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TOLERANCE OF STRAWBERRIES TO PREPLANT HERBICIDES

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Abstract. **Twelve herbicides were applied as preplant incorporated or preemergence treatments in polyethylene mulched strawberry (*Fragaria* × *ananassa* Duch.) production during the 1993-94 and 1994-95 seasons at Live Oak and during the 1994-95 season at Gainesville and Dover. Norflurazon, trifluralin, and EPTC were applied preplant incorporated. Clopyralid, metolachlor, napropamide, oryzalin, oxyfluorfen, pendimethalin, prodiamine, simazine, and terbacil were applied to the bed surface and incorporated with sprinkler irrigation before mulch application. Early and midseason vigor of strawberry plants were significantly lowered with the oryzalin treatment at the Gainesville and Live Oak locations with associated reduction in yield. Early season plant vigor and fruit yield were lowest with the pendimethalin treatment at Dover. Strawberries were tolerant of the majority of the herbicides tested. Vigor and yield were not significantly different with most herbicide treatments from that from plants with the untreated checks.**

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Methyl bromide plus chlorpicrin is labeled for use and has been highly effective in controlling nematodes, soilborne diseases, insects, and weeds in mulched strawberry production in Florida for the past 20 years. Methyl bromide was listed as a class I ozone depleting substance on 30 Nov. 1993, and a phase out date of 1 Jan. 2001 was established under the U.S. Clean Air Act (Section 602). Currently available alternative fumigants to methyl bromide will not adequately control hard seeded winter annual weeds nor nutsedges under Florida strawberry cultural conditions. Herbicides will be needed to control these weeds in an alternative production management situation.

At the present time no herbicide is labeled in strawberries for pretransplant application for weed control under mulch in Florida. Napropamide and DCPA are labeled only for posttransplant application. Diphenamid was labeled and recommended for pretransplant use (Kostewicz and Montelaro, 1974, USDA, 1982), but was voluntarily withdrawn from production and use in the US. During the early to mid 1980s, several herbicide trials on strawberries in Florida demonstrated that chloxuron was effective and safe for use on strawberries (Albregts and Howard, 1981; 1983; Gilreath and Albregts, 1984; 1985). Chloxuron use, however, has been discontinued in the U.S.

Simazine and terbacil have established tolerances for use on strawberries. The simazine label is geographically limited and terbacil is labeled for application in matted-row strawberry production only.

Strawberries have been shown to be tolerant to applications of clopyralid over the top of established plants (Murray et al., 1994). Several trials in Florida have shown clopyralid to be efficacious for the control of several broadleaf weeds when applied preemergence to the weeds (Stall, 1990). Tolerance of strawberries to preplant applications of clopyralid has not been established.

The use of oxyfluorfen applied under mulches has been studied on several crops. Bellinder et al. (1993) found that if seven days elapsed between oxyfluorfen application and mulching, transplanted cucumbers, squash, and muskmelon could safely be grown. She reasoned that oxyfluorfen residues on the soil surface and mulch would be volatilized during that period. Inconsistent safety found in other trials was due to volatilization of the herbicide. The waiting period between alternative fumigant application and transplanting strawberries would exceed the seven-day period.

Trials are ongoing to establish tolerance for the use of pendimethalin in strawberries through the IR-4 program. Here again, the requests are for matted-row strawberries.

The purpose of this study was to ascertain strawberry tolerances to pretransplant applications of napropamide, simazine, terbacil, clopyralid, oxyfluorfen, and pendimethalin. Other candidate herbicides such as norflurazon, trifluralin, EPTC, prodiamine, and oryzalin were also tested.

Materials and Methods

Four trials were conducted at three locations. Trials were conducted at the Suwannee Valley Research and Education Center, Live Oak in 1993-94 and 1994-95 on a Lakeland fine sand (sandy siliceous, Thermic, Coated, Typic Quartzipsamments). A trial was conducted at the Gulf Coast Research and Education Center, Dover on a Sefner loamy sand (sandy siliceous, hyperthermic, quartzipsammentic Haplumbrepts) and at the Horticultural Unit, Gainesville, on a Pomona sand (sandy siliceous, hypothermic, Ultic Haploquods) during the 1994-95 season. All trials were on single beds with two rows of strawberry plants per bed. The beds were on 4-ft. center to center at Gainesville and Dover and on 5 ft. centers at Live Oak. At the Live Oak location, 1, 3 dichloropropene (1, 3-D) was applied broadcast at 9 (1993-94) and 17 gallons/acre (1994-95). After three weeks, the beds were pressed and fertilizer, herbicide treatments, mulch, and drip tubing were applied. 1, 3-D was applied at 30 gpa into raised, fertilized beds after herbicide application at Dover and Gainesville. Overhead irrigation was applied to all areas before 1, 3-D was injected. This brought the soil to appropriate moisture and incorporated the preemergence (PRE) herbicides at Gainesville and Dover. Black polyethylene mulch was used in all plots. Strawberries were fertigated throughout the season through drip tubing.

