ECOLOGY AND MANAGEMENT OF TROPICAL SPIDERWORT IN GEORGIA

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Introduction

Tropical spiderwort is among the world's worst weeds, and it is considered a weed in 25 crops in 29 countries (Holm et al. 1977). In 1983, the U.S. Department of Agriculture designated tropical spiderwort as a federal noxious weed (USDA-APHIS 2000). This weed was first observed in the continental U. S. in 1928 and was reported to be common through Florida by the mid-1930's (Faden 1993). In 1998, tropical spiderwort was present in Georgia but not considered a serious pest infesting cotton. However, by 2001, it had quickly become very problematic and was ranked as the ninth most troublesome weed. By 2002, tropical spiderwort was clearly the most troublesome weed facing Georgia producers in several southern counties.

Tropical spiderwort is an exotic invasive herbaceous perennial of tropical climates that grows as an annual in temperate climates (Holm et al. 1977). Tropical spiderwort is a monocot and possesses the unique ability to produce both aerial and subterranean flowers (Maheshwari and Maheshwari 1955; Walker and Evenson 1985). Aerial flowers are chasmogamous (typical, open flowers), lilac or blue, and self-fertilized. Subterranean flowers develop on the rhizomes and are cleistogamous (flowers are self-fertilized and do not open). Walker and Evenson (1985) reported that subterranean flower formation begins by 6 wk after plant emergence, while aerial flowers form 8 to 10 wk after emergence. Plants grown from underground seeds are capable of producing 8,000 seeds/m^2, while those originating from aerial seeds may produce 12,000 seeds/m^2 (Walker and Evenson 1985). In addition, broken vegetative cuttings of stems are capable of rooting and reestablishing themselves following cultivation.

Preliminary data shows optimum temperatures for tropical spiderwort growth range from 30 to 35 C, indicating that the southeastern U.S. could provide an adequate environment for its rapid growth and reproduction (Burton et al. 2003). This, along with wide-spread planting of GR cotton and the heavy dependence upon glyphosate for weed management, suggests this problem is likely to increase across the region. The objective of our study was to evaluate response of tropical spiderwort to weed management systems in Roundup Ready cotton and to determine the factors that have allowed tropical spiderwort to become a weed in our agroecosystems.

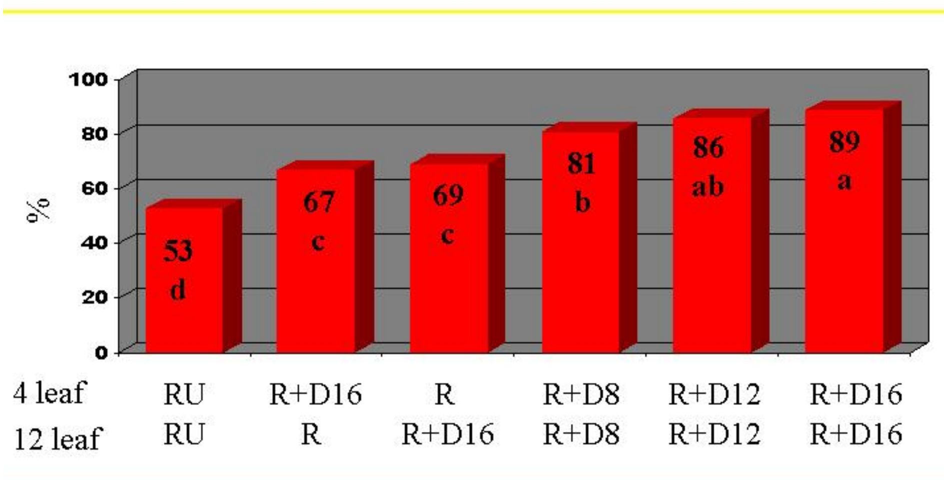
Managing Tropical Spiderwort in Roundup Ready Cotton

Studies were conducted in grower fields during 2004 and 2005 with naturalized populations of tropical spiderwort near Cairo, GA. Soils were Tifton loamy sands (thermic Plinthic Kandiudults) with organic matter ranging from 1.0 to 1.4% and pH ranging from 5.8 to 6.2.

The first experiment compared six herbicide systems focusing on application rate and timing of Dual Magnum. Systems included Roundup WeatherMax (22 oz/A) applied to 4- and 12-leaf cotton, Roundup plus Dual Magnum (16 oz/A) applied to four-leaf cotton followed by Roundup applied to 12-leaf cotton, Roundup applied to four-leaf cotton followed by Roundup plus Dual Magnum (16 oz/A) applied to 12-leaf cotton, and three sequential systems of Roundup plus Dual Magnum at 8, 12, or 16 oz/A applied to four-leaf cotton followed by the same herbicide applied again to 12-leaf cotton. These herbicides were applied topically to four-leaf cotton and directed to 12-leaf cotton. Prowl applied preemergence was a component of all treatments. A non-treated control was included.

