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(54) Title: HERBICIDAL COMPOSITION WITH INCREASED HERBICIDAL EFFICACY

(57) Abrégé/Abstract:
An herbicide composition available as a concentrate for dilution with water or a ready-to-use oil-in-water emulsion which has a significantly reduced amount of active ingredient of a broadleaf herbicide. The composition combines the reduced amount of herbicide in a mixture of oil and emulsifier.

ABSTRACT

An herbicide composition available as a concentrate for dilution with water or a ready-to-use oil-in-water emulsion which has a significantly reduced amount of active ingredient of a broadleaf herbicide. The composition combines the reduced amount of herbicide in a mixture of oil and emulsifier.

"HERBICIDAL COMPOSITION WITH INCREASED HERBICIDAL EFFICACY"

FIELD OF THE INVENTION

The invention relates to herbicidal compositions and in particular to herbicidal oil-in-water emulsions that reduce the effective amount of herbicide required for the control of broadleaf weeds in turfgrass, while being substantially non-phytotoxic to turfgrass.

BACKGROUND OF THE INVENTION

The use of oils as herbicide adjuvants is a well established practice in agriculture for improvement of weed control applications through better coverage and penetration of the active ingredient on the leaf surface of the target weed. In many cases, this permits some degree of reduction in the rate of herbicide required, which is particularly desired for synthetic herbicides that are toxic to humans and the environment. Oil-based herbicide adjuvants are often formulated as an herbicidal "emulsifiable concentrate" consisting of a 75-95 wt% hydrocarbon oil or solvent with the balance being emulsifier, and to which the herbicide is added. In use, the herbicidal emulsifiable concentrate is diluted with water to form an oil-in-water emulsion which is then sprayed onto the target area at an appropriate rate.

While most oil-based herbicidal adjuvants have been directed to the control of grassy weeds in crops, little has been done with respect to the use of such adjuvants for the control of broadleaf (dicotyledous) weeds in turfgrass. In one study by McCowan (McCowan, F.H. "Turf Herbicide Rx: Add Oil" April, 1968), it was found that the addition of Sunspray Oil 11E (a mixture of refined

paraffin oil and emulsifier at 98:2 wt%, respectively; available from Sunoco, Inc. Philadelphia PA, USA) to certain herbicides resulted in equal or better weed control in turfgrass when delivered at a rate of 2 gallons of oil per acre. However, the herbicide oil combination also resulted in a significant increase in toxicity to the turfgrass in some cases. Overall, Applicant believes McCowan's findings were not conclusive with respect to the selectivity, effectiveness and phytotoxicity of various herbicide-oil combinations. To the inventor's knowledge, there are currently no high-oil-content herbicide compositions that selectively kill broadleaf weeds on the market for use on turfgrass.

Wide use of selective herbicides like 2,4-D (2,4 dichlorophenoxyacetic acid), Mecoprop (MCPP or methylchlorophenoxypropionic acid) and dicamba (3,6-dichloro-o-anisic acid) for controlling broadleaf weed in turfgrass throughout the world are controversial. The International Agency for Research on Cancer has classified the entire family of phenoxy-type herbicides, and particularly 2-4D, as potentially carcinogenic. Mecoprop and dicamba are suspected of being human teratogens. In the interest of public safety, regulatory bodies such as US EPA and Health Canada PMRA have been making label improvements aimed primarily at exposure reduction of 2,4-D and other herbicides to environments.

Control of broadleaf weeds remains a major problem in turfgrass throughout the world. Further, public concerns related to human health and safety as well as the impact on environments resulting from the application of such herbicides, continue to arise. There is, therefore, a need in the art for improved herbicidal compositions for controlling broadleaf weeds in turfgrass that present a reduced risk to humans and to the environment.

SUMMARY OF THE INVENTION

Embodiments of the invention provide an herbicidal composition having an amount of active ingredient significantly reduced from known prescribed label rates used for conventional herbicides. The novel compositions demonstrate a significantly increased herbicidal efficacy for controlling broadleaf weeds in turfgrass while being substantially non-phytotoxic to the turfgrass.

Embodiments of the invention enable use of known herbicides at much lower active ingredient (A.I.) rates while showing at least equivalent broadleaf weed control in turfgrass when compared to prescribed label rates, typically expressed as the A.I. per unit area.

Embodiments of the invention are also directed to a method of controlling broadleaf weeds in turfgrass while being substantially non-phytotoxic to turfgrass, which comprises treating the locus thereof with an effective amount of the novel herbicidal composition. As an additional feature, embodiments of the novel herbicidal composition have been found to control insects, such as sod webworms and fall armyworms, in turfgrass.

Therefore in a broad aspect, embodiments of the herbicidal compositions having increased herbicidal efficacy comprise: a broadleaf herbicide in an effective amount of active ingredient per unit area reduced from about 90% to about 50% of a prescribed label rate, wherein the composition has low potential phytotoxicity for turfgrass when applied as an oil-in-water emulsion at a total spray volume of from about 60 to about 120 gal/acre, the oil-in-water emulsion further comprising an oil-emulsifier mixture having a ratio of oil to emulsifier from about 95:5 wt% to about 50:50 wt%.

Further, embodiments of the invention include an herbicidal composition provided as an oil-in-water emulsion comprising:

a broadleaf herbicide which is an auxin mimic-type herbicide in an effective amount, wherein the effective amount is from about 10% to about 50% of a prescribed label rate,

wherein the composition has low potential phytotoxicity for turfgrass when applied as the oil-in-water emulsion at a total spray volume of from about 60 to about 120 gal/acre, the oil-in-water emulsion comprising an oil-emulsifier mixture having a ratio of oil to emulsifier from about 95:5 wt% to about 50:50 wt%.

