Effect of Herbicide Application Method on Weed Management and Crop Injury in Transplanted Cantaloupe Production[1]

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Abstract: Field trials were conducted at the Coastal Plain Experiment Station in Tifton, GA, from 2000 to 2003 to study the effects of herbicide placement on weed control and cantaloupe injury. Herbicides halosulfuron (0.036 kg ai/ha), sulfentrazone (0.14 and 0.28 kg ai/ha), clomazone (0.6 kg ai/ha), and a nontreated control were evaluated. Methods of herbicide application were preplant incorporated (PPI) under the polyethylene mulch before transplanting, posttransplanting over-the-top (POST-OTT), and posttransplanting-directed (POST-DIR) to the shoulders of polyethylene-covered seedbeds. Across all herbicide treatments, PPI and POST-DIR applications were the least injurious, with POST-OTT applications the most injurious. In general, sulfentrazone (0.28 kg ai/ha) was the most injurious herbicide and halosulfuron the least injurious, regardless of herbicide placement. Halosulfuron effectively controlled yellow nutsedge and provided versatility in methods of application, with minimal injury to transplanted cantaloupe.

Nomenclature: Clomazone; halosulfuron; sulfentrazone; yellow nutsedge, *Cyperus esculentus* L. #[3] CYPES; cantaloupe, *Cucumis melo* L.

Additional index words: Clomazone, halosulfuron, plasticulture, sulfentrazone.

Abbreviations: POST-DIR, posttransplanting-directed; POST-OTT, posttransplanting over-the-top; PPI, preplant incorporated.

INTRODUCTION

Cucurbit crops are grown on approximately 21,800 ha in Georgia, with cantaloupe grown on 2,400 ha (Abbe and Messer 2002). Approximately 57% of cantaloupe production in Georgia is a system of hybrid cultivars seeded in greenhouses and transplanted on polyethylene-covered seedbeds (Doherty and Mizelle 2001). Hybrid seeds are costly, and transplanting reduces the risk of stand loss associated with direct seedings. Polyethylene-covered seedbeds warm the soil (Bonanno and Lamont 1987), allowing for earlier planting and harvest during periods of premium commodity prices.

Polyethylene-covered seedbeds are generally fumigated with a broad-spectrum fumigant, such as methyl bromide (bromomethane), metham (methylcarbamodithioic acid), chloropicrin (trichloronitromethane), or 1,3-D (1,3-dichloropropene). Of these, methyl bromide and metham have been the primary means to control perennial nutsedges (*Cyperus* spp.) under the polyethylene-covered seedbeds. Methyl bromide is thought to contribute to the depletion of stratospheric ozone (Anonymous 1998), which caused the U.S. Environmental Protection Agency to initiate a mandatory phase out of all methyl bromide–containing fumigants by 2005 (Noling and Becker 1994; USDA 1999). This pending regulatory action has stimulated interest in the development of alternative means to control perennial nutsedges in vegetable crops.

Halosulfuron has recently been registered for weed control on several cucurbit crops. Halosulfuron controls yellow nutsedge and purple nutsedge (*Cyperus rotundus* L.), along with several dicot weeds when applied preemergence or postemergence (Anonymous 2004a; Johnson and Mullinix 2002; Webster et al. 2003). Cucumber (*Cucumis sativus* L.) and cantaloupe are considered to be the most tolerant cucurbit crops to direct applications of halosulfuron, whereas squash (*Cucurbita pepo* L.) and watermelon [*Citrullus lanatus* (Thunb.) Mansf.] are the least tolerant cucurbit crops (Webster et al. 2003). Halosulfuron is registered for directed applications to row middles of squash and watermelon to prevent crop injury (Anonymous 2004a).

Clomazone is marketed as a prepackaged mixture with ethalfluralin to control annual weeds, and this commer-

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[3] Letters following this symbol are a WSSA-approved computer code from *Composite List of Weeds*, Revised 1989. Available only on a computer disk from WSSA, 810 East 10th Street, Lawrence, KS 66044-8897.

cial product is the only registered means by which ethalfluralin can be used on cucurbit crops, including cantaloupe. Sulfentrazone is registered for use on tobacco (*Nicotiana tabacum* L.) and soybean [*Glycine max* (L.) Merr.], providing excellent preemergence control of perennial nutsedges and many dicot weeds. However, efficacy and crop tolerance to sulfentrazone is dependent on soil type and pH. Peanut (*Arachis hypogaea* L.) was found to be very tolerant to sulfentrazone on sandy loam soils in Georgia and Florida (Grey et al. 2000a) but was severely injured by sulfentrazone on loamy sand soils in separate trials (Johnson and Mullinix 1994). Despite the dependence of sulfentrazone activity on soil factors, some cucurbit crops may be tolerant to sulfentrazone (Wells 1999).