At season's end, Prowl followed by Roundup applied twice controlled tropical spiderwort only 53% (Figure 1). Dual Magnum (16 oz/A) applied with glyphosate to 4- or 12-leaf cotton increased control only 14 to 16%. Waiting until 12-leaf cotton to apply Dual Magnum allowed the weed to become too large for control by Roundup, thus the residual activity from Dual Magnum was of minimal benefit. Dual Magnum applied at only the four-leaf stage provided excellent mid-season control, but late-emerging tropical spiderwort lessened late-season control. Roundup plus Dual Magnum applied sequentially at 8, 12, and 16 oz/A controlled tropical spiderwort 81, 86, and 89%, respectively, late in the season.

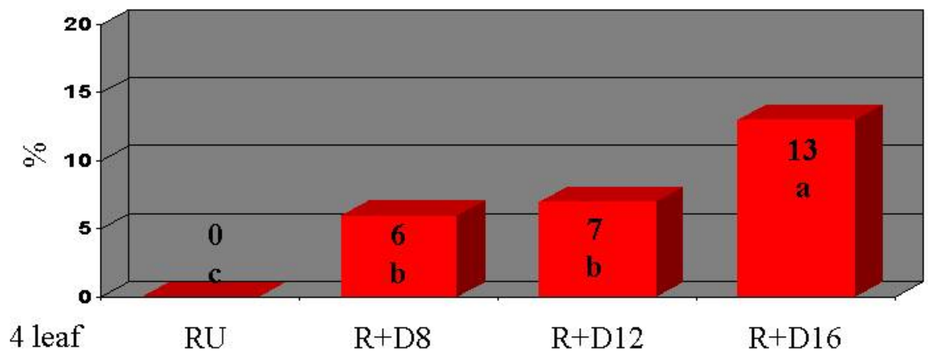
Figure 1. Late-season tropical spiderwort control.*



*Prowl PRE over trial area.

Cotton was injured 0, 6, 7, and 13% by Roundup alone or mixed with 8, 12, or 16 oz/A of Dual Magnum, respectively (Figure 2). Cotton quickly recovered from the cosmetic burn from the Dual mixtures and no injury was detectable 21 days after application.

Figure 2. Cotton Response to Herbicide Treatments at 4 day.*



*Prowl PRE over trial area.

A second experiment evaluated the most effective lay-by herbicide options to control emerged tropical spiderwort and to provide residual control. Treatments included a factorial arrangement of Roundup WeatherMax (22 oz/A), Roundup plus Aim (1.5 oz/A), Roundup plus Valor (1 oz/A), Direx (2 pt/A) plus MSMA (2 lb ai/A), and Valor (2 oz/A) plus MSMA applied alone or mixed with Dual Magnum at 16 oz/A. Prowl was applied preemergence and Roundup plus Dual Magnum (12 oz/A) were applied topically to four-leaf cotton in all treatments. Lay-by herbicides were precision directed at 15 GPA to 18-inch cotton with minimal injury.

At 9 days after application, all treatments except Roundup alone or mixed with Dual Magnum provided 89 to 99% control (Figure 3). At this time, Dual Magnum was of benefit only with Roundup plus Aim (+9%). Dual Magnum did not improve control with combinations containing Valor or Direx because both of these herbicides often offer up to 2 weeks of residual control.

By harvest, Aim mixed with Roundup did not improve control as the weed continued to emerge in the absence of residual activity (Figure 4). Roundup plus Valor, Valor plus MSMA, and Direx plus MSMA were more effective (77 to 81%) than Roundup plus Aim due to the residual activity from Valor and Direx. Dual Magnum included with lay-by applications increased late-season control 10 to 18% when in combination with Roundup plus Valor, Direx plus MSMA, or Valor plus MSMA and 30% when in combination with Roundup plus Aim.

Figure 3. Percent Spiderwort Control at 9 day after Layby.*

Layby Options	- Dual Mag.	+ Dual Mag
RU	73 c	78 c
RU + Aim	89 b	98 a
RU + Valor	93 ab	99 a
MSMA + Direx	96 ab	99 a
MSMA + Valor	92 ab	97 a

*Prowl PRE followed by Roundup + Dual Mag (12 oz) EPOST.

Figure 4. Percent Spiderwort Control at Harvest.*

Layby Options	- Dual Mag.	+ Dual Mag
RU	50 e	70 d
RU + Aim	58 e	88 ab
RU + Valor	77 cd	88 ab
MSMA + Direx	77 cd	95 a
MSMA + Valor	81 bc	91 ab

*Prowl PRE followed by Roundup + Dual Mag (12 oz) EPOST.

The Ecology of Tropical Spiderwort in Agroecosytems of the Southeast US

There are numerous factors that have allowed tropical spiderwort to become a weed in our agroecosystems and several of these factors include 1) its amazing growth habit, 2) unique emergence characteristics, 3) the ability to tolerate drought stress, 4) the slow growth habit of cotton, and 5) its ability to capitalize on unused resources following crop harvest.

