CAN GROWERS EFFECTIVELY MANAGE TROPICAL SPIDERWORT IN COTTON?

A. Stanley Culpepper[1], T. M. Webster[2], and T. Flanders[1].
University of Georgia[1] and United States Department of Agriculture[2]

Introduction

Origination and Infestation: Tropical spiderwort (*Commelina benghalensis* L.) is a noxious, exotic, invasive weed that has become a serious pest in many Georgia agricultural production areas. Tropical spiderwort is native to tropical Asia and Africa. In its native region, it is an herbaceous perennial weed. However in the temperate climate of the south, it behaves as an annual weed (Holm et al. 1977). While its path of introduction into the U.S. is unclear, tropical spiderwort was first observed in the continental U.S. in 1928 and was common throughout Florida by the mid-1930's (Faden 1993). In 1983, the U.S. Department of Agriculture designated tropical spiderwort as a Federal noxious weed (USDA-APHIS 2000). Tropical spiderwort is among the world's worst weeds, considered a weed in 25 crops in 28 countries (Holm et al. 1977). In 1998, tropical spiderwort was present in Georgia but was not considered an important weed of cotton (Webster and MacDonald 2001). However, by 2001, it had quickly become very problematic and was ranked as the ninth most troublesome cotton weed (Webster 2001). By 2003, tropical spiderwort was clearly the most troublesome weed of cotton and second most troublesome weed of peanut in several south Georgia counties.

Tropical spiderwort, also known as Bengal dayflower, is related and similar in appearance to the dayflower species that have become more common in agricultural fields over the past decade. In addition to tropical spiderwort, the most common dayflower species in Georgia include spreading dayflower (*Commelina diffusa* Burman f.), Asiatic dayflower (*Commelina communis* L.), marsh dayflower [*Murdannia keisak* (Hassk.) Hand.-Mazz.] and doveweed [*Murdannia nudiflora* (L.) Brenan.]. There are three identifying features of tropical spiderwort. First, tropical spiderwort can be distinguished from the other dayflower species by its short broad leaves (a leaf length to width ratio of < 3:1). The other dayflower species have leaf blades that are relatively longer and narrower than tropical spiderwort. Second, tropical spiderwort will often have reddish (or sometimes white) hairs on the sheath apex (point at which the leaf attaches to the stem). Finally, the most definitive way of identifying tropical spiderwort is through the presence of subterranean flowers. Tropical spiderwort is the only *Commelina* species found in the U.S. with subterranean flowers.

Results from a recent survey illustrated distribution of tropical spiderwort in at least 30 Georgia counties. Additionally, several county extension agents, particularly those near the Florida border, have ranked tropical spiderwort as the most important weed species in their county. The increase in the prevalence of tropical spiderwort in Georgia may be attributed in part to the adoption of weed management programs that lack the use of residual herbicides along with the adoption of reduced tillage production practices. Additionally, invasive plant species, after introduction, often go long periods of time (lag

period) during which the pest increases in distribution or density without being noticed as an obvious pest.

As with many troublesome weeds, tropical spiderwort is most competitive with crops when adequate moisture is present. Some of the *Commelina* species are common to wetlands. Tropical spiderwort thrives in wet areas, but once established, it can also persist in dry soils.

Biology: Upon initial observation, tropical spiderwort appears to be a grass. While not a grass, it is a monocot (in contrast to a dicot or broadleaf weed) that has some botanical similarities to other monocot families such as the sedges (Cyperaceae), rushes (Juncaceae), and grasses (Poaceae). The leaves and stems are thicker and more succulent than grasses. Leaf blades are ovate to lanceolate, 1 to 3 inches long and 0.5 to 1.5 inches wide. The stems are sprawling and will creep along the ground and root at the nodes. Broken vegetative cuttings of stem are capable of rooting and reestablishing following cultivation (Budd et al. 1979). Short rhizomes develop approximately 6 weeks after emergence and by 12 weeks can form an average of 6 rhizomes, each measuring 4 inches in length (Walker and Evenson 1985a).

