, mixtures of the invention are used to control undesired vegetation, contact of desired vegetation in the treated locus with mixtures of the invention may result in super-additive or synergistic effects with genetic traits in the desired vegetation, including traits incorporated through genetic modification. For example, resistance to phytophagous insect pests or plant diseases, tolerance to biotic/abiotic stresses or storage stability may be greater than expected from the genetic traits in the desired vegetation.

Mixtures of this invention can also be mixed with one or more other biologically active mixtures or agents including herbicides, herbicide safeners, fungicides, insecticides, nematocides, bactericides, acaricides, growth regulators such as insect molting inhibitors and rooting stimulants, chemosterilants, semiochemicals, repellents, attractants, pheromones, feeding stimulants, plant nutrients, other biologically active mixtures or entomopathogenic bacteria, virus or fungi to form a multi-component pesticide giving an even broader spectrum of agricultural protection. Mixtures of the invention with other herbicides can broaden the spectrum of activity against additional weed species, and suppress the proliferation of any resistant biotypes. Thus the present invention also pertains to a composition comprising a

mixture of the invention (in a herbicidally effective amount) and at least one additional biologically active mixture or agent (in a biologically effective amount) and can further comprise at least one of a surfactant, a solid diluent or a liquid diluent. The other biologically active mixtures or agents can be formulated in compositions comprising at least one of a surfactant, solid or liquid diluent. For mixtures of the present invention, one or more other biologically active mixtures or agents can be formulated together with a mixture of the invention, to form a premix, or one or more other biologically active mixtures or agents can be formulated separately from the mixture of the invention, and the formulations combined together before application (e.g., in a spray tank) or, alternatively, applied in succession.

A mixture of one or more of the following herbicides with a mixture of this invention may be particularly useful for weed control: acetochlor, acifluorfen and its sodium salt, aclonifen, acrolein (2-propenal), alachlor, alloxydim, ametryn, amicarbazone, amidosulfuron, aminocyclopyrachlor and its esters (e.g., methyl, ethyl) and salts (e.g., sodium, potassium), aminopyralid, amitrole, ammonium sulfamate, anilofos, asulam, atrazine, azimsulfuron, bixlozone, beflubutamid, beflubutamid-M, benazolin, benazolin-ethyl, bencarbazone, benfluralin, benfuresate, benquinotrione, bensulfuron-methyl, bensulide, bentazone, benzobicyclon, benzofenap, bicyclopyrone, bifenox, bilanafos, bipyrazone, bispyribac and its sodium salt, broclozone, bromacil, bromobutide, bromofenoxim, bromoxynil, bromoxynil octanoate, butachlor, butafenacil, butamifos, butralin, butroxydim, butylate, cafenstrole, carbetamide, carfentrazone-ethyl, catechin, chlomethoxyfen, chloramben, chlorbromuron, chlorflurenol-methyl, chloridazon, chlorimuron-ethyl, chlorotoluron, chlorpropham, chlorsulfuron, chlorthal-dimethyl, chlorthiamid, cinidon-ethyl, cinmethylin, cinosulfuron, clacyfos, clefoxydim, clethodim, clodinafop-propargyl, clomazone, clomeprop, clopyralid, clopyralid-olamine, cloransulam-methyl, cumyluron, cyanazine, cycloate, cyclopyranil, cyclopyrimorate, cyclosulfamuron, cycloxydim, cyhalofop-butyl, cypyrafluone, 2,4-D and its butotyl, butyl, isoctyl and isopropyl esters and its dimethylammonium, diolamine and trolamine salts, daimuron, dalapon, dalapon-sodium, dazomet, 2,4-DB and its dimethylammonium, potassium and sodium salts, desmedipham, desmetryn, dicamba and its diglycolammonium, dimethylammonium, potassium and sodium salts, dichlobenil, dichlorprop, diclofop-methyl, diclosulam, difenzoquat metilsulfate, diflufenican, diflufenzopyr, dimefuron, dimesulfazet, dimepiperate, dimethachlor, dimethametryn, dimethenamid, dimethenamid-P, dimethipin, dimethylarsinic acid and its sodium salt, dinitramine, dinoterb, dioxopyritrione, diphenamid, diquat dibromide, dithiopyr, diuron, DNOC, endothal, EPTC, epyrifenacil, esprocarb, ethalfluralin, ethametsulfuron-methyl, ethiozin, ethofumesate, ethoxyfen, ethoxysulfuron, etobenzanid, fenoxaprop-ethyl,

fenoxaprop-P-ethyl, fenoxasulfone, fenpyrazone, fenquinotrione, fentrazamide, fenuron, fenuron-TCA, flamprop-methyl, flamprop-M-isopropyl, flamprop-M-methyl, flazasulfuron, florasulam, fluazifop-butyl, fluazifop-P-butyl, fluazolate, flucarbazone, flucetosulfuron, fluchloralin, fluchloraminopyr, flufenacet, flufenoximacil, flufenpyr, flufenpyr-ethyl, flumetsulam, flumiclorac-pentyl, flumioxazin, fluometuron, fluoroglycofen-ethyl, flupoxam, flupyrsulfuron-methyl and its sodium salt, flurenol, flurenol-butyl, fluridone, flurochloridone, fluroxypyr, flurtamone, flusulfinam, fluthiacet-methyl, fomesafen, foramsulfuron, fosamine-ammonium, glufosinate, glufosinate-ammonium, L-glufosinate-ammonium, glufosinate-P, glyphosate and its salts such as ammonium, isopropylammonium, potassium, sodium (including sesquisodium) and trimesium (alternatively named sulfosate), halauxifen, halauxifen-methyl, halosulfuron-methyl, haloxyfop-etotyl, haloxyfop-methyl, hexazinone, hydantocidin, icafolin, icafolin-methyl, imazamethabenz-methyl, imazamox, imazapic, imazapyr, imazaquin, imazaquin-ammonium, imazethapyr, imazethapyr-ammonium, imazosulfuron, indanofan, indaziflam, indolauxipyr, indolauxipyr-cyanomethyl, indolauxipyr-propargyl, iofensulfuron, iodosulfuron-methyl, ioxynil, ioxynil octanoate, ioxynil-sodium, ipfencarbazone, iptriazopyrid, isoproturon, isouron, isoxaben, isoxaflutole, isoxachlortole, lactofen, lancotrione, lenacil, linuron, maleic hydrazide, MCPA and its salts (e.g., MCPA-dimethylammonium, MCPA-potassium and MCPA-sodium, esters (e.g., MCPA-2-ethylhexyl, MCPA-butotyl) and thioesters (e.g., MCPA-thioethyl), MCPB and its salts (e.g., MCPB-sodium) and esters (e.g., MCPB-ethyl), mecoprop, mecoprop-P, mefenacet, mefluidide, mesosulfuron-methyl, mesotrione, metam-sodium, metamifop, metamitron, metazachlor, metazosulfuron, methabenzthiazuron, methylarsonic acid and its calcium, monoammonium, monosodium and disodium salts, methyldymron, metobenzuron, metobromuron, metolachlor, S-metolachlor, metosulam, metoxuron, metribuzin, metsulfuron-methyl, molinate, monolinuron, naproanilide, napropamide, napropamide-M, naptalam, neburon, nicosulfuron, norflurazon, orbencarb, orthosulfamuron, oryzalin, oxadiargyl, oxadiazon, oxasulfuron, oxaziclomefone, oxyfluorfen, paraquat dichloride, pebulate, pelargonic acid, pendimethalin, penoxsulam, pentanochlor, pentoxazone, perfluidone, pethoxamid, pethoxyamid, phenmedipham, picloram, picloram-potassium, picolinafen, pinoxaden, piperophos, pretilachlor, primisulfuron-methyl, prodiamine, profoxydim, prometon, prometryn, propachlor, propanil, propaquizafop, propazine, propham, propisochlor, propoxycarbazone, propyrisulfuron, propyzamide, prosulfocarb, prosulfuron, pyraclonil, pyraflufen-ethyl, pyraquinate, pyrasulfotole, pyrazogyl, pyrazolynate, pyrazoxyfen, pyrazosulfuron-ethyl, pyribenzoxim, pyributicarb, pyridate, pyriflubenzoxim, pyriftalid, pyriminobac-methyl, pyrimisulfan, pyrithiobac, pyrithiobac-sodium,