Herbicide treatments were applied with a CO_2 powered backpack sprayer at the rate of 30 gpa and a pressure of 30 psi. EPTC and trifluralin treatments were applied at 3.0 and 0.75 lb/acre and preplant incorporated (PPI) in 1993-94 at Live Oak. The following herbicides were applied preemergence (PRE) to the soil surface: simazine (1.0 lb/acre), oxyfluorfen (0.5 lb/acre), clopyralid (0.187 lb/acre), metolachlor (1.5 lb/acre), oryzalin (2.0 lb/acre), prodiamine (0.33 lb/acre), and napropamide (4.0 lb/acre). A untreated check was also included. Overhead irrigation was applied at 0.5 inch/acre and the mulch was laid on 28 Oct. 1993. 'Oso Grande' transplants were planted on 2 Nov. 1993. In 1994, the above herbicides were applied with the addition of oxyfluorfen at 0.25 lb/acre, pendimethalin at 0.75 lb/acre, terbacil at 0.2 and 0.3 lb/acre, and norflurazon at 0.5 and 1.0 lb/acre. Norflurazon was applied PPI while oxyfluorfen, pendimethalin, and terbacil was applied PRE. Applications were made on 19 Oct. 1994 at Live Oak, 18 Oct. 1994 at Gainesville, and 9 Nov. 1994 at Dover. 'Chandler' transplants were planted on 19 Oct. 1994 at Live Oak and 8 Nov. 1994 at Gainesville. 'Oso Grande' was transplanted at Dover on 30 Nov. 1994.

During the season, strawberry growth vigor was rated by a system where 0 equaled no vigor (death) and 100 was no loss of vigor. Weed control was also rated on a percent control where 0 equaled no control and 100 equaling complete control. Multiple harvests were made at all locations. Yield was converted to flats/acre. Data was analyzed by analysis of variance and mean separation was performed by Duncans Multiple Range Test.

Results and Discussion

Strawberry vigor was not affected by any herbicide during the 1993-94 season except oryzalin. Growth of the strawberry transplants was significantly reduced in the oryzalin treated plots throughout the season (Table 1). Strawberry vigor was reduced with the oryzalin treatment at both Gainesville and Live Oak during the 1994-95 season. Vigor was also reduced (during the 94-95 season) with the metolachlor treatment at Gainesville and Live Oak. Vigor of strawberries with the metolachlor and oryzalin treatments was the same as with the un-

Table 1. Strawberry vigor as affected by herbicides, 1993-94, and 1994-95 at Live Oak and 1994-1995 at Dover and Gainesville.

		Plant vigor ratings (%)[z]							
		Live Oak				Dover		Gainesville	
		1993-1994		1994-1995		1994-1995		1994-1995	
Herbicide	Rate lb/acre	9 March	12 April	7 Dec.	13 March	15 Dec.	2 Feb.	7 Dec.	13 March
Check	—	93 a	97 a	93 a	90 a	74 ab	81 ab	93 a	90 a
Simazine	1.0	97 a	93 a	87 ab	97 a	74 ab	84 ab	87 ab	97 a
Oxyfluorfen	0.5	97 a	97 a	90 ab	93 a	78 a	82 ab	90 ab	93 a
Oxyfluorfen	0.25	—	—	67 abc	90 a	72 ab	82 ab	67 abc	90 a
Clopyralid	0.187	90 a	87 a	90 ab	90 a	72 ab	65 c	90 ab	90 a
Metolachlor	1.5	97 a	90 a	60 bc	67 b	72 ab	74 bc	60 bc	67 b
Oryzalin	2.0	30 b	37 b	47 c	33 c	70 ab	75 abc	47 c	33 c
Prodiamine	0.33	97 a	90 a	83 ab	93 a	72 ab	74 bc	83 ab	93 a
Pendimethalin	0.75	—	—	73 abc	87 ab	69 b	76 abc	73 abc	87 ab
Napropamide	4.0	93 a	90 a	70 abc	83 ab	73 ab	89 ab	70 abc	83 ab
Trifluralin	0.75	90 a	83 a	80 ab	87 ab	74 ab	85 ab	80 ab	87 ab
EPTC	3.0	97 a	93 a	83 ab	83 ab	76 ab	88 ab	83 ab	83 ab
Terbacil	0.2	—	—	77 abc	87 ab	75 ab	88 ab	77 abc	87 ab
Terbacil	0.3	—	—	87 ab	90 a	76 ab	90 a	87 ab	90 a
Norflurazon	0.5	—	—	80 ab	83 ab	78 a	90 a	80 ab	83 ab
Norflurazon	1.0	—	—	73 abc	80 ab	72 ab	82 ab	73 abc	80 ab

[z]Ratings of 100 = no loss of vigor, and 0 = no vigor or (death).
[y]Means separation by Duncan's Multiple Range Test (P = 0.05).