Tropical spiderwort is unique in that it produces both aerial and underground flowers (Maheshwari and Maheshwari 1955). Both aerial and underground flowers are enclosed in spathes. Each aerial flower can produce 1 large seed and 4 smaller seeds, while underground flowers can produce 1 large seed and 2 smaller seeds (Walker and Evenson 1985a). Aerial flowers are chasmogamous (normal, open flowers), lilac or blue, and are self-fertilized. The underground spathes develop on the rhizomes and are cleistogamous (flowers are self-fertilized and do not open) (Walker and Evenson 1985a). Underground flowers begin to form by 6 weeks after emergence, while aerial flowers form 8 to 10 weeks after emergence (Walker and Evenson 1985a). Two leaf seedlings of tropical spiderwort have been observed to have subterranean flowers when grown in the greenhouse (M. G. Burton, North Carolina State University, Weed Ecologist, personal communication, 2004). In aerial flowers, an immature fruit was formed within 2 to 3 days of flower opening and was ripe within 14 to 22 days after flower opening (Walker and Evenson 1985a). Growing in rice paddies in the Phillippines, tropical spiderwort produced in excess of 1,600 seeds/plant (Pancho 1964). However, plants grown from underground seeds were capableof producing 8,000 seeds/m^2, while those originating from aerial seeds produced 12,000 seeds/m^2 (Walker and Evenson 1985a).

There are four types of seed produced: large aerial seeds, small aerial seeds, large underground seeds, and small underground seeds. Small aerial seeds accounted for 73 to 79% of the total number of seeds produced. However, these seeds tended to have a stronger dormancy than large seeds. Less than 3% of freshly harvested, aerial seeds germinated when placed in favorable conditions (Walker and Evenson 1985b). Underground seeds represented less than 3% of the seeds produced and did not exhibit as much dormancy. Ninety percent of these larger seeds germinated under favorable conditions (Walker and Evenson 1985a). Clipping the seed coat or exposing the seed

to temperatures in excess of 90^0 C for 2 hours removed the state of dormancy for all seed types (Walker and Evenson 1985b).

Plants that developed from aerial seeds tended to be smaller, developed aerial flowers earlier (43 days after emergence), and produced more aerial fruits relative to plants that originated from underground seeds (Walker and Evenson 1985a). The optimum depth for tropical spiderwort emergence was 0 to 2 inches, with large seeds capable of emerging from a 6 inch depth (Walker and Evenson 1985b).

Tropical spiderwort has been identified as an alternate host of the southern root-knot nematode (*Meloidogyne incognita*) (Valdez 1968). A recent survey in Georgia has shown that the southern root-knot nematode is widely distributed across the cotton production regions of the state. In fact, southern root-knot nematodes were recovered from more than 65% of the soil samples collected in the survey. (R. C. Kemerait, University of Georgia, Extension Plant Pathologist, personal communication, 2003).

Previous Studies: Tropical spiderwort infestation has become a severe problem in several cotton producing areas. Studies evaluating response of tropical spiderwort to herbicides and herbicide systems have been conducted in Georgia over the past five years (2000-2004). Results from our 2004 efforts are discussed below. Conclusions based on these trials will be revised as future data are collected.

Materials and Methods

Studies were conducted during 2004 with naturalized populations of tropical spiderwort in Grady County, Georgia. Soils were Tifton loamy sands (thermic Plinthic Kandiudults) with organic matter ranging from 0.91 to 1.1% and pH of 5.7. Plots consisted of four rows by 25 feet in length. Prowl (1 qt/A) was applied preemergence across each trial as this herbicide has no effect on tropical spiderwort emergence or growth. Glyphosate resistant (GR) 'DP 451 B/RR'cotton was planted on May 14 using a vacuum planter dropping three seed together every 18 inches. No cultivation was preformed after planting. Other cultural practices, including fertilization, insect management, and plant growth management were standard for Georgia and followed those recommended by the Cooperative Extension Service.

The experimental design for each trial was a randomized complete block with treatments replicated four times. All treatments were applied with a CO_2-pressurized backpack sprayer equipped with extended range flat fan nozzles calibrated to deliver 14.8 GPA at 19 to 22 PSI. Layby applications were applied 3 to 4 inches up the cotton stem. Visual estimates of crop injury and tropical spiderwort control were taken throughout the season. Visual estimates were based on a scale of 0 to 100, where 0 = no weed control or cotton injury and 100 = complete weed control or cotton death. Data were subjected to ANOVA, and treatment sums of squares were partitioned to reflect the treatment design. Means were separated using Fisher's Protected LSD at P = 0.05.

Methods Specific for Each Experiment

Experiment 1 (Residual Weed Control from Cotton Herbicides) was a an effort to determine which cotton herbicides provide the greatest degree of residual weed control (Table 1). Treatments were applied the day of planting and rainfall occurred within 48 hours after planting and application. No tropical spiderwort had emerged at time of applications. Visual estimates of tropical spiderwort control were taken 9, 29, and 43 days after treatment.

