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EFFECT OF PREEMERGENCE HERBICIDES ON QUALITY AND YIELD OF TRANSPLANTED WATERMELON (*CITRULLUS LANATUS*)

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ABSTRACT: Field studies were conducted twice at two sites in St. Croix, United States Virgin Islands, to determine the effectiveness of preemergence applications of bensulide and halosulfuron in transplanted watermelon. Bensulide and halosulfuron were both applied separately. Although bensulide caused up to 5% seedling stunting and halosulfuron caused up to 10% seedling stunting and discoloration, watermelon plants were fully recovered by week 8 after planting. Yields of all treatments were similar to that of untreated plots. Control of grasses like goosegrass and of broadleaf weeds like amaranthus was not found in treated plots. Weed species, weed densities and the percentage of weed control found in bensulide and halosulfuron treated plots were similar to non-treated plots. Watermelon fruits in both treated and non-treated plots had a degree of brix of 8.5, which indicates poor quality fruits.

Nomenclature: Bensulide; goosegrass, *Eleusine indica* (L.) Gaertn. # ELEIN; halosulfuron; nutsedge, *Cyperus rotundus* (L.) Gaertn. # ELEIN; spiny amaranth, *Amaranthus spinosus* (L.) Gaertn. # ELEIN; watermelon, *Citrullus lanatus* L. 'Jubilee'

Keywords: Weed control, crop injury, quality, yield.

Abbreviations: ° Bx, degree of brix; PRE, preemergence; WAT, weeks after treatment.

Introduction

Vegetables are important commercial crops for producers within the United States Virgin Islands, and are grown mainly for the fresh vegetable market. One of the many difficulties involved in the successful production of vegetable crops is that of controlling weeds that invade vegetable cropland (Liu et al., 1987). The management of weeds in transplanted watermelon is difficult due to the potential damage by mechanical cultivation (Norton et al., 1990). The presence of weeds leads to a decrease in vegetable production, an increase in the costs of controlling weeds, and poses difficulty during harvest and reduces quality and yield (Brandenberger et al., 2005). Pigweed species (*Amaranthus* spp.) were found to be the most prevalent weeds for cucurbit crops in eight of the southeastern states of the United States (Webster, 2002). Monks and Schultheis (1998) found that the growth of crabgrass species (*Digitaria* spp.) with transplanted watermelon reduced the marketable fruit yield by approximately 1000 watermelons per ha and such decreases in yields caused a loss of $1000 to $1500 per ha. Goosegrass (*Eleusine indica* L.) is a competitive weed species in both the United States and other production areas in the world (Flower, 2001). The interference of goosegrass led to a reduction in the weight of sweet potato (*Ipomoea batatas*) transplants by 16% (Monks et al., 1996).

The interest in transplanted watermelon has increased in the United States Virgin Islands. Similar interest in growing watermelon from transplants has also increased in the state of North Carolina (Mitchem et al., 1997). Transplanting is the preferred choice over direct seeding due to more uniform plant spacing, earlier harvest and the more efficient use of seeds (Mitchem et al., 1997). The control of weed species by the use of pre-emergence herbicides has been established and documented (Culpepper et al., 2001). However, there has not been much documented work on the use of halosulfuron and bensulide in transplanted watermelon although both herbicides are registered for use as both PRE and POST in cucurbits (Mitchem, 1997; Vencil, 2002; Brandenberger et al., 2005). Bensulide can be incorporated into the soil before transplanting or it can be applied to the soil surface after transplanting and then watered in through irrigation. Bensulide primarily controls eleven weeds, which include grasses, and broadleaf weeds (Grey, 2000). Cucurbits like muskmelon (*Cucumis melo* L. *Reticulatus* group) and cucumber (*Cucumis savitus*) have shown tolerance to halosulfuron, which has shown both PRE and post- emergence activity on several weed species (Talbert et al., 1998; Buker and Stall, 2001). Other investigators have studied different herbicides in order to broaden the scope of herbicide management in melon crops (Umeda, 2002). Because Virgin Island growers are interested in expanding the use of bensulide and halosulfuron, testing is needed to determine the efficacy and safety of these herbicides in transplanted watermelon.