Amazing growth habit. Greenhouse studies evaluated tropical spiderwort growth. Five-leaf tropical spiderwort plants were transplanted into 30-cm diameter pots and growth evaluated over 11 weeks. There were five plants evaluated and the study was repeated over time. Plant growth was nearly linear between one and six weeks, with plants with 50 leaves, 10 shoots, and 10 aerial spathes (leafy bract that encloses the flowers and fruit). However, tropical spiderwort growth was geometric between six and 11 weeks after planting, with weekly additions of 70 leaves (Figure 5), 10 shoots (Figure 6), and 26 aerial spathes (Figure 7).

Figure 5. Leaf production between 6 and 11 WAP.

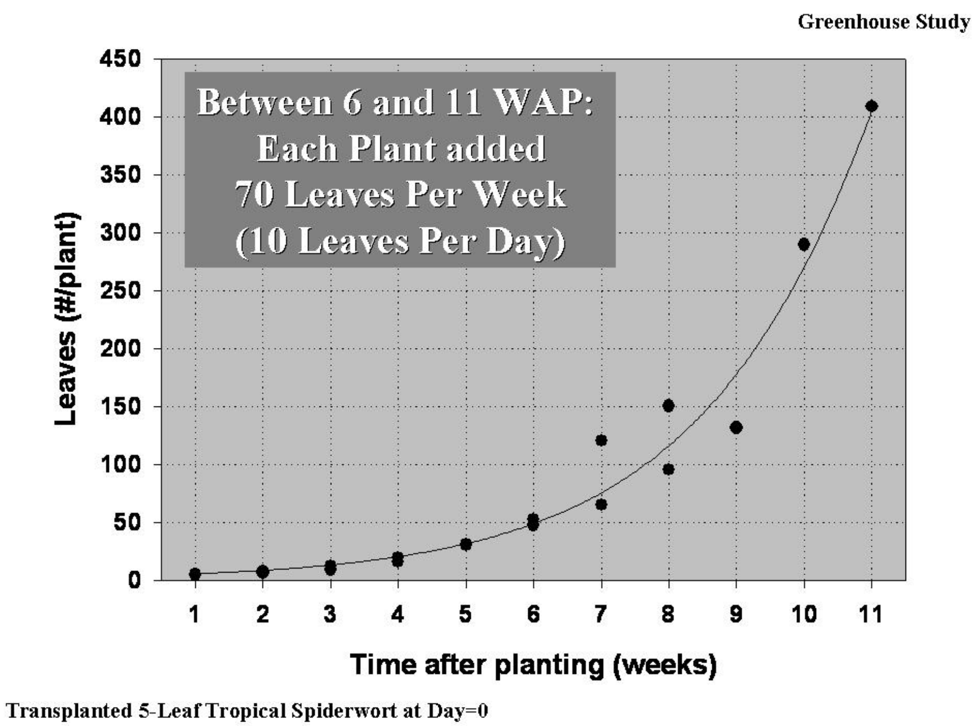


Figure 6. Shoot production between 6 and 11 WAP.

