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Cilantro, Dill, and Dandelion Greens Tolerance and Weed Control With Trifluralin

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ABSTRACT

Field studies were conducted to determine the efficacy and crop safety of trifluralin in cilantro, dill, and dandelion greens when applied pre-plant incorporated (PPI) at 0.56 and 0.84 kg ha^{-1} . Visual estimates of crop tolerance, weed population counts, crop fresh and dry weight at maturity, and leaf area were used to determine impact of trifluralin on each crop when compared to an untreated control. Coriander and dill showed no visual crop phytotoxicity and no adverse affects on crop growth, fresh and dry weight yield, or leaf area when treated with trifluralin. Dandelion greens had a 47% and 49% reduction in leaf area when treated with trifluralin at 0.56 and 0.84 kg a.i. ha^{-1} when compared to the untreated weed free dandelion treatment. Trifluralin provided good control of common purslane, Palmer amaranth, London rocket, and nettleleaf goosefoot but only marginal control of common sunflower. Trifluralin when used in combination with early season mechanical cultivation can provide selective weed control of many of the most common winter annual weeds while exhibiting a high level of crop tolerance for coriander and dill.

RESUMEN

Se realizaron estudios de campo para determinar la eficacia y la seguridad de uso en el cultivo de la aplicación de trifluralín en plantas de cilantro, eneldo y diente de león aplicado mediante la incorporación presiembra (IPS) a 0.56 y 0.84 kg ha^{-1}. Se utilizaron estimaciones visuales de la tolerancia del cultivo, los conteos de poblaciones de malezas, el peso fresco y seco de la cosecha en la madurez, y el área foliar para determinar el impacto de trifluralín sobre cada cultivo cuando se comparó con el control no tratado. Las plantas de cilantro y eneldo no mostraron signos aparentes de fitotoxicidad ni efectos adversos en el crecimiento, rendimiento expresado como peso fresco y seco o área foliar cuando fueron tratadas con trifluralín. Las plantas de diente de león tuvieron una reducción de un 47% y un 49% del área foliar cuando se trataron con trifluralín a 0.56 y 0.84 kg i.a. ha^{-1} en comparación con el tratamiento de las plantas de diente de león no tratadas y libres de malezas. Trifluralín brindó un buen control de *Portulaca oleracea* L., *Amaranthus palmeri* L., *Sisymbrium irio* L., *Chenopodium murale* L. y *Helianthus annuus* L.. El uso temprano en la estación de trifluralín en combinación con cultivo mecánico puede proveer un control selectivo de la mayoría de las malezas anuales de invierno más comunes al mismo tiempo que su empleo tiene un nivel alto de tolerancia en los cultivo de cilantro y eneldo.

Coriander *Coriandrum sativum* L., also known as cilantro, and dill *Anehtuum graveolens* L., are both members of the Umbelliferae family while dandelion *Taraxacum officinale* Weber ex Wigg., is a member of the compositae family. The leafy portion of these species are harvested for consumer use in salads or flavor enhancement. Cilantro and dill are both used as seasoning for many recipes by consumers and restaurant chefs. These vegetable crops are currently grown in South Texas, however, weed control is a major threat to the continued production and producer profitability. Weeds impose two adverse impacts; reduced yields due to competition and crop quality since weedy vegetation harvested with the crop reduces grades. Even moderate weed infestations can render the harvested foliage unmarketable. There are no herbicides currently registered for use on these crops in the United States. When weeds are present in these crops the weeds can also serve as alternative hosts for insect populations which may chew on leaves or discolor crop vegetation causing the crop to be unmarketable. Mechanical and hand removal of weeds are the only control methods currently available for producers. Hand weeding by hoeing or roughing can cost from $250 to $500 per acre or more depending upon weed species and population densities. Mechanical cultivation is a reliable method of removing inter-row weeds from cilantro, dill, and dandelion fields, however, intra-rows weeds are very difficult to effectively remove mechanically without severe damage to the crop. Herbicidal control of weeds is complicated by the fact that these crops are purchased on the basis of foliage and appearance. Stunting, discoloration, or poor growth reduces yield and consumer appeal. An effective herbicide would need to have low crop phytotoxicity, high efficacy levels on weeds, and leave no herbicide residual on the crop foliage. Registration of a herbicide would greatly enhance the economic viability of these alternative vegetables in the United States. In 1993 approximately 1000 acres of coriander, 600 acres of dill, and 600 acres of dandelions were harvested in the Lower Rio Grande Valley of Texas. There is a demand and market structure already in place for these vegetables, however the economic production is hampered by lack of economically available weed control methods. The crop acreage and production profitability of coriander, dill, and dandelion could be greatly expanded in the United States if weeds could be effectively and economically controlled. Due to the relatively warm winter