Further, embodiments of the invention are emulsion-forming broadleaf herbicide concentrates comprising: a broadleaf herbicide in an effective amount of active ingredient per unit area reduced from about 90% to about 50% of a prescribed label rate, and an oil-emulsifier mixture having a ratio of oil to emulsifier from about 50:50 wt% to about 95:5 wt%, wherein when diluted in water as an oil-in-water emulsion for application to turfgrass at a total spray volume of from about 60 to about 120 gal/acre the concentrate has a low potential phytotoxicity for turfgrass.

Further, embodiments of the invention include an emulsion-forming broadleaf herbicide concentrate comprising:

a broadleaf herbicide which is an auxin mimic-type herbicide in an effective amount, wherein the effective amount is from about 10% to about 50% of a prescribed label rate, and

an oil-emulsifier mixture having a ratio of oil to emulsifier from about 50:50 wt% to about 95:5 wt%, wherein

when diluted in water as an oil-in-water emulsion for application to turfgrass at a total spray volume of from about 60 to about 120 gal/acre the concentrate has a low potential phytotoxicity for turfgrass.

Additionally, embodiments of the invention teach a method of preparing an oil-in-water emulsion having increased herbicidal efficacy and for delivery a reduced amount of active ingredient of an herbicide to turfgrass comprising: preparing an emulsion-forming broadleaf herbicide concentrate by combining a broadleaf herbicide in an effective amount of active ingredient per unit area reduced from about 90% to about 50% of a prescribed label rate, and an oil-emulsifier mixture having a ratio of oil to emulsifier from about 50:50 wt% to about 95:5 wt%; and combining the emulsion-forming broadleaf herbicide concentrate with water sufficient to dilute the oil-emulsifier from about 5 wt% to about 35 wt% for forming an oil-in-water emulsion for application to turfgrass at a total spray volume of from about 60 to about 120 gal/acre, the oil-in water emulsion having a low potential phytotoxicity for turfgrass.

Additionally, embodiments of the invention include a method of preparing an oil-in-water emulsion comprising:

preparing an emulsion-forming broadleaf herbicide concentrate by combining

a broadleaf herbicide which is an auxin mimic-type herbicide in an effective amount, wherein the effective amount is from about 10% to about 50% of a prescribed label rate, and

an oil-emulsifier mixture having a ratio of oil to emulsifier from about 95:5 wt% to about 50:50 wt%; and

combining the emulsion-forming broadleaf herbicide concentrate with water sufficient to dilute the oil-emulsifier from about 5 wt% to about 35 wt% for forming an oil-in-water emulsion for application to turfgrass at a total spray volume of from about 60 to about 120 gal/acre, the oil-in-water emulsion having a low potential phytotoxicity for turfgrass.

Additionally, embodiments of the invention include a method for delivering a reduced amount of active ingredient of a herbicide to turfgrass with increased efficacy for controlling broadleaf weeds and substantially no phytotoxicity to the turfgrass comprising:

preparing an oil-in-water emulsion having a broadleaf herbicide which is an auxin mimic-type herbicide in an effective amount, wherein the effective amount is from about 10% to about 50% of a prescribed label rate; and

applying the oil-in-water emulsion at a total spray volume of from about 60 to about 120 gal/acre, the oil-in-water emulsion further comprising an oil-emulsifier mixture having a ratio of oil to emulsifier from about 95:5 wt% to about 50:50 wt%.

A further embodiment includes a method for delivering a reduced amount of active ingredient of a herbicide to turfgrass with increased efficacy for controlling broadleaf weeds and substantially no phytotoxicity to the turfgrass comprising applying to the turfgrass the composition provided as an oil-in water emulsion as described herein at a total spray volume of from about 60 to about 120 gal/acre.

A further embodiment includes the use of the composition provided as an oil-in water emulsion as described herein for delivering a reduced amount of active

ingredient of the herbicide to turfgrass with increased efficacy for controlling broadleaf weeds and substantially no phytotoxicity to the turfgrass.

Exemplary herbicides contemplated for use in embodiments of the invention are the auxin mimic-type herbicides which include such herbicides as KILLEX® and TRIMEC®.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a graphical representation of the effect of KILLEX® formulations according to embodiments of the invention, as described in Example 3, over time.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

As used herein, the term "control" generally refers to killing, inhibition of proliferation, or otherwise diminishing the occurrence of plants.

Further, the terms "turfgrass" or "grass" generally refer to grasses that are periodically cut or mowed to provide a groundcover for various utility, recreational or aesthetic purposes. Exemplary turfgrasses include Fescues, Rye, Bent, Bahia, St. Augustine, Centipede, Kentucky bluegrass, Zoysia Native Grasses (e.g., Buffalo grass, Blue Grama and Wheatgrasses), Seashore Paspalum, Carpet Grass, Buffo, and Beach Grass. Such grasses are typically found in locations such as parks, golf courses, sports fields, sod farms, roadsides, and lawns for housing residences, commercial sites, and institutional grounds.

Examples of "broadleaf weeds" include, but are not limited to, bedstraw, bindweed (field), birdsfoot trefoil, black medic, blackseed plantain, blueweed, broad-leaved plantain, burdock, buttercup, canada thistle, chickweed, chicory, clover, common chickweed, daisy fleabane, dandelion, devil's paint brush (hawkweed), dock (curled), english daisy, fall dandelion (fall hawkbit), grass leaved stitchwort, ground ivy, heal-all, henbit, knotweed, kochia, lamb's-quarters, mallow, mouse-ear chickweed, mustards, narrow-leaved plantain, ox-eye daisy, peppergrass, pigweed, pineapple weed, poison ivy, prostrate

pigweed, purslane, ragweed, russian thistle, sandwort (thyme-leaved), sheep sorrel, shepherd'spurse, smartweed (green), sow thistle, speedwell (purslane leaved), spotted spurge, stitchwort, stonecrop (mossy), veronica (thyme-leaved), wild lettuce, yellow hawkweed brambles, buckhorn plantain, bull thistle, carolina geranium, cocklebur, crudweed, evening primrose, false dandelion, fleabane, florida pusley, frenchweed poison oak, hawkweed, honeysuckle, jimsonweed, kudzu, little starwort, morning glory, oxalis (yellow woodsorrel), pennywort, plantains (narrow, buckhorn, broadleaf), poorjoe, povertyweed, soliva, spreadwell (annual), spurge, sumac, vervain, vetch, violet, wild aster, wild blackberry, wild carrot, wild garlic, wild geranium, wild onion, wild radish, wild raspberry and yarrow.