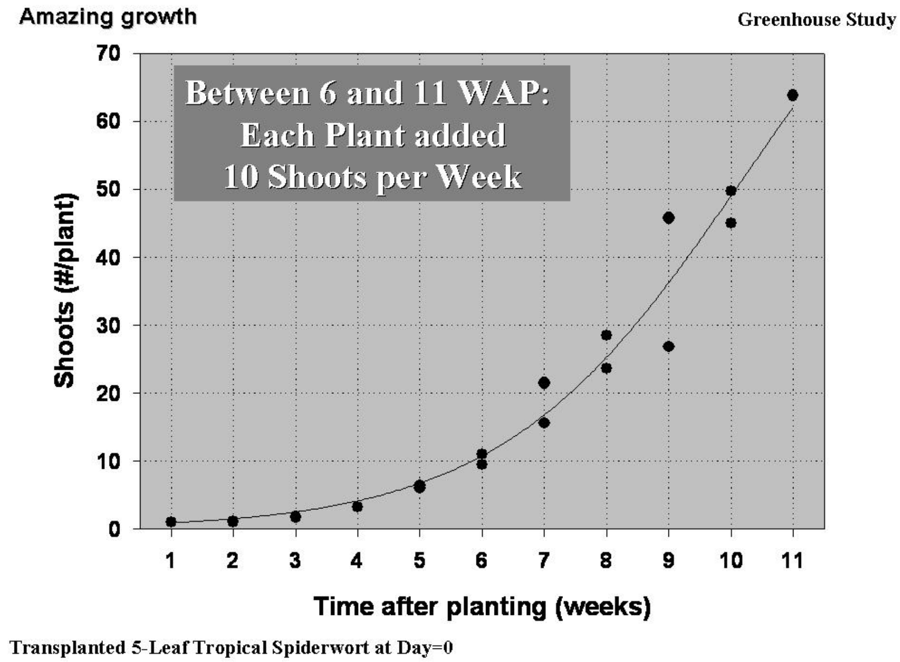
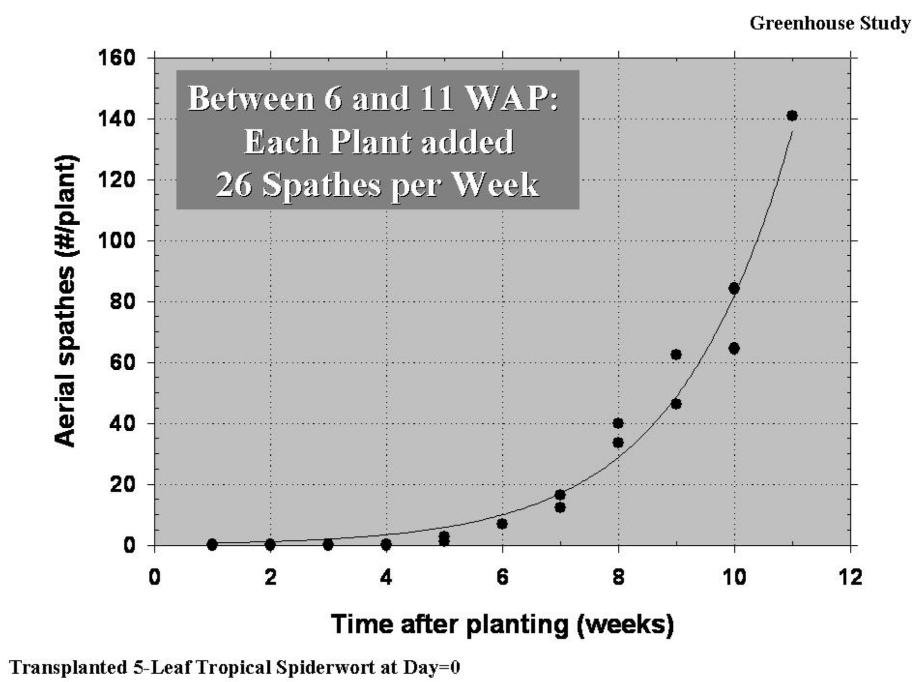
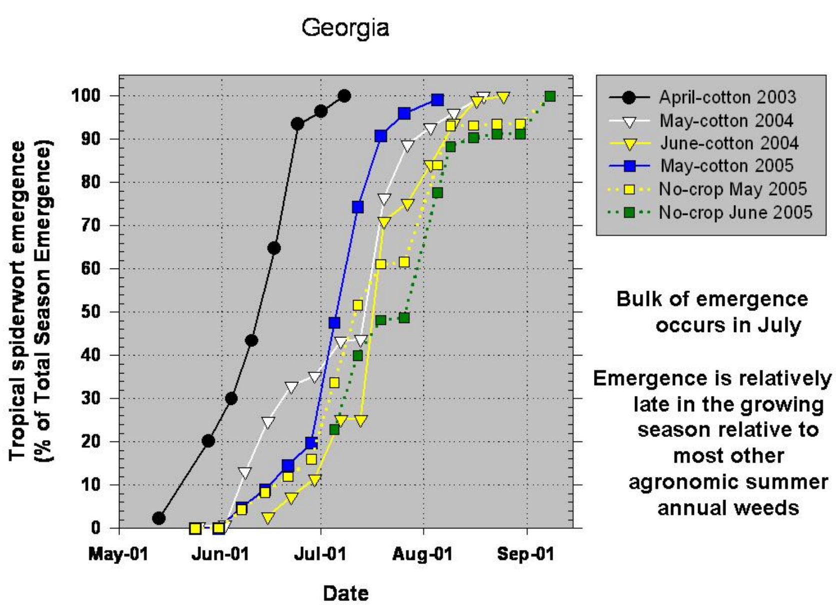


Figure 7. Spathes produced between 6 and 11 WAP.