pyroxasulfone, pyroxsulam, quinclorac, quinmerac, quinoclamine, quizalofop-ethyl, quizalofop-P-ethyl, quizalofop-P-tefuryl, rimisoxafen, rimsulfuron, saflufenacil, sethoxydim, siduron, simazine, simetryn, sulcotrione, sulfentrazone, sulfometuron-methyl, sulfosulfuron, 2,3,6-TBA, TCA, TCA-sodium, tebutam, tebuthiuron, tefuryltrione, tembotrione, tepraloxydim, terbacil, terbumeton, terbuthylazine, terbutryn, tetflupyrolimet, thenylchlor, thiazopyr, thiencarbazone, thifensulfuron-methyl, thiobencarb, tiafenacil, tiocarbazil, tolpyralate, topramezone, tralkoxydim, tri-allate, triafamone, triasulfuron, triaziflam, tribenuron-methyl, triclopyr, triclopyr-butotyl, triclopyr-triethylammonium, tridiphane, trietazine, trifloxysulfuron, trifludimoxazin, trifluralin, triflusulfuron-methyl, tripyrasulfone, tritosulfuron, vernolate, 3-(2-chloro-3,6-difluorophenyl)-4-hydroxy-1-methyl-1,5-naphthyridin-2(1*H*)-one, 5-chloro-3-[(2-hydroxy-6-oxo-1-cyclohexen-1-yl)carbonyl]-1-(4-methoxyphenyl)-2(1*H*)-quinoxalinone, 2-chloro-*N*-(1-methyl-1*H*-tetrazol-5-yl)-6-(trifluoromethyl)-3-pyridinecarboxamide, 7-(3,5-dichloro-4-pyridinyl)-5-(2,2-difluoroethyl)-8-hydroxypyrido[2,3-*b*]pyrazin-6(5*H*)-one), 4-(2,6-diethyl-4-methylphenyl)-5-hydroxy-2,6-dimethyl-3(2*H*)-pyridazinone), 5-[[(2,6-difluorophenyl)methoxy]methyl]-4,5-dihydro-5-methyl-3-(3-methyl-2-thienyl)isoxazole (previously methioxolin), 4-(4-fluorophenyl)-6-[(2-hydroxy-6-oxo-1-cyclohexen-1-yl)carbonyl]-2-methyl-1,2,4-triazine-3,5(2*H*,4*H*)-dione, methyl 4-amino-3-chloro-6-(4-chloro-2-fluoro-3-methoxyphenyl)-5-fluoro-2-pyridinecarboxylate, 2-methyl-3-(methylsulfonyl)-*N*-(1-methyl-1*H*-tetrazol-5-yl)-4-(trifluoromethyl)benzamide, 2-methyl-*N*-(4-methyl-1,2,5-oxadiazol-3-yl)-3-(methylsulfinyl)-4-(trifluoromethyl)benzamide, or their environmentally compatible salts, acids, esters and amides.

Other herbicides also include bioherbicides such as *Alternaria destruens* Simmons, *Colletotrichum gloeosporiodes* (Penz.) Penz. & Sacc., *Drechsiera monoceras* (MTB-951), *Myrothecium verrucaria* (Albertini & Schweinitz) Ditmar: Fries, *Phytophthora palmivora* (Butl.) Butl. and *Puccinia thlaspeos* Schub.

Mixtures of this invention can also be used in combination with plant growth regulators such as aviglycine, *N*-(phenylmethyl)-1*H*-purin-6-amine, epocholeone, gibberellic acid, gibberellin A_4 and A_7, harpin protein, mepiquat chloride, prohexadione calcium, prohydrojasmon, sodium nitrophenolate and trinexapac-methyl, and plant growth modifying organisms such as *Bacillus cereus* strain BP01.

General references for agricultural protectants (i.e. herbicides, herbicide safeners, insecticides, fungicides, nematocides, acaricides and biological agents) include *The Pesticide Manual, 13th Edition*, C. D. S. Tomlin, Ed., British Crop Protection Council, Farnham, Surrey,

U.K., 2003 and *The BioPesticide Manual, 2nd Edition*, L. G. Copping, Ed., British Crop Protection Council, Farnham, Surrey, U.K., 2001.

For embodiments where one or more of these various mixing partners are used, the mixing partners are typically used in the amounts similar to amounts customary when the mixture partners are used alone. More particularly in mixtures, active ingredients are often applied at an application rate between one-half and the full application rate specified on product labels for use of active ingredient alone. These amounts are listed in references such as *The Pesticide Manual* and *The BioPesticide Manual*. The weight ratio of these various mixing partners (in total) to the mixture of the invention is typically between about 1:3000 and about 3000:1. Of note are weight ratios between about 1:300 and about 300:1 (for example ratios between about 1:30 and about 30:1). One skilled in the art can easily determine through simple experimentation the biologically effective amounts of active ingredients necessary for the desired spectrum of biological activity. It will be evident that including these additional components may expand the spectrum of weeds controlled beyond the spectrum controlled by the mixture of the invention alone.

In certain instances, combinations of a mixture of this invention with other biologically active (particularly herbicidal) compounds or agents (i.e. active ingredients) can result in a greater-than-additive (i.e. synergistic) effect on weeds and/or a less-than-additive effect (i.e. safening) on crops or other desirable plants. Reducing the quantity of active ingredients released in the environment while ensuring effective pest control is always desirable. Ability to use greater amounts of active ingredients to provide more effective weed control without excessive crop injury is also desirable. When synergism of herbicidal active ingredients occurs on weeds at application rates giving agronomically satisfactory levels of weed control, such combinations can be advantageous for reducing crop production cost and decreasing environmental load. When safening of herbicidal active ingredients occurs on crops, such combinations can be advantageous for increasing crop protection by reducing weed competition.

Of note is a combination of a mixture of the invention with at least one other herbicidal active ingredient. Of particular note is such a combination where the other herbicidal active ingredient has different site of action from the mixture of the invention. In certain instances, a combination with at least one other herbicidal active ingredient having a similar spectrum of control but a different site of action will be particularly advantageous for resistance management. Thus, a composition of the present invention can further comprise (in a herbicidally effective amount) at least one additional herbicidal active ingredient having a similar spectrum of control but a different site of action.

Mixtures of this invention can also be used in combination with herbicide safeners such as allidochlor, benoxacor, cloquintocet-mexyl, cumyluron, cyometrinil, cyprosulfonamide, daimuron, dichlormid, dicyclonon, dietholate, dimepiperate, fenchlorazole-ethyl, fenclorim, flurazole, fluxofenim, furilazole, isoxadifen-ethyl, mefenpyr-diethyl, mephenate, methoxyphenone naphthalic anhydride (1,8-naphthalic anhydride), oxabetrinil, *N*-(aminocarbonyl)-2-methylbenzenesulfonamide, *N*-(aminocarbonyl)-2-fluorobenzenesulfonamide, 1-bromo-4-[(chloromethyl)sulfonyl]benzene (BCS), 4-(dichloroacetyl)-1-oxa-4-azospiro[4.5]decane (MON 4660), 2-(dichloromethyl)-2-methyl-1,3-dioxolane (MG 191), ethyl 1,6-dihydro-1-(2-methoxyphenyl)-6-oxo-2-phenyl-5-pyrimidinecarboxylate, 2-hydroxy-*N*,*N*-dimethyl-6-(trifluoromethyl)pyridine-3-carboxamide, and 3-oxo-1-cyclohexen-l-yl 1-(3,4-dimethylphenyl)-l,6-dihydro-6-oxo-2-phenyl-5-pyrimidinecarboxylate, 2,2-dichloro-1-(2,2,5-trimethyl-3-oxazolidinyl)-ethanone and 2-methoxy-*N*-[[4-[[(methylamino)carbonyl]amino]phenyl]sulfonyl]-benzamide to increase safety to certain crops. Antidotally effective amounts of the herbicide safeners can be applied at the same time as the mixtures of this invention, or applied as seed treatments. Therefore an aspect of the present invention relates to a herbicidal mixture comprising mixture of this invention and an antidotally effective amount of a herbicide safener. Seed treatment is particularly useful for selective weed control, because it physically restricts antidoting to the crop plants. Therefore a particularly useful embodiment of the present invention is a method for selectively controlling the growth of undesired vegetation in a crop comprising contacting the locus of the crop with a herbicidally effective amount of a mixture of this invention wherein seed from which the crop is grown is treated with an antidotally effective amount of safener. Antidotally effective amounts of safeners can be easily determined by one skilled in the art through simple experimentation.