The purpose of this study was to determine the effectiveness of bensulide and halosulfuron applied alone as PRE herbicides in the quality and yield of transplanted watermelon in the United States Virgin Islands.

Materials and Methods

Study Site Information

Field studies were conducted at the Albert A. Sheen campus of the University of the Virgin Islands Agricultural Experimental Station in March 2012 and March 2013. Table 1 includes site information, the description of the soil, the organic matter, the dates of planting and the cultivar used for the study.

At each site, watermelon var. "Jubilee" (an oblong melon with dark stripes on a light background), was transplanted into plots of 36 m^2 with 3 rows with 2 m between plants and 3 m between rows on April 20, 2012 and December 12, 2012. Recommended insect pests, disease control and fertilizer practices were used throughout the study. Experimental fields were drip irrigated applied for 2 hours daily during excessively dry periods and for two hours every other day, based on the weather.

Experimental Procedure

The experimental design was a randomized complete block with treatments replicated four times. Treatments consisted of the active ingredients: bensulide at 0.03 kg ai ha $^{-1}$ and halosulfuron at 0.04 kg ai ha^{-1} applied PRE before transplanting. Herbicides were applied to both treated and untreated plots with a CO^{2}- pressurized backpack sprayer delivering 140 L ha^{-1} at 414 kPa.

Data Collection and Statistical Analysis

Crop tolerance ratings were based on a scale with 0 representing no visible crop injury and 100 representing crop death, a rating scale and index adapted from the works of Vanhala et al. (2004) (Table 2). Crop tolerance was determined 2 to 6 weeks after treatment (WAT). A weed count of species was conducted during week 2 and 4 using a 1 m x 1 m quadrat. Fruits were harvested on July 13, 2012 and March 8, 2013. Yield data included number and weight of individual marketable fruit for each plot as well as °brix (°Bx) of fruits from each plot; from these data, both marketable and average fruit weight was determined. A marketable fruit weighs at least 2.0 kg. Average °brix was also determined using an analog refractometer. The °brix is one of the basic criteria used for the definition of fruit juices and it indicates the percentage of water-soluble solids in fruit juice (Türkmen and Eksi, 2011). All data were subjected to an analysis of variance using the IBM® SPSS® Statistics version 21.

When the number of fruits and number of marketable fruits were significant at a value less than the 0.05 significance level, multiple comparisons for treatment were performed using Tukey's HSD at a 0.05 significance level. Pair wise *t* tests at a 0.05 significance level were used to look at the presence of weed species in treatments.

Results and Discussion

Weed Control

Quantitative assessments of weed species showed that the PRE herbicide treatments bensulide and halosulfuron did not give good control of grasses, sedge and broadleaf weeds. Crabgrass and Bermuda grass were present in treatments, as well as *Amaranthus* and *Euphorbia* (Table 3). There was a wide range of broadleaf weed species native to the Caribbean present at the two sites, 2 to 4 WAT. Furthermore, the numbers of weeds found in bensulide and halosulfuron treated plots were similar to that of the non-treated plots. Data from Brandenberger et al. (2005) suggests that halosulfuron has high levels of control on broadleaf weeds like *Amaranthus* and grasses like goosegrass, when applied PRE. More studies are needed for the use of these PRE herbicides in the Caribbean.

Crop Injury

Bensulide at 0.03 kL/ha and halosulfuron at 0.04 kg/ha caused injury to watermelon plants in the form of stunting and crop discoloration. Bensulide caused up to 5% injury in both locations causing stunting and slight discoloration compared to the non-treated weedy controls at 2 to 4 WAT (Table 4). Stunting was detected primarily in vines and foliage.