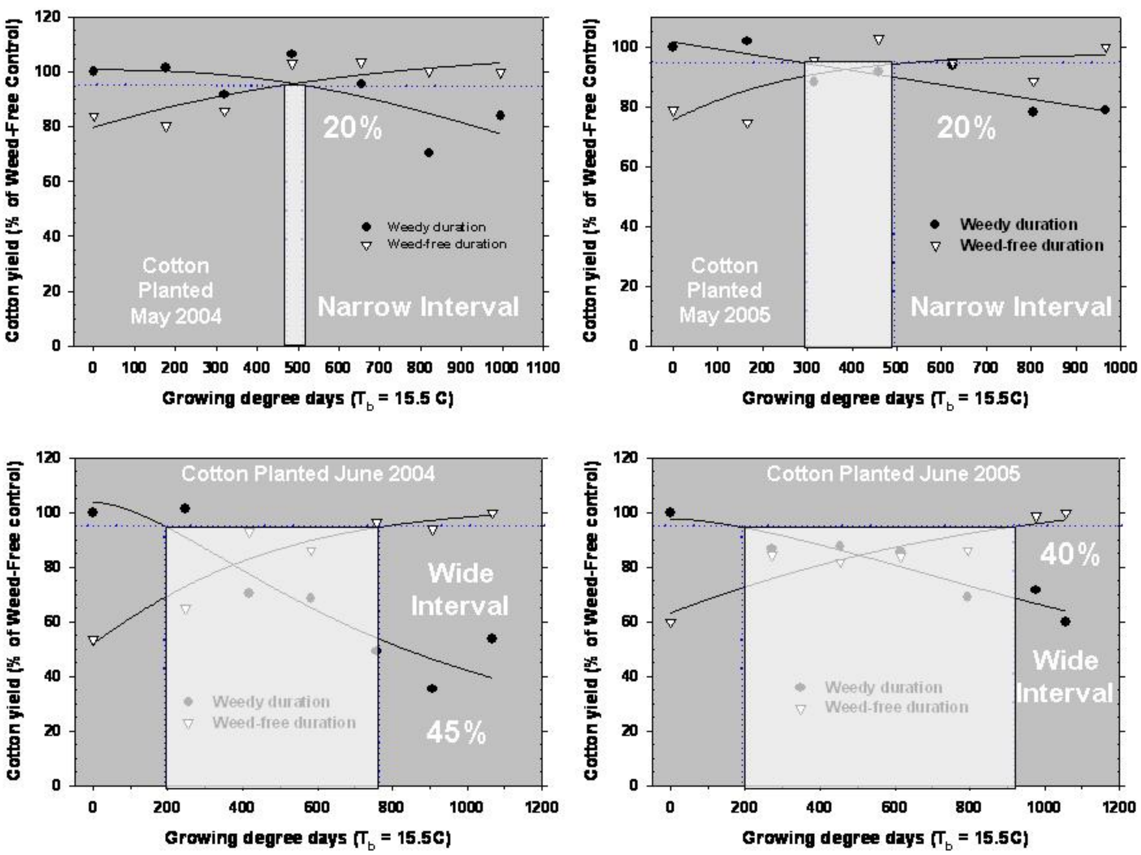
Emergence characteristics. The ability to predict tropical spiderwort emergence is critical for optimizing timing of control tactics. The lack of soil residual activity from glyphosate coupled with the plant size-linked tolerance of tropical spiderwort to glyphosate underscores the importance of understanding tropical spiderwort germination and emergence dynamics. The bulk of tropical spiderwort emergence (50 to 70%) in cotton fields in 2004 and 2005 occurred in July (Figure 8), which is at least a month later in the growing season than peak emergence for most other agronomic summer annual weeds. While up to 36% of the tropical spiderwort population emerged prior to July 1 (which will need to be addressed with some type of weed control tactic), the relatively late emergence characteristics of tropical spiderwort can be exploited to the benefit of the crop. In 2003, tropical spiderwort emergence was nearly a month earlier than was observed in 2004 and 2005. Excellent growing conditions in 2003 allowed cotton to form a light-limiting canopy in late-June and tropical spiderwort emergence was halted during the first week of July. A weak cotton canopy in 2003 would have likely allowed more tropical spiderwort emergence and may have shifted peak emergence to more resemble the results in 2004 and 2005.

Figure 8. Tropical spiderwort emergence pattern.



Based on observations of tropical spiderwort emergence patterns and these data, it was hypothesized that early planted cotton (i.e. April or May) would be more competitive than late planted cotton (i.e. June) as the crop would have more time to establish prior to peak tropical spiderwort emergence and would form a crop canopy faster. Studies were conducted to evaluate the interval that cotton must be kept free of tropical spiderwort in order to avoid a yield loss of greater than 5%. There is a time at the beginning of the season that cotton can tolerate the presence of tropical spiderwort (or any weed) as resources (i.e. water, nutrients, and especially light) are not limited. Likewise, there is also a point at which cotton has established itself and newly emerged tropical spiderwort populations will not influence cotton yield. The interval between these two times is the critical period of weed control (CPWC) during which all tropical spiderwort needs to be controlled. May-planted cotton had narrow CPWC intervals between 475 and 525 growing degree days (GDD; calculated with a base temperature of 10 C) in 2004 and approximately 300 to 500 GDD in 2005 (Figure 9). In contrast, June-planted cotton had wide CPWC intervals between 200 and 750 GDD in 2004 and 200 and 900 GDD in 2005. These data indicate that cotton was more competitive and required less aggressive management tactics when cotton was planted in May relative to June. Also supporting this contention is the maximum yield loss in the weedy controls; when tropical spiderwort competed with May-planted cotton for the entire season, yield loss was 20%. However, yield loss was at least double in the weedy control in the June-planted cotton.