Table 1. Analysis for crop by treatment interactions for fresh weights, dry weights, and leaf area 60 DAP for two locations at Weslaco, TX, 1993 and 1995[abc].

		Fresh weight			Dry weight			Leaf area		
	Degrees of freedom	sandy clay loam		clay loam	sandy clay loam		clay loam	sandy clay loam		clay loam
		1994	1995	1994	1994	1995	1994	1994	1995	1994
Total	35									
Replication	3	NS	NS	*	NS	NS	NS	NS	**	NS
Main Plot, crop (A)	2	NS	NS	*	*	*	NS	NS	NS	*
Error A	6	NS	NS	*	*	NS	NS	NS	**	NS
Subplot, treatment (B)	2	NS	NS	NS	NS	NS	NS	NS	NS	NS
crop * treatment (A*B)	4	**	*	NS	NS	*	**	**	**	*
error (B)	18									

[a]Main plots (A) consisted of the crops coriander, dill and dandelion greens.
[b]Subplots consisted of treatments of trifluralin applied pre-plamt incorporated at 0.00, 0.56, and 0.84 kg ha^{-1}
[c]An asterisks "*" indicates an interaction at alpha = 0.05 level of significance and a double asterisks "**" indicates an interaction at alpha=0.01 level of significance.

temperatures which occur in South Texas, winter annual weeds are somewhat different in many other production areas of the United States. Both winter and summer annual weed species are problems in winter grown crops in the Lower Rio Grande Valley of South Texas. Weed problems in winter grown leafy greens are purslane, (*Portulaca oleracea* L.), Palmer amaranth, (*Amaranthus Palmeri* L.) London rocket, (*Sisymbrium irio* L) nettleleaf goosefoot, (*Chenopodium murale* L.) and sunflower, (*Helianthus annuus* L.). Preliminary studies in 1992 found trifluralin to adequately control most winter weed species without adversely affecting cilantro, dill, or dandelion. The objectives of this study were to determine the crop safety and weed efficacy of trifluralin [2,6-dinitro-*N*, *N*-dipropyl-4-(trifluoromethyl) benzenamine] when used on cilantro, dill, and dandelion. This research was designed to determine the extent of crop tolerance and document efficacy for weed control for these leafy green crops. Documentation that trifluralin is a safe and effective product for weed control in these crops can help in petitioning for a special use or state use label for trifluralin on cilantro, dill, and dandelion.

MATERIALS AND METHODS

Three field trials were conducted near Weslaco, Texas on two soil types, during 1993 and 1995. Soil was tilled and prepared for planting in a conventional manner. Main plots were vegetable species and sub-plots were herbicide treatments. Sub-plots were one row by 9 to 12 meters long with four replication of treatments in a split-block design.

Herbicide treatments were established before planting the crop. Trifluralin was applied pre-plant incorporated (PPI) at 0.0, (untreated control), 0.56 kg ha^{-1}, or 0.84 kg ha^{-1} in 187 L ha^{-1} of spray solution with a CO_2 powered sprayer and treatments were immediately incorporated with one pass of a tractor powered rotary tine tiller set to operate at a soil depth of 3.8 cm and 290 revelations per minute. The untreated control was also rotary tilled to a similar depth as the trifluralin treatments to provide tillage uniformity for all treatments. Vegetable seed was planted with a "Planter Junior" planter at to a 1.5 to 2 cm depth using conventional seeding rates for each species. Cultivars included: cilantro var. "Slow Bolt", dill var. "Mammoth Long Island", and dandelion for greens, var. "Baxter Special".