Experiment 2 (Postemergence and Residual Control from Cotton Layby Herbicides) was an effort to determine the most effective layby herbicide option for both the control of emerged spiderwort as well as providing residual control late in the season (Table 2). Roundup WeatherMax was applied topically to the entire trial area when cotton was in the 4-leaf stage of growth. Treatments were then applied when cotton was 22 inches tall and tropical spiderwort was 4 inches in height or less.

Experiment 3 (Systems Approach to Managing Tropical Spiderwort) was an effort to determine the most effective complete system for the control of tropical spiderwort (Table 3). Soil applied herbicides were applied the day of planting, early directed or topical applications were made when cotton was in the 4 to 6 leaf stage and 5 to 6 inches tall and tropical spiderwort was 4 inches or less, and layby applications were made when cotton was 22 inches tall and tropical spiderwort was 4 inches in height or less.

Results and Discussion

Experiment 1: Tropical Spiderwort Response to Soil-Applied Herbicides. At 9 days after applying treatments, several herbicides provided excellent tropical spiderwort control (Table 1). However, three of the four most effective options were metolachlor products (Dual Magnum 1 pt/A, Dual Magnum 1.5 pt/A, and Stalwart). Command was the only other herbicide chemistry that provided greater than 71% control and control from Command was more of plant stunting as compared to complete control as noted with Dual Magnum. Staple was clearly the least effective program. At 29 days after treatment, trends in control were similar to those previously noted except for Direx being statistically more effective than Caparol.

By 43 days after treatment, control was greater than 80% with only Dual Magnum at 1.5 pt/A (Table 1). Dual Magnum at 1 pt/A was less effective than 1.5 pt/A with only 74% control; however, control by Dual Magnum at 1 pt was greater than control by Stalwart. Control by all other herbicides except Command (68%) was 44% or less.

Experiment 2: Tropical Spiderwort Response to Layby Herbicides. At 21 days after treatment, several new tropical spiderwort flushes had occurred since the layby applications were made, thus those programs without residual control were much less effective than those including residual control. For example, Aim provided complete control of emerged tropical spiderwort but control was only 76% by 21 days (Table 2).

Aim and MSMA were similarly effective and control was greater than that noted with ET. Mixing Roundup with Aim did not improve control as control of emerged plants was complete with Aim alone, and neither herbicide has soil residual activity. Treatments containing Valor or Dual Magnum were more effective than other programs because of the residual weed control provided by these herbicides. Dual Magnum programs provided the most residual activity with control ranging from 95 to 98% at 21 days after treatment.

By late-season, control with options containing no residual activity provided only 34 to 50% control. Mixing Direx or Valor with MSMA improved control 18 to 28% because of residual activity. However, treatments providing the greatest degree of control included Dual Magnum. Unfortunately in these programs, control was still only 85 to 90%, which is unacceptable in areas heavily infested with tropical spiderwort.

Experiment 3: Roundup Ready Cotton and Tropical Spiderwort Response to Herbicide Systems. Cotton injury greater than 10% only occurred with topical applications of Roundup WeatherMax plus Dual or Staple at 6 days after applications (Table 3). Injury was transient and essentially not detectable by 14 days after application (data not shown).

Mid-season tropical spiderwort control, which was estimated just prior to layby applications, clearly noted the two most effective early postemergence options were either Roundup plus Dual Magnum or Cotoran plus MSMA. Systems containing these options provided $\geq$87% control compared with only 62% control by Roundup alone. A greater degree of control prior to layby is essential in order to optimize layby coverage of emerged plants and to improve the amount of herbicide that contacts the soil, providing residual control late into the season.

Spiderwort control at 10 days after the layby applications was greater than 90% by 28 of the 30 herbicide systems. Weather, soil conditions, and tropical spiderwort size (<4 inch) were optimal when layby treatments were applied thereby enhancing control of emerged spiderwort.

At harvest, only one program still maintained 90% or better control. This most effective program included Cotoran applied preemergence, Cotoran plus MSMA early directed, and Direx plus MSMA plus Dual Magnum late postemergence directed. This is the first labeled herbicide program in five years of research that has provided greater than 90% control at harvest, unfortunately it is clearly not an economical option for cotton production. Nine additional programs provided control ranging from 80 to 87% control. Eight of these nine programs contained Dual Magnum applied at layby. The aforementioned conventional program was the most consistent program in the trial, however, two additional programs including sequential applications of Dual Magnum (Roundup plus Dual Magnum at 0.67 pt/A applied topical followed by Roundup plus Direx plus Dual Magnum at 0.67 pt/A applied at layby and Dual Magnum at 0.44 pt/A applied at plant followed by Roundup plus Dual Magnum at 0.44 pt/A applied topical

followed by Roundup plus Direx plus Dual Magnum at 0.44 pt/A applied at layby) were almost as effective and are more economical.