In embodiments of the invention, the herbicidal composition comprises a highly saturated oil, an emulsifier, and a broadleaf herbicide, provided as an oil-in-water emulsion (O/W emulsion) for ready-to-use applications or as an emulsifiable herbicidal concentrate which is thereafter diluted in water for application as the O/W emulsion.

In embodiments of the invention, the active ingredients (A.I.) of an herbicide selected to control broadleaf weeds are present in the oil-in-water emulsion in a range of from about a 50% reduction, compared to known prescribed label rates, to about a 90% reduction, compared to known prescribed label rates. The oil and emulsifier in the oil-emulsifier mixture are present in a weight ratio of about 95:5 wt% to about 50:50 wt%. The oil-emulsifier mixture is present in the total O/W emulsion at about 5% to about 35% by weight which is contemplated to be delivered in a total spray volume of about 60 to about 120 gallons of O/W emulsion per acre of turfgrass.

In embodiments of the invention the oil-emulsifier mixture is present in the total oil-in-water emulsion at about 10% to about 30%.

In embodiments of the invention the oil-emulsifier mixture comprises a ratio of oil to emulsifier of from about 85:15 wt% to about 90:10 wt%. The inventors have found that an oil-emulsifier mixture having less than about 5% of emulsifier does not significantly increase herbicidal efficacy, even when used at 30% in the O/W emulsion.

In embodiments of the invention, exemplary herbicides comprise auxin mimic or growth regulator type herbicides, which include the phenoxy-type herbicides, such as 2,4-D, 2,4-DB, 24-DP, benzoic acid-type herbicides, such as dicamba and MCPA and other aromatic acid herbicides such as clopyralid, fluroxypyr, picloram and quinclorac.

It is particularly contemplated that the herbicide used is either KILLEX® (Scott Canada, Mississauga, Ontario) or TRIMEC® (PBI/GORDON Corporation, Kansas City, Missouri), both of which are combinations of 2,4-D Mecoprop and dicamba. In embodiments of the invention, KILLEX® or TRIMEC® are used in a total herbicide active ingredient to oil-emulsifier mixture ratio of about 1:50 to about 1:750 by weight.

In the case of KILLEX® or TRIMEC®, the 2,4-D may be in the form of an acid, a salt or an ester, such as 2,4-D acid, 2,4-D sodium salt, 2,4-D diethyl amine, 2,4-D dimethylamine salt, 2,4-D isopropyl acid, 2,4-D triisopropyl acid, 2,4-D butoxyethyl ester, 2,4-D ethylhexyl ester or 2,4-D isopropyl ester. The Mecoprop may be in the form of an acid, a salt or an ester, such as MCPP acid, potassium salt, dimethylamine salt, diethanolamine salt or isooctyl ester. The Dicamba may be in the form of an acid, a dimethylamine or a sodium salt.

Oils used in the composition are highly saturated oils. Typically, the oils are either synthetic or produced using conventional refining techniques such as solvent extraction, severe and mild hydrocracking or hydrotreating or hydrofining and have a viscosity in the range of about 6cSt to about 34cSt at 40°C (ASTM 445). Embodiments of the invention utilize paraffinic or isoparaffinic oils.

In embodiments of the invention, isoparaffinic oils are selected to have a carbon number distribution in the range of about C_{16} to about C_{35} and is highly refined to have an aromatic content of less than about 10wt% and in embodiments of the invention less than about 5wt%. In embodiments of the invention an isoparaffinic oil having substantially no aromatics is selected.

As compared to "light oils" such as SOLVESSO™ 150 (available from ExxonMobil) or kerosene, the inventors believe heavier isoparaffinic oils evaporate less quickly from the leaf surface and do not cause severe cell membrane disruption and therefore provide a better opportunity for the O/W emulsion to spread and for the herbicide therein to penetrate the leaf surface effectively.

Emulsifiers are selected to have minimal toxicological risk, such as those included on the Environmental Protection Agency's List 3 or 4 Inert (other) Pesticide Ingredients in Pesticide Products. Appropriate emulsifiers are selected to have sufficient solvency in the oil phase such as described in US Patent 6,515,031 to Applicant.

In embodiments of the invention, suitable emulsifiers also include ethoxylated alcohols having primary C_5 – C_{20} carbon chains with an average of about 2 to about 7 ethoxylation groups and alkyl phenol ethoxylates, including

but not limited to dodecyl phenol ethoxylates, nonyl phenol ethoxylates and the like.

Commercial preparations, whether prepared as ready-to-use compositions or as emulsifiable concentrates, may further contain such additional ingredients as are known to one of skill in the art, such as preservatives to extend the shelf-life stability. In embodiments of the invention, a small amount of preservative, such as methylchloroisothiazolinone in combination with methylisothiazolinone (KATHON® CG/ICP available from Rohm and Haas) is added, typically at less than 2.25 ppm of active ingredient.