Two trials were conducted in late 1993 on a Hidalgo sandy clay loam, (a fine-loamy, mixed, hyperthermic Typic Calciustols) and a Raymondville clay loam (a fine, mixed, hyperthermic Vertic Calciustolls) soil. A third trial was conducted in 1995 on the Hidalgo soil. The Hidalgo sandy clay loam had a pH of 7.8 and an organic matter content of 0.8 percent. The Raymondville clay loam soil had a pH of 8.0 and an organic matter content of 1.8 percent.

Plots were furrow irrigated after establishment and as needed to sustain crop growth. Crop response and weed control effectiveness were evaluated at 45 and 60 DAP. Crop response was measured by counting seedling populations in a 1-meter section of row and visually estimating phytotoxicity on crop foliage. Weed control was evaluated by counting weed population and species in four 1-meter square quadrants in each subplot. At 60 DAP, crop foliage was hand harvested by cutting four samples in each subplot at ground level by hand in 0.5 m section of crop row. Crop yields were then measured by (1) determining fresh weight and leaf area (through a leaf area meter) and (2) by measuring dry matter. Fresh weight of each sample was recorded for each sample and leaves were flattened and passed through a LI-3100 (Li-Cor Inc. Lincoln, NE) leaf area meter to determine leaf area of each sample. Samples were then oven dried at 70°C for 72 hr., removed from the oven, allowed to equilibrate to room temperature, (approximately 1 hr.) and dry weights of each sample were recorded. Dry matter determinations were important since these crops are sometimes sold by as a dried material and dry weight values can help to eliminate variability associated with differential water contents of plants which may occur in fresh weight samples.

Statistical Analysis. All data were analyzed as a split-plot design and conclusions were drawn at the 5% level of probability. A significant crop by herbicide dosage interaction occurred for one location each year for crop fresh weight, dry weight, and at all locations for leaf area. This indicates that the cilantro, dill, and dandelion greens responded differently to the subplot treatments, i.e. trifluralin dosage level applied. When a significant crop by treatment interaction occurred means separation were

then performed using Duncans multiple range test (alpha = 0.05 level of significance) for each measured factor.

RESULTS AND DISCUSSION

A crop by treatment interaction was found for both locations and years (crops responded differently to the herbicide treatments), so each crop was then analyzed separately using analysis of variance for each measured variable and means separation was done using Duncans Multiple Range test ($\propto = 0.05$).

A crop by treatment interaction occurred for fresh and dry weight at the South Weslaco location in 1994 and 1995 and for leaf area at all locations (Table 1).

Cilantro grew well and had good yields when treated with trifluralin at any dosage. Trifluralin did not reduce fresh weight, dry weight, or leaf area of cilantro. At one or more locations fresh weight, dry weight, and leaf area actually increased as the trifluralin dosage increased. This yield increase may be due to larger leaves and more robust plants which did not have even small weeds competing for moisture, nutrients, or light.

Dill also had no adverse response to trifluralin applied at any dosage at any of the three locations. There were no leaf deformities or discoloration which would adversely affect yield quality or grade.

Dandelion greens however were adversely affected by trifluralin at 0.54 and 0.84 kg a.i./ha. Fresh and dry weights were reduced by 40-50% when treated with trifluralin at two of the three locations when compared to the untreated control. Further analysis (Tables 2, 3, and 4) indicated that dandelion greens responded differently (i.e. adverse response) to trifluralin applications than did dill or cilantro. This adverse response to trifluralin was especially apparent for leaf area of dandelion greens (Table 4). At the clay loam soil location dandelion leaf area was reduced by 47% and 49% when trifluralin at 0.54 and 0.84 kg ha^{-1} was applied. Trifluralin applied at 0.84 kg ha^{-1} also reduced dandelion green leaf area by 46% and 36% at the sandy clay loam location in 1994 and 1995. A positive response to trifluralin at the South Weslaco location for fresh and dry weights (Tables 2 and 3), and leaf area (Table 4) was likely due to the decreased weed competition rather than any stimulus of crop growth due to trifluralin. Leaf area of dandelion greens was reduced by 36 and 50% at two of the three locations with 0.84 kg a.i./ha trifluralin.