Injury from treatments with halosulfuron was not more excessive than the injury from treatments with bensulide. Stunting was also detected in halosulfuron treatments; however, there was no stunt loss. Injury from halosulfuron was also reported by Brandenberger et al. (2005) on watermelon and Fennimore et al. (1999) on cantaloupe (*Cucumis melo*). Injury had declined considerably in halosulfuron treatments. There was no late injury from halosulfuron treatment in crops as reported by Fennimore et al. (1999), even if they reported that there was a reduction in injury over time.

All of the plants had fully recovered by 8 WAT for both bensulide and halosulfuron. The injury sustained by watermelon plants as a result of bensulide and halosulfuron treatments did not affect the yield of watermelon.

Watermelon Yields

Watermelon yields were reduced due to severe blossom-end rot and the heavy infestation of pests and diseases. Furthermore, in field plot 13, watermelon plants contracted an unknown wilt disease during 4 to 8 WAT that caused wilting of vines already in fruit setting stage and also in plants with average sized fruits. Watermelon yield reductions were due to decreased fruit number (melons/plot) and fruit weight (kg/plot). The number of fruits produced by watermelon plants of bensulide, halosulfuron and non-treated were similar in terms of yield.

The °Bx of watermelon fruits was very similar in both locations as well as in the Bensulide, halosulfuron and non-treated plots (Table 5). Watermelon with an average of 8° Bx is poor in terms of sweetness. A sweet watermelon has a 16° Bx. Thus fruit produced in treated and untreated plots were not of high quality.

In summary, although bensulide and halosulfuron applied PRE caused obvious early stunting of watermelon seedlings, plants recovered by week 8 after planting, and there was no reduction of yield as a result of rates of application of the two herbicides. Although there was evidence of crop injury from bensulide and halosulfuron, further evidence in crop safety is necessary. Low levels of control of grasses, sedges and broadleaf weeds was evaluated from treatments that included PRE applications of bensulide and halosulfuron, but further study is required to verify that the use of bensulide and halosulfuron when applied as PRE cannot be used as methods of weed control. The quality of watermelon produced from treated plots was of poor quality, however there was not sufficient evidence to suggest that poor quality of watermelon is produced from PRE application to watermelon grown in bensulide and halosulfuron treated plots. Further study is needed to establish the quality of watermelon produced with the use of bensulide and halosulfuron as PRE. Since only one cultivar was used in this study, it is suggested that other cultivars should be used to determine the response and effect of bensulide and halosulfuron on quality and yield of transplanted watermelon.

Based on the results of this study, it is concluded that bensulide and halosulfuron used as PRE alone does not provide the much needed tool for the control of grasses, sedges and broadleaf weeds in transplanted watermelon production. Furthermore, it is suggested that studies of combinations of other PRE herbicides, and the use of POST applications should be explored instead of the lone use of PRE applications of bensulide and halosulfuron, in order to study the spectrum of control of grasses, sedges and broadleaf weeds and the quality and yield of transplanted watermelon.

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***Table 1*. Location information, including planting dates, soil organic matter, soil pH and soil description.**

Location*	Planting date	Cultivar	Soil organic matter	Soil pH	Soil description
Field plot 11	4/20/12	‘Jubilee’	2.2 %	8.1	Fredensborg clay loam (Typic calciustoll)
Field plot 13	12/12/12	‘Jubilee’	2.7%	8.1	Fredensborg clay loam (Typic calciustoll)

*Horticulture field, UVI-AES, St. Croix

***Table 2*. Rating scale with index used for evaluation of crop injury.**

Rating*	Crop Damage	Precision (%)
0	No crop reduction or injury	2
10	Slight crop discoloration or stunting	5
20	Some crop discoloration, stunting, or stunt loss	5
30	Crop injury more pronounced, but not lasting	10
40	Moderate injury, crop usually recovers	10
50	Crop injury more lasting, recovery doubtful	10
60	Lasting crop injury, no recovery	10
70	Heavy crop injury and stand loss	10
80	Crop nearly destroyed - A few surviving plants	5
90	Only occasional live crop plants left	5
100	Complete crop destruction	2

*Rating scale and index used for watermelon crop adapted from Vanhala et al. (2004).

