

## Diversified Crops Report 22

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### **AUTHORITY AND PENTAGON IN STEVIA**

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#### **SUMMARY**

Preemergence broadcast application of pendimethalin (Pentagon) at 2 lb a.i. per acre provided acceptable control of some broadleaf and all grass weeds with excellent crop tolerance. Higher rates and sequential application of Pentagon improved the control of broadleaf weeds and resulted in higher stevia plant yield. Sulfentrazone (Authority) resulted in unacceptable growth and yield reduction of stevia. Plastic mulch was effective in suppressing weeds, but competition from weeds emerging from the planting hole in the mulch and the interrow was unacceptable without additional weed control. Registration of pendimethalin is highly recommended.

#### **INTRODUCTION**

Mature stevia was found to be tolerant to over-the-top broadcast application of Authority and Pentagon in an earlier herbicide screening trial (see Diversified Crops Report 21) at Gay and Robinson (G&R). Authority is expected to control many broadleaf and some grass weeds, while Pentagon is effective on most grass and some broadleaf weeds. It is expected that a mixture of both herbicides will give the best broad-spectrum control of weeds. Both herbicides appear to provide good selectivity to stevia and may be effective on most weeds at G&R. Furthermore, both are being tested for registration in mint by IR-4, and stevia is proposed to be included in the leafy herb crop grouping with mint.

The objectives of this trial were to evaluate (1) the herbicide effectiveness for control of weeds and (2) tolerance of stevia to applications of Authority and Pentagon. The data will be used to support the registration of both herbicides for use in stevia.

#### **MATERIALS AND METHODS**

The trial site was located at G&R above the town of Kaumakani on the Island of Kauai in the Makaweli soil series. The herbicide treatments were applied on May 9, 2002 after the field was harvested by cutting the stevia plants to a height of about three inches from

ground level on May 6, 2002. The plots were hand-weeded prior to treatment on May 9, 2002. The plastic mulch was removed in several plots with the no-mulch treatments prior to herbicide application. The herbicides were broadcast at 25 gallons per acre with a CO<sub>2</sub> backpack sprayer before new shoots emerged from the cut stevia stems.

The plot dimensions were 20 ft long and 10 ft wide consisting of two beds (two rows per bed) per plot. The drip tubing was placed under the 36-inch wide plastic mulch covering each bed and between the two 14-inch spaced rows in each bed. The plant spacing within each row was 12 inches. The centers of the beds were spaced 5 ft apart. Each plot was transplanted with 80 plants about seven months ago in October of 2002. Less than half the original plants were present at the first evaluation on June 7, 2002. In an adjacent uncut field of the same age, 17.5% of the total number of plants present were dead. The number of dead plants was 58.6% in another recently cut field next to the trial site. The high number of dead plants of unknown cause was expected to confound the herbicide treatment effects.

The treatment variables were factorial combinations of two rates each of Authority (0.25 and 0.50 lb a.i. per acre) and Pentagon (1 and 2 lb a.i. per acre), with and without plastic mulch, and single and sequential applications. The untreated controls had plots with and without plastic mulch. The sequential treatments were applied on July 3, 2002, 8 weeks from the initial treatment. The 21 treatments were replicated three times for a total of 63 plots. The plots were arranged in a completely randomized block design.

Weed control was assessed by visual ratings, weed counts and weed height measurements. The control of broadleaf and grass weeds were rated separately by visually estimating the percent of the area not covered by broadleaf or grass weeds. The visual ratings were from 100% (no weeds) to 0% (complete weed cover). The number of weeds by species in each plot was counted on June 7 and July 3. Weed heights were measured only on June 7. The untreated control plots were hand-weeded on July 8 to 12. The first assessment of the herbicide treatments was made on June 7 (32 days after the last harvest or ratooning - DAR) with subsequent evaluations on July 3 (58 DAR) and August 9, 2002 (95 DAR).