Mixtures of the invention can also be mixed with: (1) polynucleotides including but not limited to DNA, RNA, and/or chemically modified nucleotides influencing the amount of a particular target through down regulation, interference, suppression or silencing of the genetically derived transcript that render a herbicidal effect; or (2) polynucleotides including but not limited to DNA, RNA, and/or chemically modified nucleotides influencing the amount of a particular target through down regulation, interference, suppression or silencing of the genetically derived transcript that render a safening effect.

Of note is a composition comprising a mixture of the invention (in a herbicidally effective amount), at least one additional active ingredient selected from the group consisting of other herbicides and herbicide safeners (in an effective amount), and at least one component selected from the group consisting of surfactants, solid diluents and liquid diluents.

Preferred for better control of undesired vegetation (e.g., lower use rate such as from synergism, broader spectrum of weeds controlled, or enhanced crop safety) or for preventing the development of resistant weeds are mixtures of this invention with an additionoal herbicide. Table A1 lists specific combinations of a Component (a) further comprising Component (b) illustrative of the mixtures, compositions and methods of the present invention where Component (a) refers to a mixture as described in the Summary of the Invention. The second column of Table A1 lists the specific Component (b) compound (e.g., "2,4-D" in the first line). The third, fourth and fifth columns of Table A1 lists ranges of weight ratios for rates at which the Component (a) mixture is typically applied to a field-grown crop relative to Component (b) (i.e. (a):(b)). Thus, for example, the first line of Table A1 specifically discloses the combination of Component (a) (i.e. a mixture of bixlozone and a photosystem I electron diverter) with 2,4-D is typically applied in a weight ratio between 1:192 – 6:1. The remaining lines of Table A1 are to be construed similarly.

TABLE A1

Component (a) (Mixture #)	Component (b)	Typical Weight Ratio	More Typical Weight Ratio	Most Typical Weight Ratio
#	2,4-D	1:192 – 6:1	1:64 – 2:1	1:24 – 1:3
#	Acetochlor	1:768 – 2:1	1:256 – 1:2	1:96 – 1:11
#	Acifluorfen	1:96 – 12:1	1:32 – 4:1	1:12 – 1:2
#	Aclonifen	1:857 – 2:1	1:285 – 1:3	1:107 – 1:12
#	Alachlor	1:768 – 2:1	1:256 – 1:2	1:96 – 1:11
#	Ametryn	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Amicarbazone	1:192 – 6:1	1:64 – 2:1	1:24 – 1:3
#	Amidosulfuron	1:6 – 168:1	1:2 – 56:1	1:1 – 11:1
#	Aminocyclopyrachlor	1:48 – 24:1	1:16 – 8:1	1:6 – 2:1
#	Aminopyralid	1:20 – 56:1	1:6 – 19:1	1:2 – 4:1
#	Amitrole	1:768 – 2:1	1:256 – 1:2	1:96 – 1:11
#	Anilofos	1:96 – 12:1	1:32 – 4:1	1:12 – 1:2
#	Asulam	1:960 – 2:1	1:320 – 1:3	1:120 – 1:14
#	Atrazine	1:192 – 6:1	1:64 – 2:1	1:24 – 1:3
#	Azimsulfuron	1:6 – 168:1	1:2 – 56:1	1:1 – 11:1
#	Beflubutamid	1:342 – 4:1	1:114 – 2:1	1:42 – 1:5
#	Benfuresate	1:617 – 2:1	1:205 – 1:2	1:77 – 1:9
#	Bensulfuron-methyl	1:25 – 45:1	1:8 – 15:1	1:3 – 3:1

Component (a) (Mixture #)	Component (b)	Typical Weight Ratio	More Typical Weight Ratio	Most Typical Weight Ratio
#	Bentazone	1:192 – 6:1	1:64 – 2:1	1:24 – 1:3
#	Benzobicyclon	1:85 – 14:1	1:28 – 5:1	1:10 – 1:2
#	Benzofenap	1:257 – 5:1	1:85 – 2:1	1:32 – 1:4
#	Bicyclopyrone	1:42 – 27:1	1:14 – 9:1	1:5 – 2:1
#	Bifenox	1:257 – 5:1	1:85 – 2:1	1:32 – 1:4
#	Bispyribac-sodium	1:10 – 112:1	1:3 – 38:1	1:1 – 7:1
#	Bromacil	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Bromobutide	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Bromoxynil	1:96 – 12:1	1:32 – 4:1	1:12 – 1:2
#	Butachlor	1:768 – 2:1	1:256 – 1:2	1:96 – 1:11
#	Butafenacil	1:42 – 27:1	1:14 – 9:1	1:5 – 2:1
#	Butylate	1:1542 – 1:2	1:514 – 1:5	1:192 – 1:22
#	Carfenstrole	1:192 – 6:1	1:64 – 2:1	1:24 – 1:3
#	Carfentrazone-ethyl	1:128 – 9:1	1:42 – 3:1	1:16 – 1:2
#	Chlorimuron-ethyl	1:8 – 135:1	1:2 – 45:1	1:1 – 9:1
#	Chlorotoluron	1:768 – 2:1	1:256 – 1:2	1:96 – 1:11
#	Chlorsulfuron	1:6 – 168:1	1:2 – 56:1	1:1 – 11:1
#	Cincosulfuron	1:17 – 68:1	1:5 – 23:1	1:2 – 5:1
#	Cinidon-ethyl	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Cinmethylin	1:34 – 34:1	1:11 – 12:1	1:4 – 3:1
#	Clacyfos	1:34 – 34:1	1:11 – 12:1	1:4 – 3:1
#	Clethodim	1:48 – 24:1	1:16 – 8:1	1:6 – 2:1
#	Clodinafop-propargyl	1:20 – 56:1	1:6 – 19:1	1:2 – 4:1
#	Clomazone	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Clomeprop	1:171 – 7:1	1:57 – 3:1	1:21 – 1:3
#	Clopyralid	1:192 – 6:1	1:64 – 2:1	1:24 – 1:3
#	Cloransulam-methyl	1:12 – 96:1	1:4 – 32:1	1:1 – 6:1
#	Cumyluron	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Cyanazine	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Cyclopyrimorate	1:17 – 68:1	1:5 – 23:1	1:2 – 5:1
#	Cyclosulfamuron	1:17 – 68:1	1:5 – 23:1	1:2 – 5:1
#	Cycloxydim	1:96 – 12:1	1:32 – 4:1	1:12 – 1:2