***Table 3*. Test location and WAT weed species present.**[a]

Weed type	Weed species	WAT weed present at each location	
		Field Plot 11	Field Plot 13
Grasses:	Crabgrass *(Digitaria ischaemum)*	*	*
	Johnsons Grass *(Sorghum halepense)*	-	*
	Goosegrass *(Eleusine indica)*	-	*
	Chloris *(Chloris barbata)*	*	-
	Bermuda Grass *(Cynodon dactylon)*	*	*
Sedges:	Nutsedge *(Cyperus rotundus)*	*	*
Broadleaf:	False Poinsettia *(Euphorbia cyathophora)*	-	*
	Milkweed *(Asclepias nivea)*	*	*
	Purslane *(Portulaca oleracea)*	*	-
	Seed under leaf *(Phyllanthus amarus)*	*	*
	Boerhavia *(Boerhavia erecta)*	-	*
	Jackswitch *(Corchorus hirsutus)*	-	*
	Spiny Amaranth *(Amaranthus spinosus)*	-	*
	Thistle *(Emilia sonchifolia)*	-	*
	Clitoria *(Clitoria ternatea)*	-	*
	Spurge *(Chamaesyce hypericifolia)*	-	*
	Button Weed *(Spermacoce assurgens)*	*	*
	Whitey Mary *(Physalis angulata)*	-	*
	Mimosa *(Mimosa pudica)*	-	*
	Amaranthus *(Amaranthus viridis)*	*	*
	Euphorbia *(Euphorbia heterophylla)*	*	*
	Whitehead Broom *(Cyanthillium cinereus)*	*	-
	Jute *(Corchorus aestuans)*	*	-
	Shy Bush *(Mimosa Pudica)*	*	-
	Wildenow *(Ipomoea triloba)*	*	-

[a] Abbreviations: WAT, weeks after treatment; -, species not present; *, species present.

***Table 4*. Watermelon injury and yield from PRE treatments averaged over locations.** [a, b]

			Field Plot 11				Field Plot 13			
			Injury		Fruit number	Fruit weight	Injury		Fruit number	Fruit weight
Herbicide[d]	Rate	Timing	2 WAT	4 WAT			2 WAT	4 WAT		
	Kg/ha		------ % ------		No./plot	Kg/plot	------ % ------		No./plot	Kg/plot
Bensulide	0.03	PRE	5ab	5ab	5d	14.79f	5ab	5ab	4d	17.17e
Halosulfuron	0.04	PRE	10a	5ab	6d	16.82f	10a	10a	5d	20.18e
Non-treated	0.00		0c	0c	4d	12.00f	0c	0c	4d	14.61e

[a] Abbreviations: PRE, preemergence; WAT, weeks after treatment.
[b] Locations were USDA field plot 11 and 13.
[c] Means in each column followed by the same letter are not different at P≤0.05 level of significance according to Tukey's HSD method of means of separation. Crop injury ratings taken at 2 and 4 weeks after treatment (WAT).
[d] Bensulide was Prefar 4-E ®, 0.03 kL/ha. Halosulfuron was Sandea ®, 0.04 kg/ha.

***Table 5*. Watermelon ° Bx from PRE treatments averaged over locations.** [a, b]

			Trial 1	Trial 2
Herbicide	Rate	Timing	° Bx	° Bx
	Kg/ha			
Bensulide	0.03	PRE	8.40 a	8.55 b
Halosulfuron	0.04	PRE	8.38 a	8.80 b
Non-treated	0.00		8.63 a	8.78 b

[a] Abbreviations: ° Bx, degrees brix; PRE, preemergence; WAT, weeks after treatment.
[b] Locations were USDA field plot 11 and 13.
[c] Means in each column followed by the same letter are not different at P≤0.05 level of significance.