The O/W emulsions to be sprayed on turfgrass are typically prepared using high shear mixing equipment such as a Polytron® Homogenizer (available from Kinematica Inc., Newark, NJ, USA). Preparation using high shear equipment results in stable emulsions which can then be applied to the turfgrass using conventional spraying equipment and techniques.

As shown in the examples below, the unique combinations of oil and emulsifier in the emulsions act to reduce the amount of active ingredient of the herbicide, particularly KILLEX® and TRIMEC®, required to kill broadleaf weeds in turfgrass as compared to conventional aqueous solutions of the same herbicides. The compositions as shown result in a lack of detectable phytotoxicity when the O/W emulsion is used at a total spray volume of about 60-120 gal /acre.

One of skill in the art would understand that embodiments of the invention using other herbicides such as listed above would similarly result in a significant reduction of the amount of active ingredient of the herbicide required to control broadleaf weeds in turf grass.

Further, Applicant has noted that embodiments of the invention are effective in controlling insects such as tropical sod webworm and fall armyworm when applied to turfgrass.

EXAMPLE 1

General Materials and Methods

Materials

The oils, emulsifiers and herbicides shown in Tables 1, 2 and 3 were used as indicated in the examples.

Table 1 - Oils

Oil	Component	Source
N65DW	Synthetic isoparaffinic oil	Petro-Canada*

*Calgary, AB, Canada

Table 2 - Emulsifiers

Emulsifier	Components	Source
AL3313	Polyoxyethyene lauryl ether, C_{10} to C_{16} alcohol ethoxylates, and glycerol oleate	Uniqema*
Atplus 300F	Non ionic surfactant blends	Uniqema*

*New Castle, DE, USA

Table 3. Herbicides

Herbicide	Component	Source
KILLEX®	2,4-D, dimethylamine @ 190 g/l (2,4-dicholorophenoxyacetic acid, dimethylamine salt)	Scott Canada*
	Mecoprop-p, Dimethylamine @ 100 g/l, (2-(2-Methyl-4-chlorophenoxy)propionic acid, dimethylamine salt)	
	Dicamba, Dimethylamine @ 18 g/l (Benzoic acid 3, 6-dichloro-2-methoxy-, dimethylamine salt)	
TRIMEC® Classic	2,4-D, dimethylamine @ 25.93 % (2,4-dicholorophenoxyacetic acid, dimethylamine salt)	PBI/Gordon**
	Mecoprop-p, Dimethylamine @ 13.85 % (2-(2-Methyl-4-chlorophenoxy)propionic acid, dimethylamine salt)	
	Dicamba, Dimethylamine @ 2.76 % (Benzoic acid 3, 6-dichloro-2-methoxy-, dimethylamine salt)	
TRIMEC® Southern	2,4-D, dimethylamine @ 18.74% (2,4-dicholorophenoxyacetic acid, dimethylamine salt)	PBI/Gordon**
	Mecoprop-p, Dimethylamine @ 17.37% (2-(2-Methyl-4-chlorophenoxy)propionic acid, dimethylamine salt)	
	Dicamba, Dimethylamine @ 3.85% (Benzoic acid 3, 6-dichloro-2-methoxy-, dimethylamine salt)	

* Mississauga, Ontario

** Kansas City, Missouri

Methods

Preparation and use of aqueous KILLEX® and TRIMEC® formulations

Conventional aqueous KILLEX® solutions were prepared by diluting KILLEX® in water as appropriate for use at the label rate ("KILLEX 100%", 0.59 gal/acre) and at a reduced rate ("KILLEX 12.5%", 0.074gal/acre,

87.5% reduction). In particular," KILLEX 100%" was used at the label rate of 0.59 gal/acre in sufficient water (approximately 107 gal/acre). "KILLEX 12.5%" was used at a reduced rate of 0.074 gal/acre in sufficient water (approximately 107 gal/acre).

TRIMEC®Classic solutions were prepared by diluting TRIMEC®Classic in water as appropriate for use at the label rate ("TRIMEC 100%", 0.5 gal/acre) and at a reduced rate ("TRIMEC 12.5%", 0.0625gal/acre), each used at a spray volume of about 62 gallons per acre.

TRIMEC®Southern solutions were prepared by diluting TRIMEC®Southern in water as appropriate for use at the label rate of 0.19 gal/acre ("TRIMEC®Southern 100%") and at a reduced rate of 0.0625 gal/acre ("TRIMEC®Southern 33%"), each used at a spray volume of about 62 gallons per acre.

Preparation and use of KILLEX® or TRIMEC® oil-in-water emulsion formulations

KILLEX® *or TRIMEC®* O/W emulsions were generally prepared by tank-mixing the components using high shear equipment such as a Polytron® Homogenizer (available from Kinematica Inc., Newark, NJ, USA) so as to produce a stable emulsion for application to turfgrass.

Various compositions of oil, emulsifier, herbicide and water were prepared, according to embodiments of the invention, varying the oil and emulsifier at 10%, 20% or 30% by weight of the total solution as shown in the examples below. The O/W emulsions were used at a rate of from about 62 gal/acre to about 107 gal/acre.

Testing of KILLEX® and TRIMEC® *formulations*

KILLEX® or TRIMEC® formulations according to the various examples were applied to 2m x 2m plots of turfgrass. Turfgrass tested at the University of Guelph, Ontario, Canada predominantly comprised perennial ryegrass, with some Kentucky bluegrass and other perennial grasses. Turfgrass tested at Michigan State University, MI, USA comprised a mixture of Kentucky blue grass, rye grass and tall fescue grass. Turfgrass tested at University of Florida, FL, USA comprised bahia grass and St. Augustine grass. The formulations were applied using standard spray procedures, as is known in the art.

For measuring the effect of the KILLEX® and TRIMEC® formulations on the control of broadleaf weeds, the number of dandelions, clovers, dollarweeds or pusley present in each plot was counted before and after treatment with KILLEX® *or TRIMEC*® formulations.