Component (a) (Mixture #)	Component (b)	Typical Weight Ratio	More Typical Weight Ratio	Most Typical Weight Ratio
#	Cyhalofop	1:25 – 45:1	1:8 – 15:1	1:3 – 3:1
#	Daimuron	1:192 – 6:1	1:64 – 2:1	1:24 – 1:3
#	Desmedipham	1:322 – 4:1	1:107 – 2:1	1:40 – 1:5
#	Dicamba	1:192 – 6:1	1:64 – 2:1	1:24 – 1:3
#	Dichlobenil	1:1371 – 1:2	1:457 – 1:4	1:171 – 1:20
#	Dichlorprop	1:925 – 2:1	1:308 – 1:3	1:115 – 1:13
#	Diclofop-methyl	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Diclosulam	1:10 – 112:1	1:3 – 38:1	1:1 – 7:1
#	Difenzoquat	1:288 – 4:1	1:96 – 2:1	1:36 – 1:4
#	Diflufenican	1:857 – 2:1	1:285 – 1:3	1:107 – 1:12
#	Diflufenzopyr	1:12 – 96:1	1:4 – 32:1	1:1 – 6:1
#	Dimethachlor	1:768 – 2:1	1:256 – 1:2	1:96 – 1:11
#	Dimethametryn	1:192 – 6:1	1:64 – 2:1	1:24 – 1:3
#	Dimethenamid-P	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Dithiopyr	1:192 – 6:1	1:64 – 2:1	1:24 – 1:3
#	Diuron	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	EPTC	1:768 – 2:1	1:256 – 1:2	1:96 – 1:11
#	Esprocarb	1:1371 – 1:2	1:457 – 1:4	1:171 – 1:20
#	Ethalfluralin	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Ethametsulfuron-methyl	1:17 – 68:1	1:5 – 23:1	1:2 – 5:1
#	Ethoxyfen	1:8 – 135:1	1:2 – 45:1	1:1 – 9:1
#	Ethoxysulfuron	1:20 – 56:1	1:6 – 19:1	1:2 – 4:1
#	Etobenzanid	1:257 – 5:1	1:85 – 2:1	1:32 – 1:4
#	Fenoxaprop-ethyl	1:120 – 10:1	1:40 – 4:1	1:15 – 1:2
#	Fenoxasulfone	1:85 – 14:1	1:28 – 5:1	1:10 – 1:2
#	Fenquinotrione	1:17 – 68:1	1:5 – 23:1	1:2 – 5:1
#	Fentrazamide	1:17 – 68:1	1:5 – 23:1	1:2 – 5:1
#	Flazasulfuron	1:17 – 68:1	1:5 – 23:1	1:2 – 5:1
#	Florasulam	1:2 – 420:1	1:1 – 140:1	2:1 – 27:1
#	Fluazifop-butyl	1:192 – 6:1	1:64 – 2:1	1:24 – 1:3
#	Flucarbazone	1:8 – 135:1	1:2 – 45:1	1:1 – 9:1
#	Flucetosulfuron	1:8 – 135:1	1:2 – 45:1	1:1 – 9:1

Component (a) (Mixture #)	Component (b)	Typical Weight Ratio	More Typical Weight Ratio	Most Typical Weight Ratio
#	Flufenacet	1:257 – 5:1	1:85 – 2:1	1:32 – 1:4
#	Flumetsulam	1:24 – 48:1	1:8 – 16:1	1:3 – 3:1
#	Flumiclorac-pentyl	1:10 – 112:1	1:3 – 38:1	1:1 – 7:1
#	Flumioxazin	1:25 – 45:1	1:8 – 15:1	1:3 – 3:1
#	Fluometuron	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Flupyrsulfuron-methyl	1:3 – 336:1	1:1 – 112:1	2:1 – 21:1
#	Fluridone	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Fluroxypyr	1:96 – 12:1	1:32 – 4:1	1:12 – 1:2
#	Flurtamone	1:857 – 2:1	1:285 – 1:3	1:107 – 1:12
#	Fluthiacet-methyl	1:48 – 42:1	1:16 – 14:1	1:3 – 3:1
#	Fomesafen	1:96 – 12:1	1:32 – 4:1	1:12 – 1:2
#	Foramsulfuron	1:13 – 84:1	1:4 – 28:1	1:1 – 6:1
#	Glufosinate	1:288 – 4:1	1:96 – 2:1	1:36 – 1:4
#	Glyphosate	1:288 – 4:1	1:96 – 2:1	1:36 – 1:4
#	Halosulfuron-methyl	1:17 – 68:1	1:5 – 23:1	1:2 – 5:1
#	Halauxifen	1:20 – 56:1	1:6 – 19:1	1:2 – 4:1
#	Halauxifen methyl	1:20 – 56:1	1:6 – 19:1	1:2 – 4:1
#	Haloxyfop-methyl	1:34 – 34:1	1:11 – 12:1	1:4 – 3:1
#	Hexazinone	1:192 – 6:1	1:64 – 2:1	1:24 – 1:3
#	Hydantocidin	1:1100 – 16:1	1:385 – 8:1	1:144 – 4:1
#	Imazamox	1:13 – 84:1	1:4 – 28:1	1:1 – 6:1
#	Imazapic	1:20 – 56:1	1:6 – 19:1	1:2 – 4:1
#	Imazapyr	1:85 – 14:1	1:28 – 5:1	1:10 – 1:2
#	Imazaquin	1:34 – 34:1	1:11 – 12:1	1:4 – 3:1
#	Imazethabenz-methyl	1:171 – 7:1	1:57 – 3:1	1:21 – 1:3
#	Imazethapyr	1:24 – 48:1	1:8 – 16:1	1:3 – 3:1
#	Imazosulfuron	1:27 – 42:1	1:9 – 14:1	1:3 – 3:1
#	Indanofan	1:342 – 4:1	1:114 – 2:1	1:42 – 1:5
#	Indaziflam	1:25 – 45:1	1:8 – 15:1	1:3 – 3:1
#	Iodosulfuron-methyl	1:3 – 336:1	1:1 – 112:1	2:1 – 21:1
#	Ioxynil	1:192 – 6:1	1:64 – 2:1	1:24 – 1:3
#	Ipfencarbazone	1:85 – 14:1	1:28 – 5:1	1:10 – 1:2

Component (a) (Mixture #)	Component (b)	Typical Weight Ratio	More Typical Weight Ratio	Most Typical Weight Ratio
#	Isoproturon	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Isoxaben	1:288 – 4:1	1:96 – 2:1	1:36 – 1:4
#	Isoxaflutole	1:60 – 20:1	1:20 – 7:1	1:7 – 2:1
#	Lactofen	1:42 – 27:1	1:14 – 9:1	1:5 – 2:1
#	Lenacil	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Linuron	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	MCPA	1:192 – 6:1	1:64 – 2:1	1:24 – 1:3
#	MCPB	1:288 – 4:1	1:96 – 2:1	1:36 – 1:4
#	Mecoprop	1:768 – 2:1	1:256 – 1:2	1:96 – 1:11
#	Mefenacet	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Mefluidide	1:192 – 6:1	1:64 – 2:1	1:24 – 1:3
#	Mesosulfuron-methyl	1:5 – 224:1	1:1 – 75:1	1:1 – 14:1
#	Mesotrione	1:42 – 27:1	1:14 – 9:1	1:5 – 2:1
#	Metamifop	1:42 – 27:1	1:14 – 9:1	1:5 – 2:1
#	Metazachlor	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Metazosulfuron	1:25 – 45:1	1:8 – 15:1	1:3 – 3:1
#	Methabenzthiazuron	1:768 – 2:1	1:256 – 1:2	1:96 – 1:11
#	Metolachlor	1:768 – 2:1	1:256 – 1:2	1:96 – 1:11
#	Metosulam	1:8 – 135:1	1:2 – 45:1	1:1 – 9:1
#	Metribuzin	1:192 – 6:1	1:64 – 2:1	1:24 – 1:3
#	Metsulfuron-methyl	1:2 – 560:1	1:1 – 187:1	3:1 – 35:1
#	Molinate	1:1028 – 2:1	1:342 – 1:3	1:128 – 1:15
#	Napropamide	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Napropamide-M	1:192 – 6:1	1:64 – 2:1	1:24 – 1:3
#	Naptalam	1:192 – 6:1	1:64 – 2:1	1:24 – 1:3
#	Nicosulfuron	1:12 – 96:1	1:4 – 32:1	1:1 – 6:1
#	Norflurazon	1:1152 – 1:1	1:384 – 1:3	1:144 – 1:16
#	Orbencarb	1:1371 – 1:2	1:457 – 1:4	1:171 – 1:20
#	Orthosulfamuron	1:20 – 56:1	1:6 – 19:1	1:2 – 4:1
#	Oryzalin	1:514 – 3:1	1:171 – 1:2	1:64 – 1:8
#	Oxadiargyl	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Oxadiazon	1:548 – 3:1	1:182 – 1:2	1:68 – 1:8

