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Weed Control in Newly Planted Strawberries in Morocco[1]

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Abstract

Four herbicides and their combinations were used to control weeds in newly planted 'Tioga' strawberries. Treatments include: terbacil (5-chloro-3-(1,1-dimethylethyl)-6-methyl-2,4(1*H*,3*H*)-pyrimidinedione) at 0.24, 0.48 and 0.72 kg/ha; three rates of terbacil plus chloroxuron (*N*'[4-(4-chlorophenoxy)phenyl]-*N*,*N*-dimethylurea) at 3.92 kg/ha; phenmedipham (3-[(methoxycarbonyl)amino]phenyl(3-methylphenyl)carbamate) at 1.47 kg/ha and sethoxydim (2-[1-(ethoxyimino)butyl]-5-[2-(ethylthio) propyl]-3-hydroxy-2-cyclohexen-1-one), 0.48 kg/ha, alone and in combination with phenmedipham. Terbacil gave excellent weed control, whereas chloroxuron controlled only broadleaf weeds. The highest rate of terbacil, alone or in combination with chloroxuron, reduced strawberry yield, fruit size, and quality. Sethoxydim gave excellent control of grasses but did not control broadleaf weeds and decreased the titratable acidity and ascorbic acid content of the harvested fruit.

Introduction

Variable results have been obtained from using herbicides in strawberries. Hertz (6) found that the combination of chloroxuron and terbacil gave commercial control of broadleaf and grass weeds, and terbacil alone gave excellent control of grasses. Ricketson (11) reported that terbacil at 0.48 and 0.72 kg/ha did not control established grass. Phenmedipham controlled sherperdspurse (*Capsella bursapastoris*) but failed to control redroot pigweed (*Amaranthus retroflexus*), while the opposite was observed with chloroxuron (2, 3, 4). Jensen (9) obtained excellent control of grasses with sethoxydim. No injury to strawberry plants with chloroxuron at 3.9 and 5.9 kg/ha alone or in combination with diphenamid was reported by Hertz (7, 8). 'Fresno' and 'Shasta' strawberries are tolerant to chloroxuron (15) while Ahrens (1) and Weller (16) showed that terbacil was phytotoxic to strawberry plants at rates greater than 0.56 kg/ha. Jensen (9), Masiunas (10), and Freeman (5) reported similar results with terbacil at 0.48 kg/ha. Skroch and Monaco (13) recommend using terbacil 6 months after planting. Freeman (5) reported that two applications of sethoxydim (0.48 kg/ha) injured strawberry plants, while one application did not, and that the combination of sethoxydim and chloroxuron at rates of 0.36 and 4.9 kg/ha were phytotoxic. Chloroxuron (1.96 and 3.92 kg/ha) did not affect runner formation, but reduced root growth of dauther plants; however, terbacil, at 0.48 and 0.96 kg/ha decreased runner formation (12, 14). This effect was not observed however, when the herbicide was combined with chloroxuron (15). A reduction in yield was reported by Ricketson (11) using terbacil at 0.56 and 1.12 kg/ha, 6 weeks after planting.

The objective of this study was to evaluate weed control and the effect of several herbicides and selected combinations on runner and daughter plant production, fruit yield and size,

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and fruit quality of newly planted 'Tioga' strawberries.