For measuring phytotoxic effects of the KILLEX® *or* TRIMEC® formulations on the turfgrass, the turfgrass was analyzed by visual rating accompanied by instrumental assessment using a chlorophyll meter.

EXAMPLE 2

Effects of KILLEX® dosage and an O/W emulsion of KILLEX® on dandelions

This example demonstrates the effect of aqueous KILLEX® formulations on dandelion counts when used at the label rate (0.59 gal/acre) and a reduced rate (12.5%, 0.074 gal/acre, 87.5% reduction), as well as the effect of an O/W emulsion formulation containing 30% by weight of oil plus emulsifier on the efficacy of KILLEX® at the reduced rate. The KILLEX® formulations were

prepared and tested as described in Example 1, with the O/W emulsions being applied at a rate of 107 gal /acre. The results are shown below in Table 4.

Table 4

Dandelion (%cover) - 21 days after treatment

Sample	KILLEX® Gal/acre	PCI Oil-emulsifier		Dandelion %cover (21DAA*)
		Oil	emulsifier	
Control (untreated)	(none)	(none)	(none)	14.0
KILLEX 100% (label rate)	0.59	(none)	(none)	5.0
KILLEX 12.5%	0.074	(none)	(none)	12.8
KILLEX 12.5% + PCI 30%	0.074	85 wt% N65DW	15 wt% AI3313	3.5

*DAA – days after application

The results shown in Table 4 demonstrate that KILLEX®, formulated as an O/W emulsion according to an embodiment of the invention, has increased efficacy with reduced herbicide and therefore lower levels of KILLEX® can be used to control dandelions.

EXAMPLE 3

Effect of KILLEX® O/W emulsion over time on dandelions

This example demonstrates the effect of KILLEX® O/W emulsion over time on dandelion counts in turfgrass. KILLEX® was used at a rate of 0.074 gal/acre in an O/W emulsion containing N65DW:AL3313 at 85:15 wt% and diluted to 30% by weight in water ("PCI 30% + KILLEX® 12.5%"). The KILLEX® formulations were prepared and tested as described in Example 1. The control used was untreated turfgrass.

As shown in Fig. 1, KILLEX®, formulated as an O/W emulsion according to an embodiment of the invention, is effective in controlling dandelions over time, expressed as days after treatment (DAT).

EXAMPLE 4

Effects of TRIMEC® dosage and an O/W emulsion of TRIMEC® on white clovers

Example 4 demonstrates the effect of aqueous TRIMEC® formulations on white clover counts when used at the label rate (0.5 gal/acre) and at a reduced rate (0.0625 gal/ Acre, 87.5% reduction).

Further Example 4 demonstrates the effect on the efficacy of TRIMEC® at the reduced rate when used as an O/W emulsion formulation according to embodiments of the invention containing 10% by weight of oil plus emulsifier and 20% by weight of oil plus emulsifier The TRIMEC® formulations were prepared and tested as described in Example 1 at Michigan State University, with the O/W emulsions being applied at a rate of 62 gal /acre. The results are shown in Table 5 below.

Table 5

Clover (%cover) 24 days after treatment

Sample	*TRIMEC®* *(gal/acre)*	PCI Oil-emulsifier		Clover %cover (24DAA*)	Turf Injury**
		Oil	emulsifier		
Control (untreated)	(none)	(none)	(none)	15.7	1.0
TRIMEC 100% label rate	0.5	(none)	(none)	1.3	1.0
TRIMEC 12.5%	0.0625	(none)	(none)	10	1.0
TRIMEC 12.5%+ PCI 10%	0.0625	85 wt% N65DW	15 wt% AI3313	1.3	1.0
TRIMEC 12.5% + PCI 20%	0.0625	85 wt% N65DW	15 wt% AI3313	1.7	1.0

* days after application

**Rating range from 0 to10, with 10 representing greatest injury (phytotoxicity)

The results in Table 5 demonstrate that TRIMEC® formulated as an O/W emulsion according to embodiments of the invention has increased efficacy and therefore significantly lower levels of TRIMEC® can be used to control clovers in turfgrass without increased phytotoxicity.

EXAMPLE 5

Effects of TRIMEC®Southern and an O/W emulsion of TRIMEC®Southern on dollarweed and pusley

Example 5 demonstrates the effect of an aqueous TRIMEC®Southern formulation on dollarweed and pusley counts when used at the label rate (0.19 gal/acre) and an O/W emulsion formulation containing 10%

by weight of oil plus emulsifier according to a embodiment of the invention applied at a reduced rate (0.0625 gal/acre, 67% reduction).

The TRIMEC®Southern formulations were prepared and tested as described in Example 1 at University of Florida, with the O/W emulsions being applied at a rate of 62 gal /acre. The results are shown in Table 6 below.

Table 6

Pusley and Dollarweed (%cover) - 24 days after treatment

Sample	*TRIMEC® Southern (gal/acre)*	PCI Oil-emulsifier		Pusley %cover (28DAA*)	Dollarweed %cover (28DAA*)
		Oil	emulsifier		
Control (untreated)	(none)	(none)	(none)	100	72
TRIMEC® Southern 100% label rate	0.19	(none)	(none)	49	47
TRIMEC® Southern 33% + PCI 10%	0.0625	85 wt% N65DW	15 wt% AI3313	39	42

* Days after application

The results in Table 6 demonstrate that TRIMEC®Southern formulated as an O/W emulsion according to an embodiment of the invention has increased efficacy and therefore significantly lower levels of TRIMEC®Southern can be used to control pusley and dollarweed.

EXAMPLE 6

Effect of KILLEX® and O/W emulsions of KILLEX® on turfgrass - Phytotoxicity

Example 6 demonstrates the phytotoxic effect of KILLEX® and various O/W emulsions of KILLEX® according to embodiments of the invention on turfgrass.