Table 1. Tropical Spiderwort Response to Soil-Applied Herbicides.*

Herbicide Options	Percent Tropical Spiderwort Control		
	9 DAT**	29 DAT	43 DAT
No herbicide	0 f	0 g	0 h
Caparol at 2.0 pt/A	55 cd	35 e	11 gh
Command at 2.0 pt/A	86 a	85 ab	68 bc
Cotoran at 2.0 pt/A	68 b	51 d	32 de
Cotoran at 2.0 pt/A + Zorial at 1.25 lb/A	71 b	66 c	44 d
Direx at 2.0 pt/A	61 bcd	48 d	22 efg
Dual Magnum at 1.0 pt/A	89 a	89 ab	74 b
Dual Magnum at 1.5 pt/A	94 a	96 a	88 a
Stalwart	86 a	82 b	61 c
Staple at 0.8 oz/A	30 e	15 f	11 gh
Valor at 1.0 oz/A	64 bc	52 d	31 e
Valor at 2.0 oz/A	70 b	51 d	24 ef
Zorial at 1.75 lb/A	52 d	26 ef	14 fg

*Means followed by the same letter within a column are not significantly different (P=0.05). Data pooled over the POST herbicide options.
**DAT = days after treatment.

Table 2. Tropical Spiderwort Response to Herbicides Applied at Layby.*

Herbicide Options	21 DAT**	98 DAT
WeatherMax	74 e	38 f
ET plus Crop Oil	50 f	34 f
Aim plus Crop Oil	76 e	50 e
WeatherMax plus Aim	72 e	39 f
WeatherMax plus Valor	87 cd	75 cd
WeatherMax plus ET	74 e	42 ef
WeatherMax plus Dual Mag.	94 ab	86 ab
WeatherMax plus Dual Mag. plus Aim	96 ab	87 ab
WeatherMax plus Dual Mag. plus Valor	98 a	85 abc
WeatherMax plus Dual Mag. plus ET	95 ab	85 abc
MSMA	76 e	50 e
MSMA plus Direx	82 d	68 d
MSMA plus Direx plus Dual Mag	97 ab	90 a
MSMA plus Valor	91 bc	78 bcd
MSMA plus Valor plus Dual Mag.	98 a	87 ab
No Layby	0 g	0 g

*WeatherMax 22 oz/A; ET 1.0 oz/A; Aim 1.5 oz/A; Crop Oil 1% vol/vol; Valor 1 oz/A when mixed with glyphosate and 2 oz/A when mixed with MSMA; MSMA 2 lb ai/A; Dual Mag 1 pt/A.
**Means followed by the same letter within a column are not significantly different (P=0.05). Data pooled over the POST herbicide options. DAT = days after treatment.

Table 3. Roundup Ready Cotton Response to Cotton Herbicide Systems.*

Herbicide Systems			Tropical Spiderwort Control		
At-Plant	Topical	Layby	6 d after topical application	11 d after topical application	9 d after layby
P**			0 e	0 d	0 a
P	RU	RU	3 de	3 cd	0 a
P	RU	RU + Direx	3 de	0 d	1 a
P	RU + Dual	RU	13 ab	6 bc	1 a
P	RU	RU + Dual	3 de	0 d	3 a
P	RU + Dual	RU + Direx	12 ab	5 bc	2 a
P	RU	RU + Dual + Direx	3 de	0 d	0 a
P + C	RU	RU + Direx	5 cd	0 d	0 a
P + C	RU	RU + Dual + Direx	3 de	3 cd	4 a
P + C	RU + Dual	RU + Direx	13 ab	4 bcd	1 a
P + C + Z	RU	RU + Direx	0 e	0 d	6 a
P + C + Z	RU	RU + Direx + Dual	0 e	0 d	0 a
P	RU + Staple	RU + Direx + Dual	12 ab	2 cd	0 a
P + C	RU + Staple	RU + Direx + Dual	9 bc	4 bcd	0 a
P	RU	RU + Command	0 e	0 d	3 a
P	RU	RU + Valor (1 oz)	0 e	0 d	1 a
P	RU	RU + Valor (2 oz)	0 e	0 d	3 a
P	RU	RU + Spartan	0 e	0 d	4 a
P	RU + Dual	RU + Command	14 ab	8 ab	1 a
P	RU + Dual	RU + Valor (1 oz)	15 a	12 a	0 a
P	RU + Dual	RU + Valor (2 oz)	13 ab	8 ab	1 a
P	RU + Dual	RU + Spartan	14 a	6 bc	0 a
P	RU + Dual	Direx + MSMA	15 a	8 ab	4 a
P	RU	Direx + MSMA + Dual	0 e	2 cd	2 a
P + C	Cotoran + MSMA	Direx + MSMA	0 e	1 d	4 a
P + C	Cotoran + MSMA	Direx + MSMA + Dual	4 de	0 d	2 a
P + C	Staple	Direx + MSMA	4 de	0 d	2 a
P + C	Staple	Direx + MSMA + Dual	5 cde	2 cd	3 a
P	RU + Dual	RU + Direx + Dual	6 cd	4 bcd	0 a
P + Dual	RU + Dual	RU + Direx + Dual	4 de	3 cd	1 a