Component (a) (Mixture #)	Component (b)	Typical Weight Ratio	More Typical Weight Ratio	Most Typical Weight Ratio
#	Oxasulfuron	1:27 – 42:1	1:9 – 14:1	1:3 – 3:1
#	Oxaziclomefone	1:42 – 27:1	1:14 – 9:1	1:5 – 2:1
#	Oxyfluorfen	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Paraquat	1:192 – 6:1	1:64 – 2:1	1:24 – 1:3
#	Pendimethalin	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Penoxsulam	1:10 – 112:1	1:3 – 38:1	1:1 – 7:1
#	Penthoxamid	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Pentoxazone	1:102 – 12:1	1:34 – 4:1	1:12 – 1:2
#	Phenmedipham	1:102 – 12:1	1:34 – 4:1	1:12 – 1:2
#	Picloram	1:96 – 12:1	1:32 – 4:1	1:12 – 1:2
#	Picolinafen	1:34 – 34:1	1:11 – 12:1	1:4 – 3:1
#	Pinoxaden	1:25 – 45:1	1:8 – 15:1	1:3 – 3:1
#	Pretilachlor	1:192 – 6:1	1:64 – 2:1	1:24 – 1:3
#	Primisulfuron-methyl	1:8 – 135:1	1:2 – 45:1	1:1 – 9:1
#	Prodiamine	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Profoxydim	1:42 – 27:1	1:14 – 9:1	1:5 – 2:1
#	Prometryn	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Propachlor	1:1152 – 1:1	1:384 – 1:3	1:144 – 1:16
#	Propanil	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Propaquizafop	1:48 – 24:1	1:16 – 8:1	1:6 – 2:1
#	Propoxycarbazone	1:17 – 68:1	1:5 – 23:1	1:2 – 5:1
#	Propyrisulfuron	1:17 – 68:1	1:5 – 23:1	1:2 – 5:1
#	Propyzamide	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Prosulfocarb	1:1200 – 1:2	1:400 – 1:4	1:150 – 1:17
#	Prosulfuron	1:6 – 168:1	1:2 – 56:1	1:1 – 11:1
#	Pyraclonil	1:42 – 27:1	1:14 – 9:1	1:5 – 2:1
#	Pyraflufen-ethyl	1:5 – 224:1	1:1 – 75:1	1:1 – 14:1
#	Pyrasulfotole	1:13 – 84:1	1:4 – 28:1	1:1 – 6:1
#	Pyrazolynate	1:857 – 2:1	1:285 – 1:3	1:107 – 1:12
#	Pyrazosulfuron-ethyl	1:10 – 112:1	1:3 – 38:1	1:1 – 7:1
#	Pyrazoxyfen	1:5 – 224:1	1:1 – 75:1	1:1 – 14:1
#	Pyribenzoxim	1:10 – 112:1	1:3 – 38:1	1:1 – 7:1

Component (a) (Mixture #)	Component (b)	Typical Weight Ratio	More Typical Weight Ratio	Most Typical Weight Ratio
#	Pyributicarb	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Pyridate	1:288 – 4:1	1:96 – 2:1	1:36 – 1:4
#	Pyriftalid	1:10 – 112:1	1:3 – 38:1	1:1 – 7:1
#	Pyriminobac-methyl	1:20 – 56:1	1:6 – 19:1	1:2 – 4:1
#	Pyrimisulfan	1:17 – 68:1	1:5 – 23:1	1:2 – 5:1
#	Pyrithiobac	1:24 – 48:1	1:8 – 16:1	1:3 – 3:1
#	Pyroxasulfone	1:85 – 14:1	1:28 – 5:1	1:10 – 1:2
#	Pyroxsulam	1:5 – 224:1	1:1 – 75:1	1:1 – 14:1
#	Quinclorac	1:192 – 6:1	1:64 – 2:1	1:24 – 1:3
#	Quizalofop-ethyl	1:42 – 27:1	1:14 – 9:1	1:5 – 2:1
#	Rimsulfuron	1:13 – 84:1	1:4 – 28:1	1:1 – 6:1
#	Saflufenacil	1:25 – 45:1	1:8 – 15:1	1:3 – 3:1
#	Sethoxydim	1:96 – 12:1	1:32 – 4:1	1:12 – 1:2
#	Simazine	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Sulcotrione	1:120 – 10:1	1:40 – 4:1	1:15 – 1:2
#	Sulfentrazone	1:147 – 8:1	1:49 – 3:1	1:18 – 1:3
#	Sulfometuron-methyl	1:34 – 34:1	1:11 – 12:1	1:4 – 3:1
#	Sulfosulfuron	1:8 – 135:1	1:2 – 45:1	1:1 – 9:1
#	Tebuthiuron	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Tefuryltrione	1:42 – 27:1	1:14 – 9:1	1:5 – 2:1
#	Tembotrione	1:31 – 37:1	1:10 – 13:1	1:3 – 3:1
#	Tepraloxydim	1:25 – 45:1	1:8 – 15:1	1:3 – 3:1
#	Terbacil	1:288 – 4:1	1:96 – 2:1	1:36 – 1:4
#	Terbuthylazine	1:857 – 2:1	1:285 – 1:3	1:107 – 1:12
#	Terbutryn	1:192 – 6:1	1:64 – 2:1	1:24 – 1:3
#	Thenylchlor	1:85 – 14:1	1:28 – 5:1	1:10 – 1:2
#	Thiazopyr	1:384 – 3:1	1:128 – 1:1	1:48 – 1:6
#	Thiencarbazone	1:3 – 336:1	1:1 – 112:1	2:1 – 21:1
#	Thifensulfuron-methyl	1:5 – 224:1	1:1 – 75:1	1:1 – 14:1
#	Tiafenacil	1:17 – 68:1	1:5 – 23:1	1:2 – 5:1
#	Thiobencarb	1:768 – 2:1	1:256 – 1:2	1:96 – 1:11
#	Tolpyralate	1:31 – 37:1	1:10 – 13:1	1:3 – 3:1

Component (a) (Mixture #)	Component (b)	Typical Weight Ratio	More Typical Weight Ratio	Most Typical Weight Ratio
#	Topramzone	1:6 – 168:1	1:2 – 56:1	1:1 – 11:1
#	Tralkoxydim	1:68 – 17:1	1:22 – 6:1	1:8 – 2:1
#	Triafamone	1:2 – 420:1	1:1 – 140:1	2:1 – 27:1
#	Triallate	1:768 – 2:1	1:256 – 1:2	1:96 – 1:11
#	Triasulfuron	1:5 – 224:1	1:1 – 75:1	1:1 – 14:1
#	Triaziflam	1:171 – 7:1	1:57 – 3:1	1:21 – 1:3
#	Tribenuron-methyl	1:3 – 336:1	1:1 – 112:1	2:1 – 21:1
#	Triclopyr	1:192 – 6:1	1:64 – 2:1	1:24 – 1:3
#	Trifloxysulfuron	1:2 – 420:1	1:1 – 140:1	2:1 – 27:1
#	Trifludimoxazin	1:25 – 45:1	1:8 – 15:1	1:3 – 3:1
#	Trifluralin	1:288 – 4:1	1:96 – 2:1	1:36 – 1:4
#	Triflusulfuron-methyl	1:17 – 68:1	1:5 – 23:1	1:2 – 5:1
#	Tritosulfuron	1:13 – 84:1	1:4 – 28:1	1:1 – 6:1

Table A2 is constructed the same as Table A1 above except that entries below the "Component (a)" column heading are replaced with the respective Component (a) Column Entry shown below. Mixture # in the Component (a) column is identified in Index Table A. Thus, for example, in Table A2 the entries below the "Component (a)" column heading all recite "Mixture #" (i.e. Mixture # identified in Index Table A), and the first line below the column headings in Table A2 specifically discloses a mixture of Mixture # with 2,4-D. Tables A3 through A4 are constructed similarly.