Control of common purslane, Palmer amaranth, and London rocket increased as trifluralin dosage increased (Table 5) in all three of the crops grown. Nettleleaf goosefoot was adequately control by either dosage level of trifluralin but common sunflower was only marginally controlled. Nettleleaf goosefoot and common sunflower populations were not uniform and consistent in all of the locations (data not presented). Palmer Amaranth populations ranged from 0.5 to 4 plants/square meter for the untreated control plots in cilantro, dill, and dandelion at all locations. Trifluralin at 0.54 kg/ha controlled at least 87% of the Palmer amaranth

Table 2. Fresh weight yield for cilantro, dill, and dandelion greens at 60 DAP for each subplot treatments at the two locations near Weslaco, Texas, 1993.

		Cilantro			Dill			Dandelion		
		1994		1995	1994		1995	1994		1995
Treatment	Dosage	N.[a]	S.	S.	N.	S.	S.	N.	S.	S.
	kg ha^{-1}	kg ha^{-1}								
Untreated control	----	2015 a[b]	776 b	1136 a	1628 a	796 a	1654 a	1174 a	824 ab	2248 a
Trifluralin	0.54	2271 a	1058 b	1039 a	1863 a	975 a	1661 a	526 b	641 b	1973 a
Trifluralin	0.84	1979 a	1963 a	1109 a	1877 a	453 a	1512 a	623 b	1088 a	1340 b
MSD		N.S	814	N.S.	N.S.	N.S.	N.S.	466	408	544
C.V.[c]		46	74	25	23	14	19	69	55	32

[a]N. loc. is an abbreviation for the North Weslaco location, and S. loc. is an abbreviation for the South Weslaco location.
[b]Means separation performed with a Duncan multiple range test ($\propto$=0.05). N.S. is an abbreviation for not significantly different at the level tested.
[c]C.V. is an abbreviation for coefficient of variation which expresses the standard deviation per experimental unit as a percent of the general mean of the experiment and provides an idea of the general viability among the plots.

Table 3. Oven dry weight yield for cilantro, dill, and dandelion greens harvested at 60 DAP for each of the subplot treatments at the two locations near Weslaco, Texas, 1993.

		Cilantro			Dill			Dandelion		
		1994		1995	1994		1995	1994		1995
Treatment	Dosage	N.[a]	S.	S.	N.	S.	S.	N.	S.	S.
	kg ha^{-1}	kg ha^{-1}								
Untreated control	----	229 a[b]	81.6 b	172 a	157 a	73.2 a	52 a	101 a	76 a	63 a
Trifluralin	0.54	243 a	125.2 ab	173 a	185 a	72.2 a	52 a	50 b	87 a	65 a
Trifluralin	0.84	218 a	183.4 a	180 a	184 a	90.8 a	46 a	59 b	46 a	35 b
MSD		N.S	77	N.S.	N.S.	N.S.	N.S.	34	N.S.	24

[a]N. loc. is an abbreviation for the North Weslaco location, and S. loc. is an abbreviation for the South Weslaco location.
[b]Means separation performed with a Duncans multiple range test ($\propto$=0.05).
[c]Data collected from one crop row per raised bed, commercial producers frequently grow 2-3 crop rows per raised bed.

Table 4. Leaf area per square meter for cilantro, dill, and dandelion greens at 60 DAP for each of the subplot treatments.