Materials and Methods

The experimental design was a randomized complete block with 4 replications. Plots consisted of 3 rows, spaced 1.2 m apart with 13 plants spaced 0.45 m within the row. Data was collected from the middle row of each plot. Four herbicides, terbacil, chloroxuron, phenmedipham, and sethoxydim were used alone and in selected combinations (Table 1). Each herbicide was mixed with the surfactant, Atplus 411F, at the rate of 1.16L/ha and applied with a compressed air sprayer in 190 L/ha at 206 kPa. 'Tioga' strawberry was planted November 5, 1981, and data collected April, 1982. The study included weedy and weed-free checks, the latter being maintained weedfree by hand hoeing. The post-emergence treatments were applied when the broadleaf weeds had 2 to 4 true leaves and were 6 to 8 cm tall. The grasses averaged 7 cm. The predominant weed species were corn spurry, *Spergula arvensis* L.; common lambsquarters, *Chenopodium album* L.; nettleleaf goosefoot, *Chenopodium murale* L.; redroot pigweed, *Amaranthus retroflexus* L.; prostrate pigweed, *Amaranthus blitoides S. Wats.*; animated oat, *Avena sterilis* L.; and Bermuda grass, *Cynodon dactylon* L. Weed control was evaluated as a percentage of plot covered by grass and broadleaf weeds. Plant injury was based on either chlorosis or necrosis of the strawberry leaves, and visually estimated on a scale of 0 to 5; 0 = no injury and 5 = dead plants. Average berry size was determined from a 20 fruit sample at each harvest. Large fruits were > 7g, medium from 4 to 7g and small < 4g.

Table 1. Herbicides and their rate of application.

Herbicides	Rate (kg/ha)	Time of application[z]
Terbacil	0.24	PRE
Terbacil	0.48	PRE
Terbacil	0.72	PRE
Chloroxuron	3.92	PO
Terbacil + chloroxuron	0.24 + 3.92	PO
Terbacil + chloroxuron	0.48 + 3.92	PO
Terbacil + chloroxuron	0.72 + 3.92	PO
Phenmedipham	1.47	PO
Sethoxydim	0.48	PO
Phenmedipham + sethoxydim	1.47 + 0.48	PO

[z]Application: PRE = preemergence, PO = postemergence.

Titratable acidity was determined by using 150 gram sample of fruit which was then blended and filtered. Twenty five ml of the filtrate was collected and neutralized with NaOH (0.1M). Total sugars and soluble solids were measured from a 20 fruit sample, using the Abbe refractometer. Ascorbic acid was determined using a 300 g sample of fresh fruit, blended, then added to 800 ml of distilled water, boiled for one hour, cooled, and diluted to volume and filtered. The method is described in "Official Methods of Analysis," A.O.A.C., 10th edition.

Results

Weed Control. Excellent grass control was obtained with sethoxydim alone or in combination with phenmedipham (Table 2). The combination of terbacil and chloroxuron (0.72 + 3.92 kg/ha) gave 84% weed control, when compared to the non-weeded check.

Broadleaf weed control was more effective at the two higher rates of terbacil (Table 2). Terbacil plus chloroxuron (0.72 + 3.92 kg/ha) was the most effective herbicide treatment, the tank mix giving better control than either herbicide alone. Phenmedipham failed to control broadleaved weeds after 60 days, due to its short soil persistence. Corn spurry (*Spergula arvensis*) was resistant to all herbicides except the highest rates of terbacil and chloroxuron. Redroot pigweed appeared in all plots, however, plots treated with chloroxuron, alone or in combination with terbacil, had a lower incidence.

Table 2. The percent grass and broadleaf weed cover two months after herbicide application.

Treatment	Rate (kg/ha)	Weed cover (%)	
		Grass	Broadleaf
Terbacil	0.24	9 b-d[z]	35 e[z]
Terbacil	0.48	7 a-d	18 c-d
Terbacil	0.72	9 b-d	19 c-d
Chloroxuron	3.92	13 d	32 e
Terbacil + chloroxuron	0.24 + 3.92	5 a-c	15 bc
Terbacil + chloroxuron	0.48 + 3.92	6 a-c	21 c-e
Terbacil + chloroxuron	0.72 + 3.92	2 a	4 ab
Phenmedipham	1.47	9 b-d	78 f
Sethoxydim	0.48	0 a	77 f
Phenmedipham + sethoxydim	1.47 + 0.48	1 a	84 f
Hand weeded	———	0 a	0 a
Untreated	———	12 cd	88 f

[z]Means separated within each column by Student-Newman-Keuls test, 5% level. Means within the same column followed by the same letter are not significantly different.