Measurements to assess crop tolerance were as follow: (1) crop phytotoxicity which was determined visually using a rating system of 1 to 9 for all evaluation dates where 1 was normal stevia plants, 5 was 50% of foliage adversely affected, and 9 was for dead plants, (2) count of all stevia plants in each plot on June 7 and August 9, (3) average crop height for all evaluation dates, and (4) fresh plant yield at harvest on August 9. Digital photographs were taken of every plot on the three evaluation dates.

## RESULTS AND DISCUSSION

### Weed Control

#### Weed Counts

Weeds present at this site were garden spurge (*Euphorbia hirta*), graceful spurge ((*Euphorbia glomerifera*), spiny amaranth (*Amaranthus spinosus*), cheeseweed (*Malva parviflora*), composite species, purslane (*Portulaca oleracea*), prostrate spurge (*euphorbia prostrata*), smooth rattlepod (*Crotalaria mucronata*), vervain (*Stachytarpheta jamaicensis*), Japanese tea (*Cassia leschenaultiana*), hila hila (*Mimosa pudica*), thickhead (*Crassocephalum crepidioides*), nightshade species, Spanish needle (*Bidens pilosa*), crabgrass species, bristly foxtail (*Setaria verticillata*), haole koa (*Leucaena leucocphala*), horseweed (*Erigeron bonariensis*), indigo (*Indigofera suffuticosa*), ageratum (*Ageratum conyzoides*), alexandergrass (*Brachiaria plantaginea*), peria (*Momordica charantia*), legume species, vaseygrass (*Paspalum urvillei*) and guineagrass (*Panicum maximum*). The weed counts on June 7 and July 3 indicated that this site had ample weeds to evaluate the herbicide treatments. The untreated plots had an average weed count of 141 broadleaf and 51 grass weeds per 200-ft<sup>2</sup> plot (222 and 42 for unmulched and 60 and 60 for mulched untreated plots) on June 7, while the least effective herbicide treatments had 39 broadleaf and 18 grass weeds. The weed counts and weed control ratings were highly correlated and provided similar statistical trends. The unmulched, untreated control had significantly (0.05 level) more weeds than any other treatment including the mulched, untreated control. The weed counts among the treated plots were not significantly different at the 0.05 level where all herbicides provided acceptable weed control on June 7, 29 days after treatment.

#### Control of Broadleaf Weeds

The higher rates of both Authority and Pentagon controlled more broadleaf weeds, but the results were inconsistent for some treatments. The best control of the broadleaf weeds was achieved with treatments where Authority and Pentagon were applied in combination. The efficacy of each herbicide appears to be partially additive in controlling broadleaf weeds. The average broadleaf control for all the combination treatments was 95, 90 and 69% on June 7, July 3 and August 9, respectively. The combination treatments with the highest rates gave the best control of broadleaf weeds and were still commercially acceptable at 75 to 85% on August 9 compared to the highest rates of Authority or Pentagon alone at 60%.

#### Control of Grass Weeds

Pentagon provided excellent control of grass weeds throughout the season with complete control on June 7 and July 3, and 98% control on August 9 at harvest (Table 2). The 1 and 2 lb a.i. per acre rates of Pentagon provided excellent and similar control of grass weeds. Authority was less effective than Pentagon but was still significantly better than the untreated control with 80, 80 and 53% control on June 7, July 3 and August 9,

respectively, where the control plots were rated at 51% control for June 7 and July 3.

### Single Herbicide Effects on Weed Control Ratings

Combined statistical analysis for all of the single herbicide treatments and the untreated control in Table 1 show the following: (1) the herbicide treatments had significantly better weed control ratings than the untreated controls, (2) Authority and Pentagon provided similar control of broadleaf weeds, and (3) Pentagon was better on grass weeds than Authority. These results were significantly differences at the 0.01 level for all weed control ratings on June 7, July 3 and August 9. The control of broadleaf weeds with either Authority or Pentagon treatments was 88% (good) on June 7, 74% (acceptable) on July 3 and 52% (marginal to poor) at harvest on August 9. The untreated control plots were rated at a 50 and 32% for June 7 and July 3. No ratings were made on August 9 for the untreated control plots, because they were hand-weeded after July 3.