*P = Prowl at 2 pt/A, RU = Roundup WeatherMax at 22 fl oz/A, Dual = Dual Magnum at 1.33 pt/A except in treatment 29 (0.67 pt/A each application) and treatment 30 (0.44 pt/A each application), Staple = 1.2 oz/A plus nonionic surfactant, Cotoran = 1 qt/A, MSMA = 2 lb ai/A, Direx = 1.5 pt/A when mixed with glyphosate and 1 qt/A when mixed with MSMA, Spartan = 5.5 oz/A, Command = 1.33 pt/A, Valor = 1 or 2 oz/A as noted. Cotoran plus MSMA was only treatment directed during early season.

Table 4. Tropical Spiderwort Response to Cotton Herbicide Systems.*

Herbicide Systems			Tropical Spiderwort Control		
At-Plant	Topical	Layby	9 d after topical prior to layby	10 d after layby	Late-season
P**			0 k	0 i	0 i
P	RU	RU	62 hij	90 fg	50 h
P	RU	RU + Direx	52 j	93 def	60 fgh
P	RU + Dual	RU	92 ab	98 abc	70 c-g
P	RU	RU + Dual	65 gh	94 b-e	70 c-g
P	RU + Dual	RU + Direx	88 a-d	99 a	78 bcd
P	RU	RU + Dual + Direx	63 hi	99 a	78 bcd
P + C	RU	RU + Direx	73 fg	92 ef	53 h
P + C	RU	RU + Dual + Direx	79 def	98 abc	87 ab
P + C	RU + Dual	RU + Direx	94 a	99 a	62 e-h
P + C + Z	RU	RU + Direx	82 b-f	95 b-e	52 h
P + C + Z	RU	RU + Direx + Dual	77 ef	99 a	82 a-d
P	RU + Staple	RU + Direx + Dual	75 f	99 a	80 a-d
P + C	RU + Staple	RU + Direx + Dual	77 ef	99 a	82 a-d
P	RU	RU + Command	62 hij	83 h	78 bcd
P	RU	RU + Valor (1 oz)	53 ij	87 gh	47 h
P	RU	RU + Valor (2 oz)	57 hij	92 ef	75 b-f
P	RU	RU + Spartan	56 hij	94 cde	79 bcd
P	RU + Dual	RU + Command	89 abc	98 abc	85 abc
P	RU + Dual	RU + Valor (1 oz)	87 a-e	99 a	60 fgh
P	RU + Dual	RU + Valor (2 oz)	89 abc	96 a-d	77 b-e
P	RU + Dual	RU + Spartan	91 abc	98 abc	76 b-e
P	RU + Dual	Direx + MSMA	91 abc	98 abc	78 bcd
P	RU	Direx + MSMA + Dual	58 hij	99 a	88 ab
P + C	Cotoran + MSMA	Direx + MSMA	87 a-e	97 abc	69 d-g
P + C	Cotoran + MSMA	Direx + MSMA + Dual	95 a	98 ab	95 a
P + C	Staple	Direx + MSMA	77 f	95 b-e	58 gh
P + C	Staple	Direx + MSMA + Dual	81 c-f	99 a	85 abc
P	RU + Dual	RU + Direx + Dual	91 abc	99 a	88 ab
P + Dual	RU + Dual	RU + Direx + Dual	94 a	99 a	85 abc

*P = Prowl at 2 pt/A, RU = Roundup WeatherMax at 22 fl oz/A, Dual = Dual Magnum at 1.33 pt/A except in treatment 29 (0.67 pt/A each application) and treatment 30 (0.44 pt/A each application), Staple = 1.2 oz/A plus nonionic surfactant, Cotoran = 1 qt/A, MSMA = 2 lb ai/A, Direx = 1.5 pt/A when mixed with glyphosate and 1 qt/A when mixed with MSMA, Spartan = 5.5 oz/A, Command = 1.33 pt/A, Valor = 1 or 2 oz/A as noted. Cotoran plus MSMA was only treatment directed during early season.

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