Plant Injury. Terbacil injury is expressed as chlorosis of the leaves between veins. Chloroxuron showed burned and brown leaf tissue from the edge of the leaf and toward the center and bottom, as severity increased. Black colored tissue between leaf veins was the injury symptom of phenmedipham.

All herbicides except sethoxydim injured the strawberry plants within five days after application (Table 3). The greatest injury (necrotic leaves), resulted with terbacil (0.48 and 0.72 kg/ha) alone or when tank mixed with chloroxuron. The least injury was observed with sethoxydim and phenmedipahm. Thirty days after herbicide application, those plants which had received phenmedipham and sethoxydim had recovered normal plant growth.

Runner Production. Terbacil at the rate of 0.72 kg/ha, alone or in combination with chloroxuron, reduced the number of runners per plant by 43 and 38%, when compared to the hand weeded check. Daughter plant pro-

Table 3. Effect of herbicides on the number of runners and daughter plants and injury to strawberry plants.

Treatment	Rate (kg/ha)	Runners/ plant (no.)	Daughter plants/runner (no.)	Plant injury[y]	
				5 days after treatment	30 days after treatment
Terbacil	0.24	7.0 bc[z]	1.0 ab	2.8 ab	1.9 c
Terbacil	0.48	6.7 bc	0.7 bc	3.2 ac	2.8 d
Terbacil	0.72	4.3 a	0 a	3.7 cd	2.8 d
Chloroxuron	3.92	5.6 ab	1.8 cd	2.9 ab	1.8 c
Terbacil + chloroxuron	0.24 + 3.92	5.5 ab	0.8 ab	3.3 bc	1.7 c
Terbacil + chloroxuron	0.48 + 3.92	6.4 bc	0.8 ab	3.6 b-d	2.6 d
Terbacil + chloroxuron	0.72 + 3.92	4.7 a	0.6 ab	3.9 d	3.3 d
Phenmedipham	1.47	8.4 c	1.4 c	1.3 a	0.2 a
Sethoxydim	0.48	7.2 bc	1.1 ab	0 a	0 a
Phenmedipham + sethoxydim	1.47 + 0.48	5.6 ab	1.4 c	2.4 a	0.5 b
Hand weeded	———	7.5 bc	1.3 c	0 a	0 a
Untreated	———	4.7 a	0.9 ab	0 a	0 a

[z]Means separated within each column by Student-Newman-Keuls test, 5% level. Means within the same column followed by the same letter are not significantly different.
[y]Plant injury scale: 0 = no injury and 5 = plants dead.

Table 4. Effect of herbicides on strawberry fruit size and yield.

Treatment	Rate (kg/ha)	Yield (g/plant)	Fruit size (%)[y]		
			large	medium	small
Terbacil	0.24	184 cd[z]	26 de	52 bc	22 a
Terbacil	0.48	179 cd	23 cd	51 ab	26 bc
Terbacil	0.72 cd	174 cd	17 a	55 d-f	28 cd
Chloroxuron	3.92 ab	197 cd	18 ab	53 bc	29 d
Terbacil + chloroxuron	0.24 + 3.92	232 d	21 bc	53 bc	26 bc
Terbacil + chloroxuron	0.48 + 3.92	204 cd	17 a	59 f	24 ab
Terbacil + chloroxuron	0.72 + 3.92	161 bc	15 a	56 ef	28 cd
Phenmedipham	1.47	217 d	25 de	51 ab	24 ab
Sethoxydim	0.48	83 a	27 e	56 ef	17 a
Phenmedipham + sethoxydim	1.47 + 0.48	160 bc	25 de	54 cd	21 a
Hand weeded	———	237 d	24 c-e	53 bc	23 ab
Untreated	———	96 ab	18 ab	49 a	33 d

[z]Means separated within each column by Student-Newman-Keuls test, 5% level. Means within the same column followed by the same letter are not significantly different.
[y]Fruit size separation was large > 7g, medium from 4 to 7g, and small < 4g.

duction was inhibited in all combinations of the terbacil plus chloroxuron (Table 3).