**Table 1.** Weed control ratings of broadleaf and grass weeds on June 7, July 3 and August 9, 2002. Only the treatments with either Pentagon or Authority and the untreated control plots were used for this analysis. The treatments with the same letter for respective columns and dates were not significantly different at the 0.01 level using the least square difference method (LSD).

<b>Treatment</b>	<b>Broadleaf Rating (%)</b>	<b>Grass Rating (%)</b>
<b><u>6/7/2002</u></b>		
Pentagon	87 a	100 a
Authority	89 a	80 b
Control	50 b	51 c
<b><u>7/3/2002</u></b>		
Pentagon	77 a	100 a
Authority	72 a	80 b
Control	32 b	51 c
<b><u>8/9/2002</u></b>		
Pentagon	57 a	98 a
Authority	47 a	53 b
Control	-	-

### Sequential Application

The sequential application on July 3 had a significant effect (0.05 level) on the control of broadleaf weeds on August 9 where the weed control rating was improved by 11% with the second application. The control of grass weeds was not influenced by the sequential application. Pentagon had adequate soil residual to maintain near complete control of grass weeds until harvest, while Authority did not maintain sufficient control of grass weeds to harvest at any rate or with sequential application. Though insignificant, sequential application of Pentagon appeared to increase stevia yield (1,847 lb per acre with versus 1,402 lb per acre without sequential application), while it decreased yields with Authority (718 versus 817 lb per acre). The yield gain with Pentagon is likely due to

better control and reduced competition of broadleaf weeds. The yield loss with Authority is primarily due to poor crop tolerance. The treatment effect on yield is expected to be greater with longer period between the sequential application and harvest, especially with Pentagon. This period was only 37 days for this trial.

### Mulching

The treatments with plastic mulch suppressed weeds resulting in higher weed control ratings and fewer weeds (except for the number of grasses on June 7) than plots without mulch. The results were significant at the 0.05 level for the number of broadleaf weeds on June 7 and July 3, the broadleaf rating and the number of grass weeds on July 3, and the yield on August 9. On June 7, the untreated control plot without mulch had twice as many weeds as the untreated control plot with mulch. The broadleaf and grass weed control ratings at harvest were insignificant despite the higher ratings of 16 and 17% more with mulch for broadleaf and grass weeds, respectively. The yield was significantly higher at the 0.05 level with mulch at 1,212 lb per acre compared to 724 lb per acre without mulch.



## **Crop Tolerance**

### Plant Population

The average number of live stevia plants per treatment on June 7 ranged from 21 to 40 plants per plot or 26 to 50% of the original 80 plants. Some of the plant mortality may be attributed to nematodes, which were present in moderately high numbers in the surrounding fields. The plant population differences were not significantly (0.20 level)

related to the herbicide treatments though trends appear to suggest that treatments with Authority may be contributing to low plant numbers. When comparing the change in the plant population from June 7 to August 9, the Authority alone treatments had an average decrease of 35% compared to decreases of 14 and 23% for the Pentagon alone and the untreated control treatments, respectively. However, the latter results were not significant at the 0.05 level. By grouping and statistically analyzing the treatments with either Authority or Pentagon and the untreated control treatments, Pentagon had significantly less relative loss of plants at the 0.01 level as compared to Authority and was similar to the untreated control. The plant loss from June 7 to August 9 was 36% for the unmulched, untreated control, while the mulched, untreated treatment loss was only 9%. It appears that severe competition from high number of weeds in the unmulched, untreated control plots may have also contributed to plant mortality.