Table Number	Component (a) Column Entries
A2	bixlozone + paraquat + diquat
A3	bixlozone + paraquat
A4	bixlozone + diquat

Preferred for better control of undesired vegetation (e.g., lower use rate such as from synergism, broader spectrum of weeds controlled, or enhanced crop safety) or for preventing the development of resistant weeds are mixtures of a mixture of this invention with a herbicide selected from the group consisting of chlorimuron-ethyl, clomazone, nicosulfuron, mesotrione, thifensulfuron-methyl, flupyrsulfuron-methyl, tetflupyrolimet, tribenuron, pyroxasulfone, pinoxaden, tembotrione, pyroxsulam, rimisoxafen, metolachlor and *S*-metolachlor.

The following Tests demonstrate the control efficacy of the mixtures of this invention against specific weeds. The weed control afforded by the mixtures is not limited, however, to these species. See Index Tables A for mixture descriptions. The abbreviation "Cmpd. No." stands for "Mixture Number". The abbreviation "Ex." stands for "Example" and is followed by a number indicating in which example the mixture is prepared.

BIOLOGICAL EXAMPLES OF THE INVENTION

TEST A (*Brachiaria decumbens*)

Preparation of the compositions for testing

A 400 g/L SC formulation of Isoflex™ Active was prepared (bixlozone 35.87%, water 53.7%) that included a liquid diluent, an anionic surfactant, a thickener, a silicone defoamer an antifreeze and an antimicrobial agent (e.g., Example G above).

A 200 g/L SL formulation of diquat was provided by Reglone® (Brazilian Registration No. at MAPA 01768502)

Efficacy testing

The compositions described above were tested for herbicidal efficacy on *Brachiaria decumbens*. For the post-emergence test, the weed was planted in 240 mL pots filled with substrate with 3 repetitions for each treatment. The pots were left in a greenhouse under automatic irrigation until they reached the target size for the application compositions. The test compositions were applied by spray application, individually and in combination at the rates indicated when *Brachiaria decumbens* reached 3 to 4 leaves stage (15 cm), and the control of weeds was assessed at 7, 14 and 21 days after the application and weed shoots was also collected at 21 days after the application to measure dry mass accumulation, as indicated in Tables 1, 2, 3 and 4 below.

Expected Control (%) is calculated by the following formula (Colby, 1967):

$$E = 100 - \frac{(100 - X) * (100 - Y)}{100}$$

wherein X and Y are the Control Observed (%) provided by the herbicides applied individually, and E is the Expected Control (%) for the combination at the same rate (X + Y).

Table 1: Control of *Brachiaria decumbens* 7 days after application.

No	Treatment	g a.i./ha	Control Observed %	Expected Control (Colby method) %

1	Isoflex™ Active	150	1,0	-
2	Isoflex™ Active	300	7,7	-
3	Isoflex™ Active	600	11,7	-
4	Diquat	100	66,7	-
5	Diquat	200	88,0	-
6	Diquat	300	98,3	-
7	Isoflex™ Active + Diquat	150 + 100	94,3*	67,0
8	Isoflex™ Active + Diquat	300 + 200	93,7	88,9
9	Isoflex™ Active + Diquat	600 + 300	100,0	98,5

Table 2: Control of *Brachiaria decumbens* 14 days after application.

No	Treatment	g a.i./ha	Control Observed %	Expected Control (Colby method) %
1	Isoflex™ Active	150	7,3	-
2	Isoflex™ Active	300	8,3	-
3	Isoflex™ Active	600	15,0	-
4	Diquat	100	43,3	-
5	Diquat	200	62,7	-
6	Diquat	300	100,0	-
7	Isoflex™ Active + Diquat	150 + 100	92,0*	47,5
8	Isoflex™ Active + Diquat	300 + 200	78,3*	65,7
9	Isoflex™ Active + Diquat	600 + 300	100,0	100,0

Table 3: Control of *Brachiaria decumbens* 21 days after application.

No	Treatment	g a.i./ha	Control Observed %	Expected Control (Colby method) %
1	Isoflex™ Active	150	1,7	-
2	Isoflex™ Active	300	0,0	-
3	Isoflex™ Active	600	0,0	-
4	Diquat	100	38,3	-
5	Diquat	200	53,3	-
6	Diquat	300	96,7	-
7	Isoflex™ Active + Diquat	150 + 100	77,0*	39,4
8	Isoflex™ Active + Diquat	300 + 200	73,3*	53,3

9	Isoflex™ Active + Diquat	600 + 300	100,0	96,7

Table 4: Inverse of the dry matter content of *Brachiaria decumbens*.

No	Treatment	g a.i./ha	Control Observed %	Expected Control (Colby method) %
1	Isoflex™ Active	150	6,1	-
2	Isoflex™ Active	300	6,1	-
3	Isoflex™ Active	600	0,0	-
4	Diquat	100	51,1	-
5	Diquat	200	69,7	-
6	Diquat	300	100,0	-
7	Isoflex™ Active + Diquat	150 + 100	89,0*	54,1
8	Isoflex™ Active + Diquat	300 + 200	83,2*	71,6
9	Isoflex™ Active + Diquat	600 + 300	100,0	100,0

As clearly shown in Tables 1, 2, 3 and 4, combinations of Isoflex™ Active and Diquat demonstrated synergistic weed control, with higher measured weed control than predicted by the Colby formula.

TEST B (*Lolium multiflorum*)

Preparation of the compositions for testing

A 400 g/L SC formulation of Isoflex™ Active was prepared as described in TEST A.

A 200 g/L SL formulation of diquat was provided by Reglone® (Brazilian Registration No. at MAPA 01768502)

Efficacy testing

The compositions described above were tested for herbicidal efficacy on *Lolium multiflorum*. For the post-emergence test, the weed was planted in 240 mL pots filled with substrate with 5 repetitions for each treatment. The pots were left in a greenhouse under automatic irrigation until they reached the target size for the application compositions. The test compositions were applied by spray application, individually and in combination at the rates indicated when *Lolium multiflorum* reached the 2 tillers stage, and the control of weeds was assessed at 5, 7, 14 and 28 days after the application and weed shoots was also collected at 28 days after the application to measure dry mass accumulation, as indicated in Tables 5, 6, 7, 8 and 9 below.

Expected Control (%) is calculated by the following formula (Colby, 1967):

$$E = 100 - \frac{(100 - X) * (100 - Y)}{100}$$

wherein X and Y are the Control Observed (%) provided by the herbicides applied individually, and E is the Expected Control (%) for the combination at the same rate (X + Y).

Table 5: Control of *Lolium multiflorum* 5 days after application.

No	Treatment	g a.i./ha	Control Observed %	Expected Control (Colby method) %
1	Isoflex™ Active	150	31,0	-
2	Isoflex™ Active	300	29,0	-
3	Isoflex™ Active	600	37,0	-
4	Isoflex™ Active	720	35,0	
5	Diquat	100	26,0	-
6	Diquat	200	57,0	-
7	Diquat	300	43,0	-
8	Diquat	400	65,0	-
9	Diquat	500	52,0	-
10	Isoflex™ Active + Diquat	150 + 100	40,0	48,9
11	Isoflex™ Active + Diquat	300 + 200	62,0	69,5
12	Isoflex™ Active + Diquat	600 + 300	75,6*	64,1
13	Isoflex™ Active + Diquat	600 + 400	85,6*	78,0
14	Isoflex™ Active + Diquat	720 + 500	88,2*	68,8

Table 6: Control of *Lolium multiflorum* 7 days after application.