The KILLEX® formulations were prepared and tested as described in Example 1, with the O/W emulsions comprising oil plus emulsifier at 20% by weight in water. The formulations were applied at a total spray volume 107 gal/acre. The results are shown in Table 6 below.

Table 6

Turfgrass phytotoxicity - KILLEX® formulations applied at 0.0885 gal/acre

Sample	Oil-emulsifier		Phyto-toxicity (scale 0 – 10)**
	Oil	Emulsifier	
Control	(none)	(none)	0.25
KILLEX 12.5%	(none)	(none)	0.25
KILLEX 12.5%+PCI 20%	85 wt% N65DW	15 wt% AI3313	0.25
KILLEX 12.5%+PCII 20%	85 wt% N65DW	15 wt% Atplus300	0.5
KILLEX 12.5%+PCIII 20%	50 wt% N65DW	50 wt% Atplus300	0.25

** Phytoxicity scale from 0 to 10, 10 representing greatest phytotoxicity

The results shown in Table 6 demonstrate that the ratio of oil to emulsifier and the type of emulsifier used in the oil-emulsifier mixture can affect the phytotoxic effects of KILLEX® in O/W formulations according to embodiments of the invention.

EXAMPLE 7

Effect of TRIMEC® O/W emulsion on the control of tropical sod webworms

Applicant has found that TRIMEC® O/W emulsions, according to embodiments of the invention described herein, are also effective to control sod webworms and fall armyworms in turfgrass.

Example 7 demonstrates the effect of the O/W formulations according to embodiments of the invention on killing tropical sod webworm larvae on St. Augustinegrass.

The O/W formulation was prepared having a reduced rate of TRIMEC® (0.0625 gal/acre) containing 10% by weight of oil plus emulsifier. The field trial was carried out at University of Florida on St. Augustine grass. Ten medium sized tropical sod webworm larvae per PVC ring were used, the larvae in the rings being retained outside on turfgrass for 4 days after the application of the O/W emulsion. The O/W emulsion was applied at a rate of 80 gal/acre. Live larvae numbers were counted four days after application. The results are shown in Table 7 below.

Table 7

Live Tropical Sod Webworm larvae 4 days after treatment

Treatment #	# live larvae - untreated Control (4DAA)	# live larvae - O/W herbicide emulsion treated plot (4DAA)
1	4	2
2	4	0
3	7	2
4	7	1
5	4	5
6	5	1
7	7	5
8	5	1
9	6	3
mean	5.44	2.22
% control	0	59.18

The results in Table 7 demonstrate that TRIMEC® formulated as an O/W emulsion according to an embodiment of the invention is effective to control sod webworms in turfgrass.

WHAT IS CLAIMED IS:

1. An herbicidal composition provided as an oil-in-water emulsion comprising:

a broadleaf herbicide which is an auxin mimic-type herbicide in an effective amount, wherein the effective amount is from about 10% to about 50% of a prescribed label rate,

wherein the composition has low potential phytotoxicity for turfgrass when applied as the oil-in-water emulsion at a total spray volume of from about 60 to about 120 gal/acre, the oil-in-water emulsion comprising an oil-emulsifier mixture having a ratio of oil to emulsifier from about 95:5 wt% to about 50:50 wt%.

2. The composition of claim 1, wherein the ratio of oil to emulsifier in the oil-emulsifier mixture is from about 85:15 wt% to about 90:10 wt%.
3. The composition of claim 1 or 2, wherein the oil-emulsifier mixture is diluted in water from about 5 wt% to about 35 wt% for forming the oil-in-water emulsion.
4. The composition of claim 1 or 2, wherein the oil-emulsifier mixture is diluted in water from about 10 wt% to about 30 wt% for forming the oil-in-water emulsion.
5. The composition of any one of claims 1 to 4, wherein the broadleaf herbicide comprises:

2,4-dichlorophenoxyacetic acid in the form of an acid, a salt, an ester, or combinations thereof;

2-(2-methyl-4-chlorophenoxy)propionic acid, in the form of an acid, a salt, an ester or combinations thereof; and

3,6-dichloro-o-anisic acid in the form of an acid, a salt, or combinations thereof.

6. The composition of claim 5, wherein the effective amount of active ingredients of the broadleaf herbicide to oil-emulsifier mixture is in a ratio of about 1:50 to about 1:750 by weight.
7. The composition of any one of claims 1 to 6, wherein the oil is a highly saturated oil.
8. The composition of claim 7, wherein the oil has a carbon number distribution of from about C_{16} to about C_{35}.
9. The composition of claim 7, wherein the oil has an aromatic content of less than about 10 wt%.
10. The composition of claim 7, wherein the oil has an aromatic content of less than about 5 wt%.
11. The composition of claim 7, wherein the oil has substantially no aromatic content.
12. The composition of claim 7, wherein the oil is a synthetic isoparaffinic oil.
13. The composition of any one of claims 1 to 12, wherein the emulsifier is selected to be soluble in the oil.
14. The composition of claim 13, wherein the emulsifier is an ethoxylated alcohol.
15. An emulsion-forming broadleaf herbicide concentrate comprising:

a broadleaf herbicide which is an auxin mimic-type herbicide in an effective amount, wherein the effective amount is from about 10% to about 50% of a prescribed label rate, and

an oil-emulsifier mixture having a ratio of oil to emulsifier from about 50:50 wt% to about 95:5 wt%, wherein

when diluted in water as an oil-in-water emulsion for application to turfgrass at a total spray volume of from about 60 to about 120 gal/acre the concentrate has a low potential phytotoxicity for turfgrass.