Figure 9. Critical weed free period for cotton.



Drought stress. Preliminary studies indicated that tropical spiderwort is affected by drought stress, but maintained green leaves and produced spathes under extreme drought. Single plants were grown in the greenhouse for eight weeks in replicated trials. Treatments included four weekly watering regimes: field capacity (1X), half of field capacity (½X), one-fourth of field capacity (¼X), and one-eighth of field capacity (1/8X). Tropical spiderwort width was a more robust measurement of growth than was plant height, as tropical spiderwort is a low-growing, sprawling plant. Plant width was reduced greater than 50% by watering at ½X relative to 1X (Figure 10). Plants from all watering regimes produced aerial and subterranean spathes and numbers increased in a linear manner with amount of water (Figure 11). In spite of the severe lack of moisture in the 1/8X treatment, reproduction by aerial and subterranean spathes did occur, though the study was terminated prior to seed maturation, therefore seed viability was not evaluated.

Figure 10. Tropical spiderwort response to drought stress.

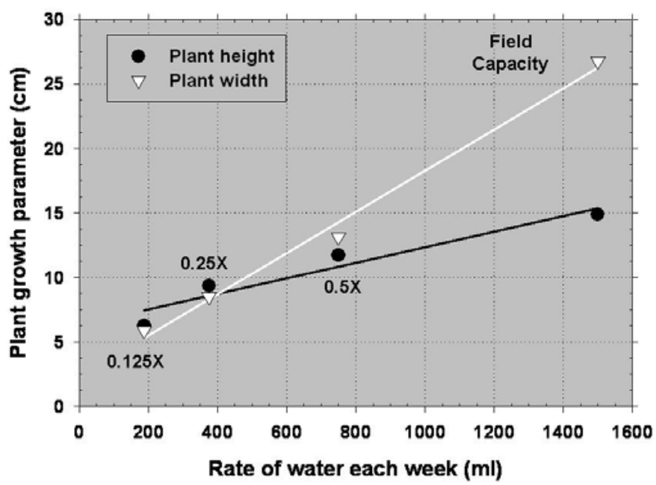
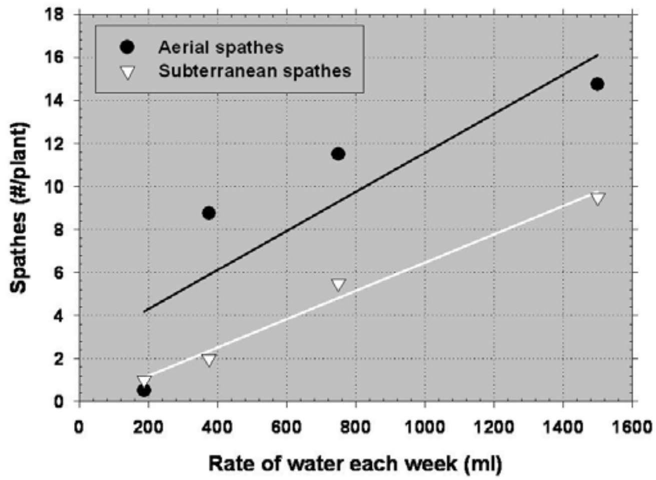


Figure 11. Tropical spiderwort spathes production relative to water amount available.



Crop types affects tropical spiderwort emergence and growth. Field studies were conducted in Grady County, Georgia in 2004 and 2005 to evaluate the effect of crop type on tropical spiderwort emergence and growth. Corn, cotton, peanut, and soybean were planted the final week of April in replicated plots with a naturalized tropical spiderwort population. Tropical spiderwort emergence was similar among crops early in the season, with divergence among crop types occurring around 450 GDD in 2004 and 300 GDD in 2005 (T_b=10C) (Figure 12). Total season emergence was greatest in cotton in both seasons. Peanut and soybean had 30 and 40% less emergence than cotton, respectively. Cotton is slow to form a light-limiting canopy relative to soybean and peanut; low light levels tended to suppress tropical spiderwort emergence. Emergence in corn was variable between seasons, but 8 to 22% less than cotton. Tropical spiderwort biomass in the non-cropped (fallow) plots were greater than in any of the crop treatments (Figure 13). However, only soybean had less tropical spiderwort biomass than peanut, which had the most tropical spiderwort biomass per plant in the four crops. Therefore, while cotton allowed the most new tropical spiderwort seedlings to emerge throughout the season, once established tropical spiderwort plants growing in competition with peanut attained the greatest growth.

Figure 12. Spiderwort emergence in cotton compared to other agronomic crops.