Yield and Fruit Size. Highest fruit yields occurred from the combination of terbacil and chloroxuron (0.24 and 3.92 kg/ha). The reduction in yield in the sethoxydim treatment was due to the presence of broadleaf weeds. The high percentage of large fruits reflected low fruit set and reduced competition between fruits (Table 4). The combination of terbacil and chloroxuron (0.72 and 3.92 kg/ha) significantly reduced yield of fruit, when compared to the weed free check. The low yield at the highest rate of terbacil plus chloroxuron was partly due to a reduced number of flower stalks and a low number of flowers. Even though they did not significantly reduce total fruit yield, terbacil (0.72 kg/ha) and chloroxuron plus terbacil (0.72 + 3.92 kg/ha) affected fruit size by reducing the number of large fruits and increasing the number of medium and small fruits. The tank mixture of phenmedipham plus sethoxydim also reduced fruit yield.

Fruit Quality: Sethoxydim reduced several components of fruit quality (Table 5). Although it had no affect

Table 5. Effect of herbicides on strawberry fruit quality.

Treatment	Rate (kg/ha)	Total sugars (%)	Titratable acidity (ml)[z]	Soluble solids (%)	Ascorbic acid (mg)[y]
Terbacil	0.24	8.4	6.8	5.3	32.9 de[x]
Terbacil	0.48	8.5	6.5	4.3	27.7 a-c
Terbacil	0.72	8.9	5.9	4.3	26.5 a
Chloroxuron	3.92	8.3	6.8	4.1	32.6 de
Terbacil + chloroxuron	0.24 + 3.92	9.7	7.1	6.4	32.7 de
Terbacil + chloroxuron	0.48 + 3.92	8.2	7.1	5.9	33.5 de
Terbacil + chloroxuron	0.72 + 3.92	8.0	7.0	5.0	31.5 c-e
Phenmedipham	1.47	7.6	6.7	5.3	31.0 b-e
Sethoxydim	0.48	5.7	6.1	4.6	26.9 ab
Phenmedipham + sethoxydim	1.47 + 0.48	8.3	6.4	5.1	30.5 b-d
Hand weeded	———	9.4	7.3	5.8	35.1 e
Untreated	———	5.9	6.9	4.2	31.8 c-e

[z]Titratable acidity was ml of NaOH (.1M) to neutralize 25 ml of juice filtrate.
[y]Soluble solids equal mg/100 g of fresh fruit.
[x]Means separated within each column by Student-Newman-Keuls test, 5% level. Means within the same column followed by the same letter are not significantly different.

on total sugars when tank-mixed with phenmedipham, ascorbic acid content of the fruit was reduced by 14% when compared to the weeded check. As separate treatments, chloroxuron and terbacil reduced soluble solids, while the combination had no effect.

Discussion

Terbacil was the most effective herbicide; however, weed control was significantly improved when tank-mixed with chloroxuron. The highest rates of terbacil severely injured the strawberry plants and resulted in a reduction in yield and fruit size. Phenmedipham would be more effective if applied 2 times during the season, since its persistance in soil is very short. Although sethoxydim controlled grass weeds for two months following application, it had no effect on broadleaf weeds and it reduced ascorbic acid and total sugar content of the fruit.

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Paradoxes Surrounding Our Understanding of Plum Leaf Scald

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Abstract

Xylella fastidiosa Wells et al., a xylem limited bacterium (XLB) and the causal agent of plum leaf scald, has also been shown to be the causal agent of Pierce's disease in grape, phony peach, and almond leaf scorch and has produced blight symptoms in citrus. Scientific and circumstantial evidence are presented for and against all 5 crop diseases being caused by the same XLB. This XLB has been transmitted among the 5 crops, but not in all combinations. The XLB has a wide host range, is transmitted by similar leafhoppers, is characterized by occlusions in the xylem with plant symptoms appearing most severely following stress (heavy crops), and results in decreased productivity and general

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