Information on the use of these herbicides is needed in transplanted cantaloupe and other cucurbit crops grown on coarse-textured soils. Therefore, trials were conducted from 2000 through 2003 to evaluate application methods and new herbicides for weed control and transplanted cantaloupe tolerance.

MATERIALS AND METHODS

Irrigated field trials were conducted at the Coastal Plain Experiment Station Ponder Farm near Tifton, GA, from 2000 to 2003. The soil was a Tifton loamy sand (fine-loamy, kaolinitic, thermic Plinthic Kandiudults), composed of the following fractions—88% sand, 6% silt, and 6% clay, with 0.6% organic matter and pH 6.2.

The experimental design was a split plot with four replications. Main plots were herbicide application methods: preplant incorporated (PPI) under black polyethylene mulch, posttransplanting over-the-top (POST-OTT) of polyethylene mulch and transplants, and posttransplanting-directed (POST-DIR) to the shoulders of polyethylene mulch and interrow areas. Subplots were herbicides: halosulfuron (0.036 kg ai/ha), sulfentrazone (0.14 and 0.28 kg ai/ha), clomazone (0.6 kg ai/ha), and a nontreated control.

Plots were 1.8 m wide and 6.1 m long, with cantaloupe transplanted in one row centered in the middle of the plot. Three weeks before transplanting, 'Vienna'[4] cantaloupe were seeded in greenhouse trays,[5] each tray containing 128 cells and each cell being 3.8 by 3.8 cm in dimension. Seedlings were established in the field using a transplanter[6] that cut holes in the polyethylene mulch and transplanted in one operation. Cantaloupe seedlings were spaced 56 cm apart. Plots were irrigated with a solid set sprinkler system, as needed, based on crop and meteorological conditions. Ethalfluralin (0.6 kg ai/ha) was applied for the maintenance of weed control after transplanting in the row middles to the entire experiment using a hooded sprayer that treated a band 71 cm wide. In addition, sethoxydim (0.11 kg ai/ha) was applied broadcast 21 d after planting to control escaped annual grasses. Neither ethalfluralin nor sethoxydim affected the weeds of interest in this study, perennial nutsedges and large-seeded dicot weeds. Excluding weed control, cultural practices and pest management decisions for transplanted cantaloupe were based on recommendations from the Georgia Cooperative Extension Service (Boyhan et al. 1999).

All herbicide treatments were applied on the same day. PPI treatments were applied with a PTO-powered tiller (1.8 m wide) that sprayed herbicides the entire width of the plot at 234 L/ha and simultaneously incorporated to a depth of 7.6 cm. Black polyethylene mulch (1 mil thick and 61 cm wide) was spread in a separate operation using a mulch layer.[7] POST-OTT treatments were applied with a tractor-mounted plot sprayer pressurized with CO_2, calibrated to deliver 234 L/ha using fan spray tips,[8] treating a swath 1.8 m wide. POST-DIR treatments were applied with the same tractor-mounted plot sprayer reconfigured with off-center nozzle tips[9], directing spray to the edges of the polyethylene-covered seedbed and into the row middles. All plots were sprinkler irrigated (1.3 cm) immediately after the last herbicide application.

Visual estimates of weed control and crop injury were taken by species midseason each year on a scale of 0 to 100 (compared with the nontreated control, where 0 = no weed control or crop injury and 100 = complete weed control or crop injury). Visual estimates of weed control for each species were a composite of weeds emerging through the polyethylene mulch and weeds emerging in the row middle. Yields were measured by harvesting mature fruits from the entire plot at multiple intervals, depending on the continued presence of marketable fruits. The number and weight of cantaloupe fruits were recorded by harvest date. Yields were not measured in 2002 because of severe late-season infestation of southern root knot nematode [*Meloidogyne in-*

[4] Seminis Inc., 2700 Camino del Sol, Oxnard, CA 93030-7967.
[5] Speedling® Incorporated, P.O. Box 7220, Sun City, FL 33586-7220.
[6] Kennco Manufacturing Inc., P.O. Box 1149, Ruskin, FL 33575.
[7] Pro-Junior Series mulch layer, Buckeye Tractor Company, P.O. Box 123, Columbus Grove, OH 45830.
[8] Turbo TeeJet® TT11003VP spray tips, Spraying Systems Co., P.O. Box 7900, Wheaton, IL 60189-7900.
[9] TeeJet® OC-03 spray tips, Spraying Systems Co., P.O. Box 7900, Wheaton, IL 60189-7900.