### Visual Observations of Crop Phytotoxicity

Crop phytotoxicity, expressed as off-colored leaves, was observed only on June 7, 29 days after treatment. Subsequent evaluation had little or no evidence of leaf damage. For this short 95-day crop, severe crop damage expression at or after 29 days may lead to lower yields. The untreated control treatments had an average rating of 2.5 due to the hot, windy environment, while the treated plots had ratings of 3.0 to 4.5. For most crops, ratings of 3 or less are commercially acceptable, while higher ratings are not. Treatments with Authority had the poorest plants and crop phytotoxicity of about 4, and the crop phytotoxicity rating was significantly higher at the 0.05 level than that for the untreated controls. The treatments with only Pentagon were not significantly different from the untreated control. The differences among all the treated means were not significant. By July 3, all treatments had no visual symptom of crop damage.

### Stevia Height

The crop heights for all treatment means ranged from 11 to 15 cm on June 7, 19 to 25 cm on July 3, and 26 to 34 cm on August 9. The heights measured on June 7 and August 9 were not significantly different at the 0.20 level between the untreated control and treated plots. The heights on August 9 were not significant probably due to the difficulty and variability of measuring the recumbent plants. The results for July 3 were slightly significant at the 0.10 level where the plants treated with Authority were shorter than the untreated control. The untreated control was similar to treatments with only Pentagon. The differences between Authority and Pentagon were not significant.

### Yield

The plots were harvested for fresh stem and leaf weights to determine the weight per plant and yield per acre (Table 2). The weights among all treatments were not significantly different even with weights of 1,904 lb per acre and 143 g per plant for sequential application of Pentagon at 2 lb a.i. per acre compared to 524 lb per acre and 53 g per plant for sequential application of Authority at 0.50 lb a.i. per acre. The yield for the untreated mulched plots was 2.78 fold larger than the untreated unmulched plots. The spatial variation affecting the plant population confounded the treatment effects. The

data was reanalyzed by grouping the treatments with Authority alone, Pentagon alone, treatments with both herbicides and the untreated controls. This latter analysis resulted in differences significant at the 0.05 level. The Pentagon group had heavier individual plants and higher yields than for the Authority group. The yield for the combination group containing Authority was significantly lower than the Pentagon group. The yield results for the untreated control was not significantly different from Pentagon, but was significantly higher than for Authority. The effects of sequential application and mulching on yield were discussed in the weed control section where sequential application of Pentagon increased yield but decreased yields with Authority and mulching increased yields.

**Table 2.** Weight (g) per plant and yield (lb per acre) for the grouped treatments on August 9 for the 95-day crop. Treatment weights in the respective columns followed by the same letter were not significantly different at the 0.05 level using LSD.

<b>Treatment</b>	<b>Weight (g/plant)</b>	<b>Yield (lb/acre)</b>
Pentagon	111 a	1,481 a
Untreated	93 ab	1,218 ab
Combination	95 a	941 bc
Authority	75 b	719 c

## **CONCLUSIONS AND RECOMMENDATIONS**

Registration of pendimethalin for use in stevia is highly recommended. A single application of Pentagon provided excellent control of all grass weeds to harvest at the G&R site with the lowest rate of 1 lb a.i. per acre. Testing of lower rates on grass weeds is recommended. Many broadleaf weeds were controlled with 1 lb a.i. per acre of Pentagon, but the control of broadleaf weeds was improved with 2 lb a.i. per acre and with a sequential application. The highest stevia yield was with sequential application of Pentagon at 2 lb a.i. per acre. Stevia appeared to be fairly tolerant to Pentagon and had no adverse effect on its growth or yield. Authority is not recommended, because it adversely affected stevia. The proposed label for Pentagon should allow up to 2 lb a.i. per acre per application with a second post application at sites with high numbers of broadleaf weeds.

Plastic mulch can be an effective means of controlling weeds if it can cover more of the planted and interrow areas. Mulching was effective in reducing the weed population and produce higher yields. However, the weeds emerging from the transplanted holes in the plastic must be controlled. The plastic is expected to tear after harvest and may be less effective for future ratoon crops. Cultivation may be a mechanical alternative in weed control, which may require a modification of the irrigation system to prevent damage to the drip tubes. Also, a higher plant density with closer row and narrower interrow spacings are recommended for rapid shading of the soil surface to minimize weed seed germination and suppress existing weeds.