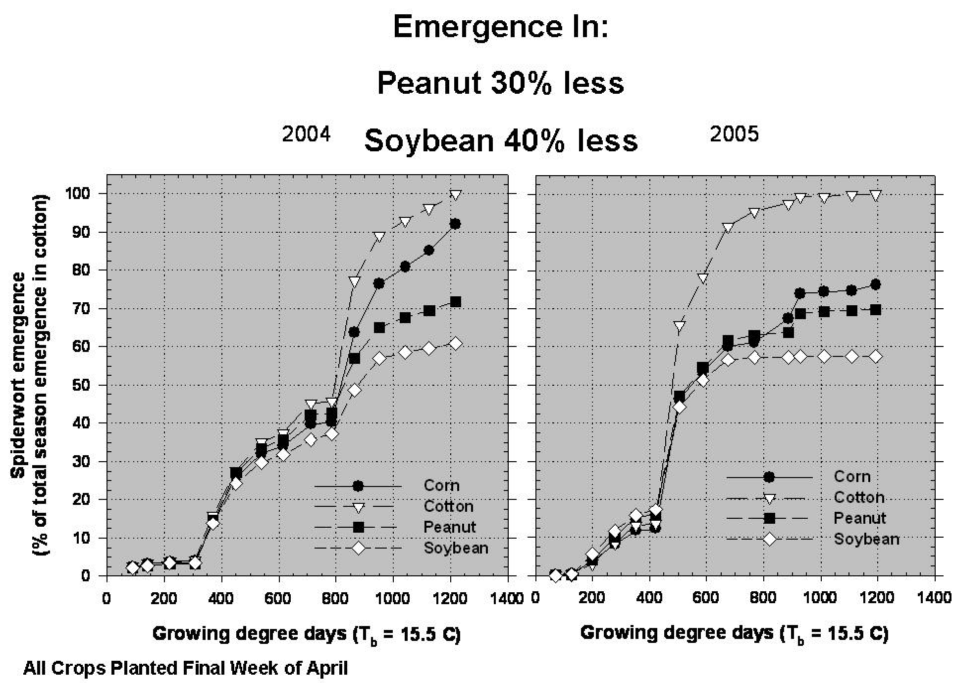
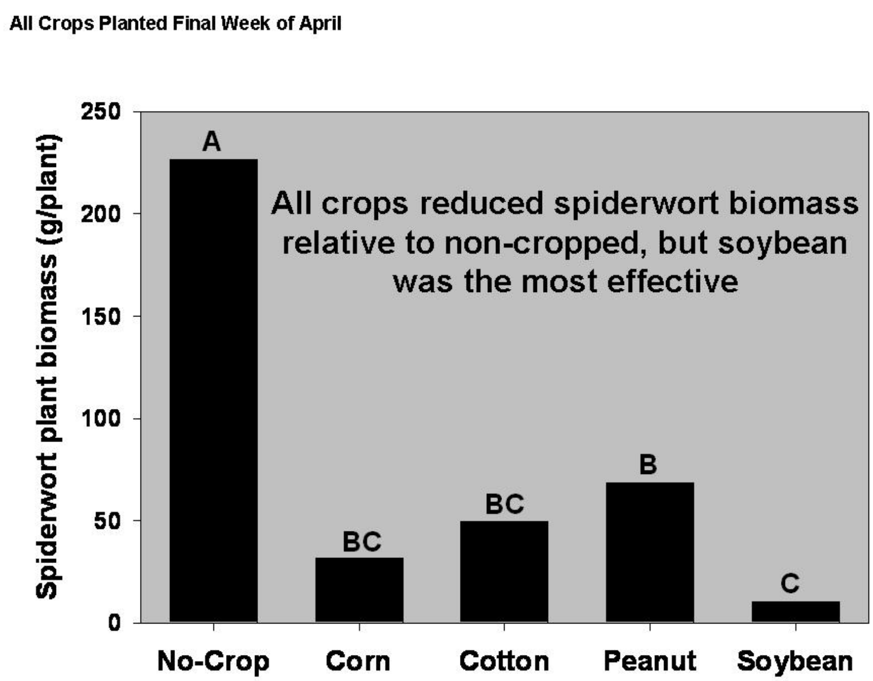


Figure 13. Tropical spiderwort biomass as impacted by agronomic crop.



Corn is often planted prior to the last week in April in Georgia, therefore the comparisons of growth between the crops in the above study may not reflect the differences in actual planting dates that occur in south Georgia. Another study was conducted in 2005 where corn was planted April 14; cotton, peanut, and soybean planted May 16; and 1-leaf tropical spiderwort transplanted June 16. These dates were selected to simulate the differences in crop planting dates as well as the late emergence characteristics of tropical spiderwort. At 12 weeks after tropical spiderwort transplanting (WATr), tropical spiderwort plants in corn and soybean were less than one-third the plant width of those in cotton and peanut (Figure 14). Similarly, there were less than 5 aerial spathes per plant in corn and soybean treatments, while peanut and cotton had 40 and 55 aerial spathes per plant, respectively (Figure 15). Leaf area, leaf biomass, and total plant biomass revealed similar trends (data not shown).

Figure 14. Spiderwort spathes produced in various agronomic crops.