Table 1. Weed control with herbicides in transplanted cantaloupe averaged across all application methods at Tifton, GA, 2000–2003.

Herbicide	Rate	Smallflower morningglory	Yellow nutsedge
	kg ai/ha	%	
Sulfentrazone	0.14	94	89
Sulfentrazone	0.28	94	91
Clomazone	0.6	77	67
Halosulfuron	0.036	86	88
Nontreated	—	0	0
LSD (0.10)		7	8

cognita (Kofoid & White) Chitwood] that caused termination of the trial before crop maturity.

Across all years, data were subjected to ANOVA to determine sources of variation and significant interactions. Differences in treatment means were determined using the Fisher's protected LSD test at $P \leq 0.10$.

RESULTS AND DISCUSSION

Data analysis showed nonsignificant year by treatment interactions for all parameters evaluated. Therefore, all data were pooled across years.

Weed Control. Yellow nutsedge was the predominant weed in all trials, with dense, uniform stands each year (10 to 30 plants/m^2). Methods of herbicide application had no effect on weed control throughout the term of the study (data not shown). Halosulfuron (88%) and both rates of sulfentrazone (89 and 91%) were equally effective in controlling yellow nutsedge (Table 1). These results are consistent with earlier studies with sulfentrazone on other crops (Grey et al. 2000a; Johnson and Mullinix 1994) and halosulfuron POST-DIR on watermelon and cantaloupe (Johnson and Mullinix 2002; Wells 1999). Clomazone (67%) was ineffective in controlling yellow nutsedge.

Sulfentrazone at 0.14 and 0.28 kg/ha provided the most effective control (94%) of smallflower morningglory [*Jacquemontia tamnifolia* (L.) Griseb. # IAQTA] of the treatments evaluated (Table 1). Smallflower morningglory control with halosulfuron was lesser than either rate of sulfentrazone, averaging 86%. Clomazone (77%) was the least effective herbicide in controlling smallflower morningglory.

Cantaloupe Injury. There was a significant interaction between methods of herbicide application and herbicide treatments for cantaloupe injury. Overall, halosulfuron was the least injurious herbicide evaluated in these trials, with no difference in halosulfuron injury among the methods of application (Table 2). Compared with the nontreated control, halosulfuron applied POST-OTT significantly injured transplanted cantaloupe. However, within the POST-OTT application method, halosulfuron was among the least injurious herbicides evaluated. There was no significant visual injury to cantaloupe when halosulfuron was applied PPI or POST-DIR.

Sulfentrazone at 0.28 kg/ha was the most injurious herbicide of those evaluated to transplanted cantaloupe, regardless of method of application (Table 2). The most injurious method for applying the high rate of sulfentrazone was POST-OTT, causing 63% visual injury on cantaloupe. In contrast, POST-DIR applications caused 28% visual injury. Sulfentrazone at 0.14 kg/ha caused 45%

Table 2. Interactive effects of application methods and herbicides on visual injury, total cantaloupe yield, and fruit size at Tifton, GA, 2000–2003.[a,b]

Application technique	Herbicide	Rate	Visual injury	Total yield	Fruit size
		kg ai/ha	%	no./ha	kg/fruit
Preplant incorporated	Sulfentrazone	0.14	11	12,180	4.1
	Sulfentrazone	0.28	45	8,440	3.8
	Clomazone	0.6	9	11,060	4.2
	Halosulfuron	0.036	6	13,450	4.0
	Nontreated	—	0	10,980	3.9
Posttransplant over-the-top	Sulfentrazone	0.14	45	8,290	3.7
	Sulfentrazone	0.28	63	4,780	2.9
	Clomazone	0.6	18	9,410	3.7
	Halosulfuron	0.036	13	10,830	4.1
	Nontreated	—	0	11,430	4.1
Posttransplant-directed	Sulfentrazone	0.14	6	15,390	3.9
	Sulfentrazone	0.28	28	10,240	3.9
	Clomazone	0.6	9	11,580	4.2
	Halosulfuron	0.036	6	13,820	4.2
	Nontreated	—	0	11,580	3.9
LSD (0.10)			13	4,590	NS

[a] Abbreviation: NS, not significant.

[b] Crop yields not measured in 2002 because of late-season root knot nematode injury.

Table 3. Effect of herbicides on cantaloupe yield at individual harvest dates, averaged across all application methods at Tifton, GA, 2000–2003.[a,b]

Herbicide	Rate	First harvest	Second harvest	Third harvest	Fourth harvest
	kg ai/ha	no./ha			
Sulfentrazone	0.14	4,780	5,030	1,910	1,310
Sulfentrazone	0.28	2,660	1,850	2,540	2,430
Clomazone	0.6	3,780	4,410	2,650	1,080
Halosulfuron	0.036	4,900	5,450	2,090	1,420
Nontreated	—	5,880	3,880	1,050	1,310
LSD (0.10)		3,250	2,700	NS	NS

[a] Abbreviation: NS, not significant.