No	Treatment	g a.i./ha	Control Observed %	Expected Control (Colby method) %
1	Isoflex™ Active	150	32,0	-
2	Isoflex™ Active	300	29,0	-
3	Isoflex™ Active	600	38,0	-
4	Isoflex™ Active	720	36,0	
5	Diquat	100	27,0	-
6	Diquat	200	56,0	-
7	Diquat	300	43,0	-
8	Diquat	400	65,0	-

9	Diquat	500	52,0	-
10	Isoflex™ Active + Diquat	150 + 100	40,0	50,4
11	Isoflex™ Active + Diquat	300 + 200	62,0	68,8
12	Isoflex™ Active + Diquat	600 + 300	76,0*	64,7
13	Isoflex™ Active + Diquat	600 + 400	86,2*	78,3
14	Isoflex™ Active + Diquat	720 + 500	88,2*	69,3

Table 7: Control of *Lolium multiflorum* 14 days after application.

No	Treatment	g a.i./ha	Control Observed %	Expected Control (Colby method) %
1	Isoflex™ Active	150	26,0	-
2	Isoflex™ Active	300	32,0	-
3	Isoflex™ Active	600	43,0	-
4	Isoflex™ Active	720	42,0	
5	Diquat	100	12,0	-
6	Diquat	200	26,0	-
7	Diquat	300	17,0	-
8	Diquat	400	52,0	-
9	Diquat	500	27,0	-
10	Isoflex™ Active + Diquat	150 + 100	34,0	34,9
11	Isoflex™ Active + Diquat	300 + 200	54,0	49,7
12	Isoflex™ Active + Diquat	600 + 300	76,2*	52,7
13	Isoflex™ Active + Diquat	600 + 400	88,0*	72,6
14	Isoflex™ Active + Diquat	720 + 500	89,0*	57,7

Table 8: Control of *Lolium multiflorum* 28 days after application.

No	Treatment	g a.i./ha	Control Observed %	Expected Control (Colby method) %
1	Isoflex™ Active	150	35,0	-
2	Isoflex™ Active	300	36,0	-
3	Isoflex™ Active	600	35,0	-
4	Isoflex™ Active	720	37,0	
5	Diquat	100	28,0	-
6	Diquat	200	32,0	-
7	Diquat	300	37,0	-

8	Diquat	400	46,0	-
9	Diquat	500	31,0	-
10	Isoflex™ Active + Diquat	150 + 100	22,0	53,2
11	Isoflex™ Active + Diquat	300 + 200	37,0	56,5
12	Isoflex™ Active + Diquat	600 + 300	54,0	59,1
13	Isoflex™ Active + Diquat	600 + 400	75,0*	64,9
14	Isoflex™ Active + Diquat	720 + 500	76,3*	56,5

Table 9: Inverse of the dry matter content of *Lolium multiflorum*.

No	Treatment	g a.i./ha	Control Observed %	Expected Control (Colby method) %
1	Isoflex™ Active	150	47,9	-
2	Isoflex™ Active	300	50,2	-
3	Isoflex™ Active	600	54,8	-
4	Isoflex™ Active	720	52,7	
5	Diquat	100	45,0	-
6	Diquat	200	44,0	-
7	Diquat	300	44,0	-
8	Diquat	400	57,0	-
9	Diquat	500	39,0	-
10	Isoflex™ Active + Diquat	150 + 100	38,4	71,4
11	Isoflex™ Active + Diquat	300 + 200	53,7	72,1
12	Isoflex™ Active + Diquat	600 + 300	71,9	74,7
13	Isoflex™ Active + Diquat	600 + 400	89,7*	80,6
14	Isoflex™ Active + Diquat	720 + 500	94,6*	71,2

As clearly shown in Tables 5, 6, 7, 8 and 9, combinations of Isoflex™ Active and Diquat demonstrated synergistic weed control, with higher measured weed control than predicted by the Colby formula.

TEST C: Annual Ryegrass

Four populations of annual ryegrass (one with a moderate level of bixlozone resistance, one with a high level of paraquat resistance, one population found to be glyphosate-resistant and one population fully herbicide susceptible) were sown in pots (3 replicates, 8 seedlings per replicate) and exposed to different herbicide treatments as detailed in Table 10. The two populations with moderate bixlozone resistance / tolerance previously identified "developing

resistant" by resistance testing with single-dose essays (100 ungerminated seeds treated with one single herbicide dosage). The percent survival in response to the treatment with the full label rate of Overwatch® was 13% and 10.3% and 4.3%.

Table 11. List of herbicide post-emergence (POST) treatments used in the study with paraquat and bixlozone. Gramoxone 360 Pro applied with 0.25% BS1000 wetter in treatments 7 to 20.

ID	Treatment
1	UTC
2	Overwatch 375 mL/ha (150 g ai/ha)
3	Overwatch 813 mL/ha (325 g ai/ha)
4	Overwatch 1250 mL/ha (500 g ai/ha)
5	Gramoxone 360 Pro 208 mL/ha (75 g ai/ha)
6	Gramoxone 360 Pro 417 mL/ha (150 g ai/ha)
7	Gramoxone 360 Pro 625 mL/ha (225 g ai/ha)
8	Gramoxone 360 Pro 833 mL/ha (300 g ai/ha)
9	Overwatch 375 mL/ha + Gramoxone 360 Pro 208 mL/ha
10	Overwatch 375 mL/ha + Gramoxone 360 Pro 417 mL/ha
11	Overwatch 375 mL/ha + Gramoxone 360 Pro 625 mL/ha
12	Overwatch 375 mL/ha + Gramoxone 360 Pro 833 mL/ha
13	Overwatch 813 mL/ha + Gramoxone 360 Pro 208 mL/ha
14	Overwatch 813 mL/ha + Gramoxone 360 Pro 417 mL/ha
15	Overwatch 813 mL/ha + Gramoxone 360 Pro 625 mL/ha
16	Overwatch 813 mL/ha + Gramoxone 360 Pro 833 mL/ha
17	Overwatch 1250 mL/ha + Gramoxone 360 Pro 208 mL/ha
18	Overwatch 1250mL/ha + Gramoxone 360 Pro 417 mL/ha
19	Overwatch 1250 mL/ha + Gramoxone 360 Pro 625 mL/ha
20	Overwatch 1250 mL/ha + Gramoxone 360 Pro 833 mL/ha

Herbicide dose response.

Annual ryegrass seeds were sown in 100 mm x 100 mm pots containing a potting mix (50% peatmoss, 25% pine bark, 25% river sand with approximately 2% OC).

Herbicide solutions were prepared in 250 mL water for each herbicide. Herbicide solutions were prepared at least 30 mins before application to allow each herbicide commercial product to be fully dissolved in water. Bottles containing final herbicide solutions were vigorously agitated at least 10 times prior to herbicide application. Herbicide treatments at various dosages with the pre-emergence herbicide bixlozone were applied pre-emergence (PRE) with the herbicide in full contact with the weed seed. The seeds were not pre-germinated on agar but were counted and placed into pots. Post-emergence (POST) herbicide treatments were applied to two-leaf stage ryegrass seedlings. Plant survival (emergence followed by active growth) and plant growth (aboveground biomass) were assessed 6 weeks after treatments. Tillers and plant heads were counted 16-14 weeks after spraying and the ability of each plant to set seed was expressed as percentage of untreated control. Herbicide treatments listed in Table 10 were applied using a twin-nozzle laboratory sprayer calibrated to deliver 110 L of spray volume ha^{-1} at each pass at 210 kPa. Two hours after the PRE herbicide treatment weed and crop seeds were covered with a layer of potting mix of 0.5 cm and gently watered afterwards. Each herbicide dose was applied to three replicated pots. The replicated pot was the experimental unit. The experiment was not repeated.