16. The concentrate of claim 15, wherein the concentrate is diluted in water sufficient to dilute the oil-emulsifier from about 5 wt% to about 35 wt% for forming the oil-in-water emulsion.
17. The concentrate of claim 15, wherein the concentrate is diluted in water sufficient to dilute the oil-emulsifier from about 10 wt% to about 30 wt% for forming the oil-in-water emulsion.
18. The concentrate of any one of claims 15 to 17, wherein the ratio of oil to emulsifier in the oil-emulsifier mixture is from about 85:15 wt% to about 90:10 wt%.
19. The concentrate of any one of claims 15 to 18, wherein the oil is a highly saturated oil having a carbon number distribution of from about C_{16} to about C_{35} and an aromatic content of less than about 10 wt%.
20. The concentrate of claim 19, wherein the oil has an aromatic content of less than about 5 wt%.
21. The concentrate of claim 19, wherein the oil has substantially no aromatic content.
22. The concentrate of claim 19, wherein the oil is a synthetic isoparaffinic oil.
23. The concentrate of any one of claims 15 to 22, wherein the broadleaf herbicide comprises:

2,4-dichlorophenoxyacetic acid in the form of an acid, a salt, an ester, or combinations thereof;

2-(2-methyl-4-chlorophenoxy)propionic acid, in the form of an acid, a salt, an ester or combinations thereof; and

3,6-dichloro-o-anisic acid in the form of an acid, a salt, or combinations thereof.

24. The concentrate of any one of claims 15 to 23, wherein the emulsifier is selected to be soluble in the oil.

25. A method of preparing an oil-in-water emulsion comprising:

preparing an emulsion-forming broadleaf herbicide concentrate by combining

a broadleaf herbicide which is an auxin mimic-type herbicide in an effective amount, wherein the effective amount is from about 10% to about 50% of a prescribed label rate, and

an oil-emulsifier mixture having a ratio of oil to emulsifier from about 95:5 wt% to about 50:50 wt%; and

combining the emulsion-forming broadleaf herbicide concentrate with water sufficient to dilute the oil-emulsifier from about 5 wt% to about 35 wt% for forming an oil-in-water emulsion for application to turfgrass at a total spray volume of from about 60 to about 120 gal/acre, the oil-in-water emulsion having a low potential phytotoxicity for turfgrass.

26. The method of claim 25, wherein the combining of the concentrate with the water is performed using high shear.

27. The method of claim 25 or 26, wherein the ratio of oil to emulsifier in the oil-emulsifier mixture is from about 85:15 wt% to about 90:10 wt%.

28. The method of any one of claims 25 to 27, wherein the oil-emulsifier mixture is diluted in water from about 10 wt% to about 30 wt% for forming the oil-in-water emulsion.

29. The method of any one of claims 25 to 28, wherein the broadleaf herbicide comprises:

2,4-dichlorophenoxyacetic acid in the form of an acid, a salt, an ester, or combinations thereof;

2-(2-methyl-4-chlorophenoxy)propionic acid, in the form of an acid, a salt, an ester or combinations thereof; and

3,6-dichloro-o-anisic acid in the form of an acid, a salt, or combinations thereof.

30. The method of any one of claims 25 to 29, wherein the effective amount of active ingredients of the broadleaf herbicide to oil-emulsifier mixture is in a ratio of about 1:50 to about 1:750 by weight.
31. The method of any one of claims 25 to 30, wherein the oil is a highly saturated oil.
32. The method of claim 31, wherein the oil has a carbon number distribution of from about C_{16} to about C_{35}.
33. The method of claim 31, wherein the oil has an aromatic content of less than about 10 wt%.
34. The method of claim 31, wherein the oil has an aromatic content of less than about 5 wt%.
35. The method of claim 31, wherein the oil has substantially no aromatic content.
36. The method of claim 31, wherein the oil is a synthetic isoparaffinic oil.
37. The method of any one of claims 25 to 36, wherein the emulsifier is selected to be soluble in the oil.
38. The method of claim 37, wherein the emulsifier is an ethoxylated alcohol.
39. A method for delivering a reduced amount of active ingredient of a herbicide to turfgrass with increased efficacy for controlling broadleaf weeds and substantially no phytotoxicity to the turfgrass comprising:

preparing an oil-in-water emulsion having a broadleaf herbicide which is an auxin mimic-type herbicide in an effective amount, wherein the effective amount is from about 10% to about 50% of a prescribed label rate; and

applying the oil-in-water emulsion at a total spray volume of from about 60 to about 120 gal/acre, the oil-in-water emulsion further comprising an oil-emulsifier mixture having a ratio of oil to emulsifier from about 95:5 wt% to about 50:50 wt%.

40. The method of claim 39, wherein the preparing the oil-in-water emulsion further comprises:

preparing an oil-emulsifier mixture having a ratio of oil to emulsifier in from about 85:15 wt% to about 90:10 wt%;

mixing the broadleaf herbicide in the oil-emulsifier mixture; and

diluting the oil-emulsifier mixture and herbicide, in water from about 5 wt% to about 35 wt% for forming the oil-in-water emulsion.

41. The method of claim 40, further comprising:

diluting the oil-emulsifier mixture with herbicide in water from about 10 wt% to about 30 wt% for forming the oil-in-water emulsion.

42. The method of any one of claims 39 to 41, wherein the oil-emulsifier mixture is diluted in water from about 5 wt% to about 35 wt% for forming the oil-in-water emulsion.

43. The method of any one of claims 39 to 41, wherein the oil-emulsifier mixture is diluted in water from about 10 wt% to about 30 wt% for forming the oil-in-water emulsion.