[b] Crop yields not measured in 2002 because of late-season root knot nematode injury.

visual injury when applied POST-OTT. When the low rate of sulfentrazone was applied PPI or POST-DIR, there was no significant visual injury to cantaloupe. Given the effective control of yellow nutsedge with sulfentrazone at 0.14 kg/ha, these data suggest that applying the herbicide PPI or POST-DIR gives transplanted cantaloupe growers opportunity to control yellow nutsedge without undue risk of injury.

The degree of clomazone injury was similar to halosulfuron injury, including the comparative response to methods of application. There was no difference in cantaloupe injury from clomazone among the three methods of application. However, compared with the nontreated control, clomazone applied POST-OTT significantly injured transplanted cantaloupe, whereas PPI or POST-DIR applications did not. This is in general agreement with studies by Grey et al. (2000b), who found that clomazone applied PPI or preemergence to either transplanted or direct-seeded watermelon on a sandy loam soil was not overly injurious.

Cantaloupe Yield and Fruit Size. Cantaloupe yields, by harvest date, were affected by herbicides but not by methods of application (Table 3). Cantaloupe yields were reduced at the first and second harvest dates by the high rate of sulfentrazone, whereas the other herbicide treatments had no significant effect on yield. At the third and fourth harvest dates, there were no differences in cantaloupe yield among herbicides.

Total cantaloupe yield was significantly affected by the method of application–herbicide interaction; however, cantaloupe fruit size (kg/fruit) was not affected (Table 2). Plots treated with the high rate of sulfentrazone had the lowest total yield of any herbicide evaluated, regardless of the method of application. This is because of the consistently severe phytotoxicity caused by the high rate of sulfentrazone. Total yield from halosulfuron-treated cantaloupe plots did not differ among the three possible methods of application, indicating excellent versatility for halosulfuron in transplanted cantaloupe production. Total yield from cantaloupe treated with the low rate of sulfentrazone applied PPI or POST-DIR was among the highest of all treatment combinations.

Interestingly, total cantaloupe yield in nontreated plots did not differ from total yields in plots treated with the least injurious herbicides. The predominant weed at all sites was yellow nutsedge. Even with minimal crop injury from herbicides, controlling yellow nutsedge in transplanted cantaloupe did not improve yield in our trials. This suggests that in this production system, yellow nutsedge is not overly competitive with cantaloupe. In our trials, polyethylene mulch was spread on freshly tilled, weed-free seedbeds and cantaloupe seedlings were transplanted soon thereafter. We propose that these procedures combined with rapid early-season cantaloupe growth minimized yield reductions from yellow nutsedge interference.

These data clearly show the utility and versatility of halosulfuron in transplanted cantaloupe production. Halosulfuron at 0.036 kg/ha can adequately control yellow nutsedge in transplanted cantaloupe with minimal phytotoxicity when applied PPI or POST-DIR and to a lesser extent POST-OTT. In addition, halosulfuron effectively controls many dicot weeds, including common cocklebur (*Xanthium strumarium* L.), smallflower morningglory, pigweeds (*Amaranthus* spp.), and ragweed (*Ambrosia artemisiifolia* L.) (Anonymous 2004a). Sulfentrazone at 0.14 kg/ha applied PPI or POST-DIR effectively controlled yellow nutsedge and smallflower morningglory in transplanted cantaloupe. Sulfentrazone at this rate also controls many troublesome dicot weeds (Anonymous 2004b), which adds to its utility. These data suggest that the low-rate sulfentrazone evaluated in these trials has potential for use by cantaloupe growers. Further research is needed to refine its use on different crop cultivars and soil conditions. Although clomazone controls some annual weeds and is not overly phytotoxic, clomazone will not adequately control yellow nutsedge and smallflower morningglory at the rate evaluated in these trials (0.6 kg/ha).

Yellow nutsedge is widely considered to be among the most common and troublesome weeds of cucurbit vegetable crops. However, transplanted cantaloupe yields were not improved over the nontreated controls when yellow nutsedge was controlled with minimal injury using halosulfuron or the low rate of sulfentrazone. We propose that the production practices used in these trials gave the competitive advantage to transplanted cantaloupe over yellow nutsedge. An integrated management system for yellow nutsedge in transplanted cucurbit crops should include a foundation of production practices that maximize crop competition, with herbicides serving in a supportive role.

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