		Cilantro			Dill			Dandelion		
		1994		1995	1994		1995	1994		1995
Treatment	Dosage	N.[a]	S.	S.	N.	S.	S.	N.	S.	S.
	kg ha^{-1}	----------			kg ha^{-1}			----------		
Untreated control	----	4.94 a	1.73 b	3.2 a	3.02 a	1.53 a	3.4 a	2.60 a	1.87 a	5.0 a
Trifluralin	0.54	5.00 a	2.33 b	2.8 a	3.52 a	1.20 a	3.4 a	1.37 b	2.33 a	5.2 a
Trifluralin	0.84	4.67 a	3.82 a	3.6 a	3.45 a	1.99 a	3.5 a	1.32 b	1.01 a	3.2 b
MSD		N.S	1.1	N.S.	N.S.	N.S.	N.S.	.959	N.S.	1.7

[a]N. loc. is an abbreviation for the North Weslaco location, and S. loc. is an abbreviation for the South Weslaco location.
[b]Means comparison are made within a column and performed using a Waller-Duncab multiple range test (α=0.05).

Table 5. Weed population per square meter as affected by trifluralin treatments for cilantro, dill, and dandelion.

		Palmer amaranth			common purslane			London rocket		
		1994		1995	1994		1995	1994		1995
Treatment	Dosage	N.[a]	S.	S.	N.	S.	S.	N.	S.	S.
	kg ha^{-1}	----------			weed number meter^{-2}			----------		
Cilantro										
Untreated control	----	2.5 a	4.0 a	4.0 a	0.4 a	1.2 a	2.0 a	2.6 a	1.8 a	3.0 a
Trifluralin	0.54	0.0 b	0.0 b	0.5 b	0.1 b	0.0 b	0.0 a	0.0 c	0.0 b	0.1 b
Trifluralin	0.84	0.0 b	0.0 b	0.0 c	0.0 b	0.0 b	0.0 a	0.2 b	0.0 b	0.0 c
Dill										
Untreated control	----	2.0 a	1.8 a	2.0 a	1.2 a	1.3 a	1.5 a	1.4 a	1.5 a	2.0 a
Trifluralin	0.54	0.0 b	0.0 b	0.0 b	0.1 b	0.5 b	0.0 a	0.0 b	0.0 b	0.0 b
Trifluralin	0.84	0.0 b	0.0 b	0.0 c	0.0 b	0.3 b	0.0 a	0.0 b	0.0 b	0.0 b
Dandelion										
Untreated control	----	1.8 a	0.5 a	0.8 a	1.0 a	0.8 a	1.3 a	1.0 a	1.8 a	1.4 a
Trifluralin	0.54	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.3 b	0.0 b	0.2 b
Trifluralin	0.84	0.0 b	0.0 b	0.0 c	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b

[a]N. loc. is an abbreviation for the North Weslaco location, and S. loc. is an abbreviation for the South Weslaco location.
[b]Means comparison are made within a column and crop species and performed using a Waller-Duncab multiple range test (α=0.05).

species, 77% of the common purslane species, and 77% of the London rocket species regardless of location or crop. Trifluralin at 0.84 kg ai/ha usually controlled all of the Palmer amaranth species, at least 77% of the common purslane, and 92% of the London rocket plants and usually almost 99% was control for the three crops and three locations.

SIGNIFICANCE OF RESULTS

Results of this study have shown that trifluralin when applied PPI at 0.56, or 0.84 kg a.i. ha^{-1} exhibited no visual crop phytotoxicity and no adverse affects on crop growth, fresh or dry weight yield, or leaf area for cilantro and dill. Dandelion crop tolerance (visual crop phytotoxicity) was adversely affected by trifluralin at two locations as were the fresh and dry weight yields and leaf area. The adverse impact of trifluralin need to be further examined to determine if trifluralin can be used safely on dandelion greens. Trifluralin when used in combination with early season mechanical cultivation can provide selective weed control of many of the most common winter annual weeds in South Texas while exhibiting a high level of crop tolerance for cilantro and dill. Palmer amaranth, common purslane, London rocket, and nettleleaf goosefoot were adequately controlled by trifluralin at either dosage level (0.54 or 0.84 kg a.i./ha). Common sunflower was not uniformly distributed throughout the locations and treatments but was only moderately controlled by trifluralin treatments. Registration and labeling of trifluralin for use PPI on cilantro and dill would greatly enhance the production capabilities and economic potential for production in the United States.