44. The method of any one of claims 39 to 43, wherein the broadleaf herbicide comprises:

2,4-dichlorophenoxyacetic acid in the form of an acid, a salt, an ester, or combinations thereof;

2-(2-methyl-4-chlorophenoxy)propionic acid, in the form of an acid, a salt, an ester or combinations thereof; and

3,6-dichloro-o-anisic acid in the form of an acid, a salt, or combinations thereof.

45. The method of any one of claims 39 to 44, wherein the effective amount of active ingredients of the broadleaf herbicide to oil-emulsifier mixture is in a ratio of about 1:50 to about 1:750 by weight.

46. The method of any one of claims 39 to 45, wherein the oil is a highly saturated oil.

47. The method of claim 46, wherein the oil has a carbon number distribution of from about C_{16} to about C_{35}.

48. The method of claim 46, wherein the oil has an aromatic content of less than about 10 wt%.

49. The method of claim 46, wherein the oil has an aromatic content of less than about 5 wt%.

50. The method of claim 46, wherein the oil has substantially no aromatic content.

51. The method of claim 46, wherein the oil is a synthetic isoparaffinic oil.

52. The method of any one of claims 39 to 51, wherein the emulsifier is selected to be soluble in the oil.

53. The method of claim 52, wherein the emulsifier is an ethoxylated alcohol.

54. A method for delivering a reduced amount of active ingredient of a herbicide to turfgrass with increased efficacy for controlling broadleaf weeds and substantially no phytotoxicity to the turfgrass comprising applying to the turfgrass the composition provided as an oil-in water emulsion of any one of claims 1 to 14 at a total spray volume of from about 60 to about 120 gal/acre.

55. Use of the composition provided as an oil-in water emulsion of any one of claims 1 to 14 for delivering a reduced amount of active ingredient of the herbicide to turfgrass with increased efficacy for controlling broadleaf weeds and substantially no phytotoxicity to the turfgrass.

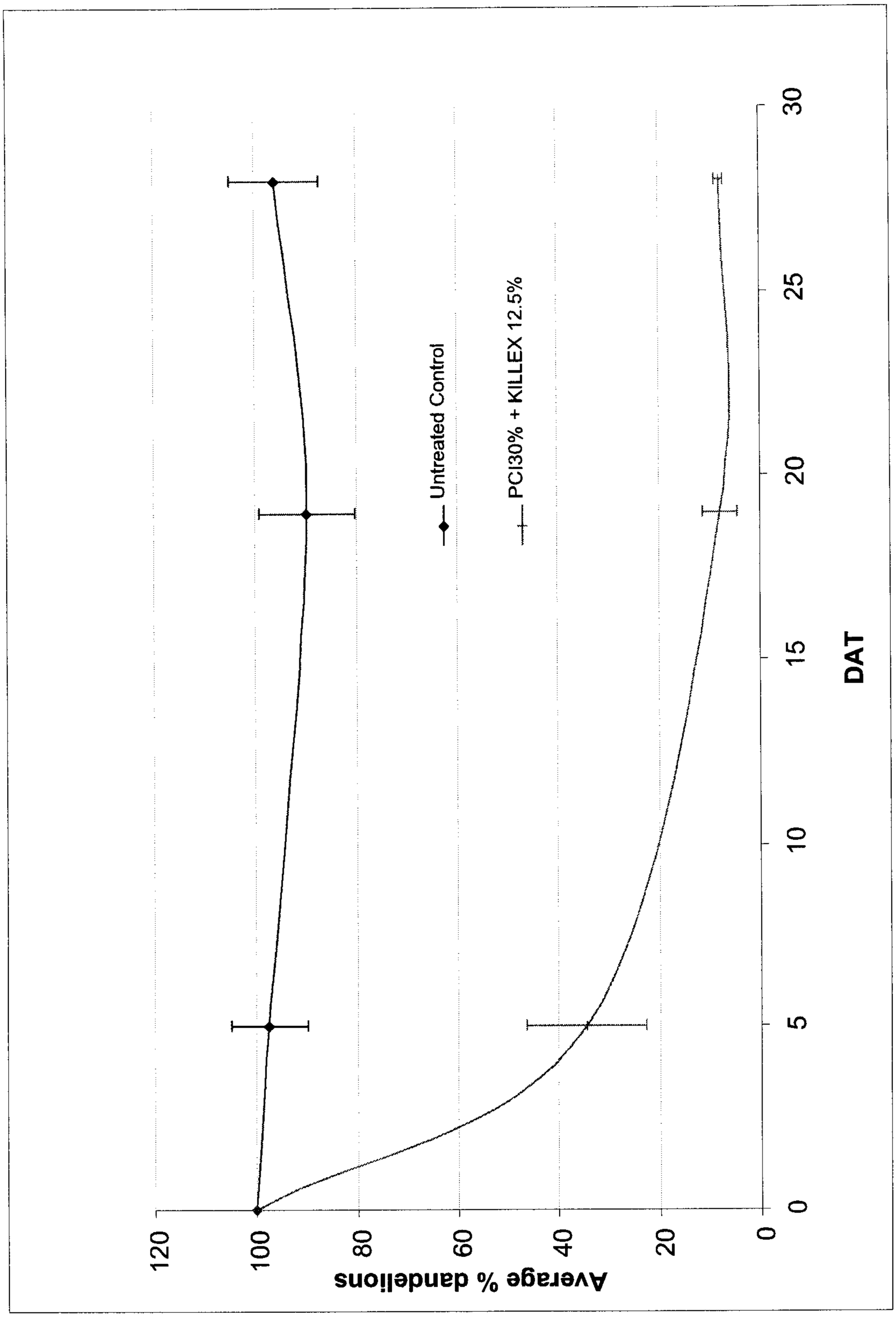
Average % dandelions
120
100
80
60
40
20
0
0
5
10
15
20
25
30
DAT
Untreated Control
PCI30% + KILLEX 12.5%

Fig. 1