Statistical analysis – Colby

For the pre-emergence herbicide treatments the percent plant survival values were calculated by dividing the number of survivors (ie plants able to emerge, establish and grow) by 33 which was the total number of seeds sown in each replicated pot. For post-emergence plant survival (survivors / number of seedlings counted before the application of POST treatments) was also expressed as percentage. Plant growth was visually assessed and expressed as percent of the aboveground biomass of untreated control. Data were then transformed and expressed as plant mortality / kill rate percentage (100 – plant survival %) or percentage of plant biomass suppression (100 – visually estimated % of untreated control). The seed set was estimated by counting the number of fertile tillers of plants surviving the herbicide treatment that could produce a fertile head with seeds filling and developing towards full maturity. Similarly to plant survival and biomass, the seed set data collected were transformed as percent of seed set reduction relative to the untreated control (100 – seed set % of untreated control).

The Colby equation ($E= (X_1 + X_2)-[(X_1 * X_2)/100]$) was used to assess the type of interaction between the herbicides tested in this study applied as stand-alones vs their respective binary mixtures. E is the expected level of weed control indicating additive interaction when two herbicides are combined in a mixture, X_1 is the percentage of observed

control with one herbicide (eg bixlozone) and X_2 is the percentage of weed control with the second herbicide examined (eg paraquat or atrazine). T-test was used to compare expected additive herbicide responses calculated with Colby equation and observed herbicide responses (plant mortality % or plant biomass suppression %) and P-values calculated. For annual ryegrass P-values < 0.05 related to a positive discrepancy between observed ryegrass mortality percentages and expected additive wild ryegrass mortality / control percentages it was concluded that the herbicide mixture tested was synergistic. For the same scenario related to the crop the conclusion was that there was a significantly greater crop effect with the specific herbicide mixture. When a difference between observed and expected control was found not to be statistically significant, it was concluded that the mixture was additive. When a negative difference between observed and expected control was found to be statistically significant, it was concluded that the mixture was antagonistic for ryegrass control.

Table 11. *Annual ryegrass observed vs expected additive mortality calculated with Colby equation for paraquat and bixlozone two-way mixtures applied POST post-emergence. Sample size n = 12 for each dose of bixlozone and n = 36 for each dose of paraquat (pooling data of the three respective bixlozone doses: 125, 250 and 500 g ai / ha).*

Paraquat / Bixlozone g ai/ha	Treatment ID	Plant mortality / weed control (%)	Expected (additive) plant mortality (%)	Observed – Expected additive
75 Para		83.7	75.0	+8.7
150 Bix	9	82.3	67.8	+14.5
325 Bix	13	81.3	72.8	+8.5
500 Bix	17	87.5	84.3	+3.2
150 Para		91.4	86.6	+4.8
150 Bix	10	89.9	82.7	+7.2
325 Bix	14	93.8	85.2	+8.6
500 Bix	18	90.6	91.9	-1.3
225 Para		95.1	88.7	+6.4
150 Bix	11	85.3	85.3	+0.0
325 Bix	15	93.8	87.4	+6.4
500 Bix	19	97.9	93.4	+4.5
300 Para		96.2	92.6	+3.6

150 Bix	12	92.7	90.3	+2.4
325 Bix	16	96.9	91.7	+5.2
500 Bix	20	99.0	95.8	+3.2

Table 12. *Data sub-sample relative to the paraquat-resistant annual ryegrass. Observed vs expected additive mortality calculated with Colby equation for paraquat and bixlozone two-way mixtures applied POST post-emergence. Sample size n = 3 for each dose of bixlozone and n = 9 for each dose of paraquat (pooling data of the three respective bixlozone doses: 125, 250 and 500 g ai / ha).*

Paraquat / Bixlozone	Treatment ID	Plant mortality / weed control (%)	Expected (additive) plant mortality (%)	Observed – Expected additive
75 Para		70.8	45.6	+25.2
150 Bix	9	54.2	28.5	+25.7
325 Bix	13	87.5	38.9	+48.6
500 Bix	17	70.8	69.4	+1.4
150 Para		71.3	58.0	+13.3
150 Bix	10	68.1	44.8	+23.3
325 Bix	14	75.0	52.8	+22.2
500 Bix	18	70.8	76.4	-5.6
225 Para		81.9	60.4	+21.5
150 Bix	11	75.0	48.0	+27.0
325 Bix	15	79.2	55.6	+23.6
500 Bix	19	91.0	77.8	+13.2
300 Para		84.7	70.3	+14.4
150 Bix	12	70.8	61.0	+9.8
325 Bix	16	87.5	66.7	+20.8
500 Bix	20	95.8	83.3	+12.5

The interaction of paraquat and bixlozone was often observed to be synergistic and deliver greater than additive control of annual ryegrass. Such a synergistic interaction resulted in full control of a multiple resistant population field-selected to be highly resistant to clethodim, glyphosate and paraquat. For example, the kill rate caused by bixlozone applied post-emergence at 500 g / ha (Overwatch® 1,250 mL/ha) was only 58% but when Overwatch®

was applied at the same rate in a mixture with paraquat the control of ryegrass significantly increased from 88% up to 99%, depending on the paraquat dose used. It was observed that paraquat applied at dosages ≥ 225 g ai / ha interacted synergistically with bixlozone (Tables 11-12). Analysis (ANOVA) confirms that the overall efficacy delivered by the binary mixture bixlozone + paraquat is often significantly greater than bixlozone at the highest tested rate. The results of this study show the mixture of paraquat and bixlozone delivered > 90% control of paraquat-resistant annual ryegrass.

CLAIMS

What is claimed is:

1. A mixture comprising bixlozone and at least one herbicide selected from photosystem I electron diverters and agriculturally acceptable salts and esters thereof.

2. The mixture described in Claim 1 wherein the photosystem I electron diverter is selected from cyperquat, diquat, diquat dibromide, morfamquat and paraquat or combinations thereof.

3. The mixture of Claim 2 wherein the photosystem I electron diverter is selected from diquat and paraquat or combinations thereof.

4. The mixture of any of Claims 1 to 3 wherein the photosystem I electron diverter is a combination of diquat and paraquat.

5. The mixture of Claim 2 wherein the mixture comprises bixlozone and diquat.

6. The mixture of Claim 5 wherein the ratio of bixlozone to diquat is from about 1.5 : 1 to about 3 : 2.

7. The mixture of Claim 5 wherein the application rate of bixlozone is from about 100 to about 700 g/ha.

8. The mixture of Claim 2 wherein the photosystem I electron diverter is selected from paraquat.

9. The mixture of Claim 8 wherein the ratio of bixlozone to paraquat is from about 2.5 : 1 to about 1 : 1.

10. The mixture of Claim 9 wherein the application rate of bixlozone in from about 100 to about 700 g/ha.

11. A herbicidal composition comprising a mixture of any of Claims 1 through 10 and at least one component selected from the group consisting of surfactants, solid diluents and liquid diluents.

12. The herbicidal composition comprising a mixture of any of Claims 1 through 10, at least one additional active ingredient selected from the group consisting of other herbicides and herbicide safeners, and at least one component selected from the group consisting of surfactants, solid diluents and liquid diluents.

13. A method for controlling the growth of undesired vegetation comprising contacting the vegetation or its environment with a herbicidally effective amount of the mixture of any of Claims 1 through 11 or the composition of Claims 11 or 12.

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2024/035696

A. CLASSIFICATION OF SUBJECT MATTER

INV. A01N43/80 A01N43/40 A01N43/84 A01N43/90 A01P13/00
ADD.

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

B. FIELDS SEARCHED

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

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, CHEM ABS Data, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 10 932 467 B2 (BAYER AG [DE]; BAYER CROPSCIENCE AG [DE]) 2 March 2021 (2021-03-02)	1-5,8, 11-13
Y	column 2, line 36 - line 38 column 3, line 16 column 4, line 11 claim 2	1-13

Y	EP 3 971 170 A1 (ZHEJIANG ZHUJI UNITED CHEMICALS CO LTD [CN]) 23 March 2022 (2022-03-23) paragraphs [0068] - [0074] formula (I) claims 1-12	1-13

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

x See patent family annex.

* Special categories of cited documents :

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

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

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

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

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

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

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

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Date of the actual completion of the international search	Date of mailing of the international search report
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1

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1

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