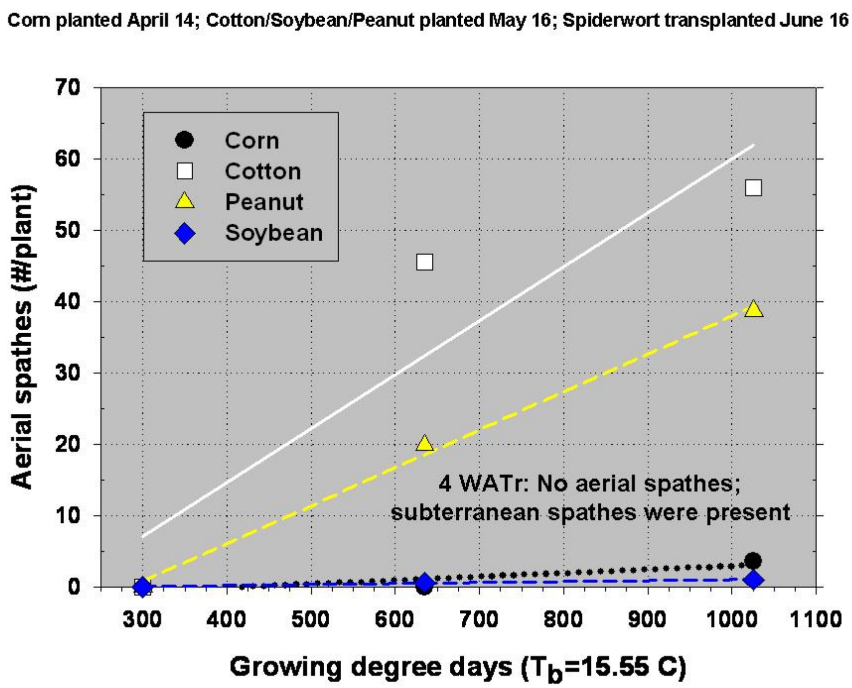
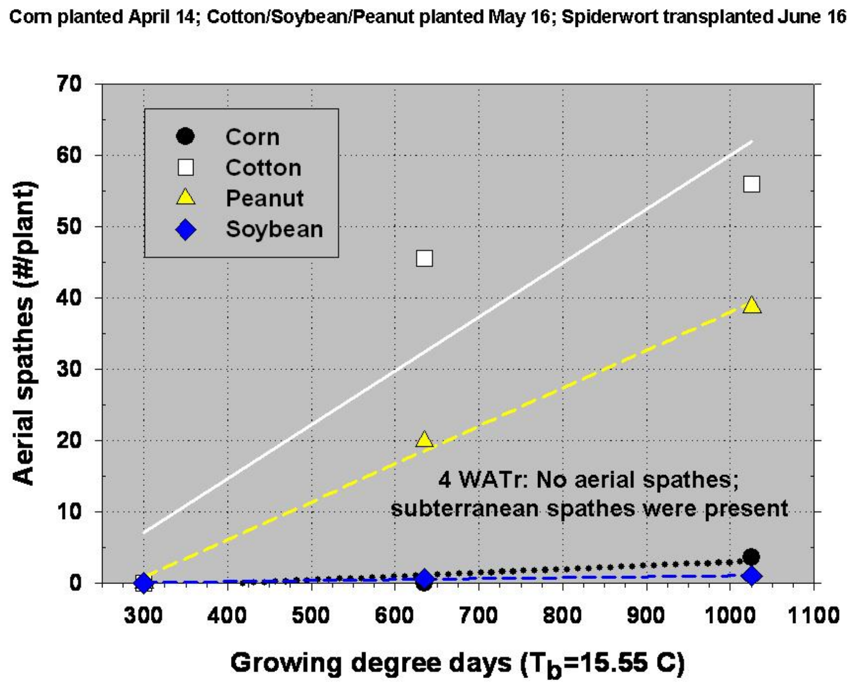


Figure 15. Spiderwort spathes produced in various agronomic crops.



Conclusions

It is vital that cropping systems are developed that possess low susceptibilities to tropical spiderwort invasion (preventing new establishment) and high tolerance to tropical spiderwort presence (suppressing impact of an existing population). Characteristics of these cropping systems will include: 1) an effective use of aggressive control tactics, including the use of s-metolachlor in cotton and effective herbicides rotation crops, 2) optimizing the benefits of cultural practices (i.e. early planting dates, aggressive crop cultivars, inclusion of some type of tillage), and 3) elimination of tropical spiderwort safe-sites (conditions that allow for tropical spiderwort germination, emergence, and establishment) such as after a corn crop is harvested.

It is likely that as long as conservation tillage and glyphosate are relied on heavily in agronomic crop production, this weed will continue to spread across the Southeast. Additionally, with no new management technology being developed to assist in controlling this weed a growers' ability to manage this pest economically compared to most other pests will not exist.

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