Table 2. Weed control as affected by herbicide application and rate, Live Oak, FL 1993-1994 and 1994-1995.

		Control (%)								
	Rate	GERCA[z]		OEOLA		APULE		GERCA	OEOLA	*CORMI*
Herbicide	(lb/acre)	9 March[x]	12 April	9 March	12 April	9 March	12 April	13 March	13 March	13 March
		1994						1995		
Check	—	0 b[y]	0 c	0 c	3 c	0 c	3 d	0 d	0 c	0 c
Simazine	1.0	93 a	93 a	97 a	97 a	90 ab	87 ab	97 ab	100 a	90 a
Oxyfluorfen	0.5	100 a	100 a	100 a	100 a	90 ab	90 ab	100 a	100 a	100 a
Oxyfluorfen	0.25	—	—	—	—	—	—	100 a	100 a	100 a
Clopyralid	0.187	100 a	57 ab	67 b	73 ab	70 b	13 cd	70 abc	50 b	73 ab
Metolachlor	1.5	97 a	97 a	97 a	87 a	77 ab	47 c	97 ab	63 ab	100 a
Oryzalin	2.0	73 a	60 ab	100 a	87 a	83 ab	77 ab	67 abc	93 ab	60 ab
Prodiamine	0.33	90 a	87 a	97 a	97 a	87 ab	83 ab	100 a	77 ab	100 a
Pendimethalin	0.75	—	—	—	—	—	—	97 ab	80 ab	43 b
Napropamide	4.0	100 a	83 ab	90 ab	83 a	100 a	100 a	64 bc	93 ab	87 a
Trifluralin	0.75	77 a	77 ab	77 ab	70 ab	70 b	77 ab	63 bc	87 ab	83 ab
EPTC	3.0	100 a	100 a	100 a	87 a	70 b	54 bc	47 c	83 ab	100 a
Terbacil	0.2	—	—	—	—	—	—	53 c	73 ab	97 a
Terbacil	0.3	—	—	—	—	—	—	80 abc	90 ab	100 a
Norflurazon	0.5	—	—	—	—	—	—	73 abc	93 ab	63 ab
Norflurazon	1.0	—	—	—	—	—	—	53 c	73 ab	90 a

[z](GERCA) Carolina geranium, (OEOLA) cutleaf eveningprimrose, (APULE) wild celery, (CORMI) slender fumeroot.
[y]Mean separation by Duncan's Multiple Range Test (P = 0.05).
[x]Rating date.

Table 3. Total yield as affected by herbicide application and rate, Live Oak, Dover, and Gainesville.

		Yield (Flats/acre)			
	Rate	Live Oak		Dover	Gainesville
Herbicide	lb/acre	1993-1994	1994-1995	1994-1995	1994-1995
Check	—	1071 ab[z]	1257 a	1923 ab	781 ab
Simazine	1.0	904 ab	1453 a	2157 ab	947 ab
Oxyfluorfen	0.5	1186 a	1349 a	2135 ab	792 ab
Oxyfluorfen	0.25	—	1312 a	2204 ab	949 ab
Clopyralid	0.187	728 bc	1490 a	2124 ab	966 ab
Metolachlor	1.5	769 bc	1068 a	2196 ab	992 ab
Oryzalin	2.0	443 c	623 b	2083 ab	705 b
Prodiamine	0.33	1151 a	1334 a	2102 ab	882 ab
Pendimethalin	0.75	—	1345 a	1882 b	760 ab
Napropamide	4.0	1029 ab	1254 a	2295 ab	1109 a
Trifluralin	0.75	830 ab	1244 a	2192 ab	837 ab
EPTC	3.0	790 b	1212 a	2292 ab	788 ab
Terbacil	0.2	—	1254 a	2210 ab	854 ab
Terbacil	0.3	—	1365 a	2309 ab	985 ab
Norflurazon	0.5	—	1179 a	2376 a	745 ab
Norflurazon	1.0	—	1134 a	2342 ab	785 ab

[z]Mean separation by Duncan's Multiple Range Test (P = 0.05)

treated check at the Dover location, but strawberry vigor with the clopyralid treatment was significantly less than with the check late in the season. Also, at the Dover location, the vigor of strawberry transplants was reduced early in the season, but not significantly, with the pendimethalin treatment.

The two major weeds that emerged at all three locations were Carolina geranium, *(Geranium carolinianum* L., # GERCA (@ approved 5 letter code by Weed Science Society of America, 1984, Weed Science 32, Suppl. 2) and cutleaf eveningprimrose, *(Oenotheria laciniata* Hill # OEOLA.)

There were no significant differences in control of Carolina geranium due to herbicide treatment at Gainesville and Dover. This was possibly due to extremely light infestations at Dover and uneven distribution of the weed at Gainesville. There was also no significant differences in the control of cutleaf eveningprimrose at the Dover locations. Control of cutleaf eveningprimrose at Gainesville was 100% in the oxyflurofen, metolachlor, EPTC, and terbacil treatments. Control of the weed by pendimethalin was significantly lower than the above treatments at 80% control but was not significantly different than the remaining treatments (data not shown).

Weed pressure was much higher at the Live Oak location (Table 2). Wild celery *(Apium leptophyllum* (Pers.) F. Muell. ex Benth. #APULE) was prevalent during the 1993-94 season and slender fumeroot [*Corydalis micrantha* (Engelm.) Gray ssp. *australis* (Chapman) Quinby #CORMI] was heavy in 1994-95 along with Carolina geranium and cutleaf eveningprimrose.

Simazine, both oxyfluorfen rates, and the high terbacil rate provided excellent season-long control of each of these weeds. Control of Carolina geranium late in the 1994-95 season was significantly lower with the napropamide, trifluralin, terbacil (0.2 lb) and norflurazon (0.5 lb) treatments than with the oxyflurofen treatments. Only the clopyralid treatment gave significantly lower cutleaf eveningprimrose control than the oxyfluorfen and simazine treatments. Clopyralid, metolachlor, and EPTC provided unsatisfactory control of wild celery. Control of slender fumeroot late in the season was weak with the oryzalin and norflurazon treatments and unsatisfactory with the pendimethalin treatment.

Strawberries were harvested when ripe throughout the season in each of the four trials. Beginning and ending harvest dates were different in each of the trials due to weather and other factors. Total yield in flats per acre are listed in Table 3. Yield from strawberries treated with oryzalin were the lowest at Live Oak and Gainesville. This closely follows the vigor ratings for this treatment at the two locations. In 1993-94 yields with the clopyralid, metolachlor, and EPTC treatments were significantly lower than yields with the oxyfluorfen and prodiamine treatments.

In 1994-95, only the oryzalin treated plots produced fewer berries than the other treatments. Yields with the pendimethalin treatment were the lowest at Dover. These yields were only significantly lower than the norflurazon (0.5 lb/acre) plots which produced the highest yields at this location. Other than the above-mentioned treatments, total yields were not significantly different due to herbicide application and rate at each of the three locations.

Strawberries were tolerant to being transplanted into soil treated with the majority of herbicides tested. With the probable future loss of the use of methyl bromide in strawberry production, work in establishing tolerances and labels for several of the herbicides tested should proceed.

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USE OF ENDOSULFAN ON VEGETABLE CROPS IN DADE AND COLLIER COUNTIES FROM 1989-90 TO 1994-95

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Abstract. **The insecticide endosulfan is registered for the control of a range of insect pests on vegetables grown in Dade and Collier Counties, including beans, cucumbers, summer squash, eggplant, peppers, southern peas, sweet corn, and tomatoes. Growers have experienced problems with several pest insects, especially the silverleaf whitefly (*Bemisia argentifolia*), which can serve as a vector for geminiviruses on both tomatoes and beans. A number of climatic events, such as Hurricane Andrew and a flood in Dade County and a major freeze and other climatic factors in both counties have influenced cropping patterns and plant pest problems. This paper will examine the recorded sales patterns for endosulfan in Dade and Collier Counties over a five year period, and will discuss concurrent insect and insect-vectored disease problems.**

Controlling insect pests is one of several management decisions facing vegetable producers in southern Florida. During the past ten years, and more especially the years from 1989-90 through 1994-95, new insect or insect-related problems have required changes in pest management strategies. These, in combination with climatic events, have influenced both planted acreage for the major vegetable crops grown in Collier and Dade Counties and strategies used to manage insect pests on these vegetables.

The Florida Agricultural Statistics Service (1995) reported that the major vegetable crops grown in Collier County were sweet corn, cucumbers, eggplant, peppers, potatoes, squash, tomatoes and watermelon. In Dade County the major vegetable crops were bush and pole beans, cabbage, sweet