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TITLE: Effect of Incremental Sub-Threshold Levels of Insect Defoliation on Yield of Soybeans in Mississippi

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ABSTRACT

In 2016, defoliating insects alone cost Mississippi producers over $75,000,000 (Musser, Catchot et al. 2017). Previous research has shown that while defoliation during the vegetative growth stages typically causes minimal yield reduction, excessive foliage loss that occurs during the R3-R5 growth stages can have devastating effects on yield. The objective of these tests were to refine the current treatment recommendations by simulating situations commonly encountered by producers. Tests were conducted in 2015 and 2016 in Starkville and Stoneville, Mississippi with an additional location in Marianna, Arkansas in 2016. Soybeans were defoliated at various levels and growth stages throughout the growing season to mimic the effects of compounding defoliation. Multiple defoliation events did not compound to further increase yield loss when compared to a single defoliation event. Soybeans planted in mid-April to early-May typically had less yield reduction associated with defoliation than soybeans planted at earlier and later dates. These tests could help producers by creating a variable threshold based on planting date or defoliation that occurred during previous growth stages.

INTRODUCTION

Injury from defoliating insects is responsible for more yield loss to Mississippi soybean producers than any other feeding guild of insects. In 2016, defoliating insects alone cost Mississippi producers $75,000,000 (Musser, Catchot et al. 2017). Insects that commonly contribute to defoliation include bean leaf beetles [*Ceratoma trifurcata* (Forster)], soybean loopers [*Chrysodeixis includens* (Walker)], velvetbean caterpillar [*Anticarsia gemmatalis* (Hübner)], green cloverworm [*Hypena scabra* (Fabricius)], armyworms [*Spodoptera* spp.], grape colaspis [*Colaspis brunnea* (Fabricius)], and grasshoppers [(Orthoptera: Caelifera)]. Previous research conducted by Owen (2012) showed that while soybeans in the vegetative growth stages can tolerate a relatively large amount of defoliation, excessive foliage loss that occurs during the R3-R5 growth stages can have devastating effects on yield.

Current Mississippi treatment thresholds for defoliation in Mississippi are set at 35% pre-bloom and 20% during and after bloom (Catchot, Allen et al. 2016). However, a producer may be required to treat for defoliating pests multiple times during a single growing season. In these situations it is not known if multiple defoliation events compound to further increase yield loss. For instance, if a pest defoliates a soybean crop 30% during the vegetative stage then another pest defoliates the crop an additional 20% during the reproductive stage, is there an additive effect on yield.

Soybeans are planted over an extended period of time in the Midsouthern U.S., ranging from mid-March to mid-July. April 20th is typically the optimum planting date for maximum yield in Mississippi (MSU Ext 2014). Earlier planted soybeans that have defoliation occur during the vegetative growth stages should have more time to recover lost leaf area before reaching the more sensitive reproductive stages, as opposed to later planted soybeans that have a shorter time to recover. These differences in recovery time could be an important factor with respect to treatment timing and the soybeans' ability to compensate for yield loss.

The objective of these tests were to refine treatment recommendations by evaluating the effects of multiple defoliation events on soybean yield loss and how soybean planting date can further affect yield loss associated with defoliation of Mississippi soybeans.

MATERIALS AND METHODS

All trials were planted at 110,000 seeds/acre in 38-in.-wide rows using Asgrow 5335. Plot sizes were 4 rows wide by 10 feet long, with treatments arranged in a randomized complete block design. All plots were periodically treated with insecticide/fungicide to eliminate effects of various pests. The middle two rows of each plot were hand-defoliated at the specified growth stages and levels for each test. Leaf area index and plant heights were taken periodically throughout the growing season. Stand density and yield was recorded for all plots. All data were analyzed using JMP 12 (1989-2007) with an ANOVA model. Means were separated using Tukey's HSD ($P > 0.05$).

Effects of Compounding Defoliation on Soybeans

Tests were conducted during the 2015 and 2016 growing seasons at the R.R. Foil Plant Science Research Center at Starkville, MS and the Delta Research and Extension Center at Stoneville, MS. Two tests were conducted to evaluate the effects of compounding defoliation on soybeans. All treatments were replicated 4 times.

Objective 1. Evaluate the effects of compounding defoliation on vegetative soybeans. Tests were set up as a full factorial arrangement of treatments within a randomized complete block design. Factors were defoliation level (0, 33, 67, or 100%) and soybean growth stages (V3 and/or V6), resulting in 16 treatments. The Starkville and Stoneville locations were nonirrigated and irrigated, respectively.

Objective 2. Evaluated compounding defoliation on vegetative and reproductive stage soybeans. Plants were defoliated weekly, maintaining at a constant 17, 33, or 67% reduction in leaflet number throughout the vegetative growth stage, during the entire growing season, or 17, 33, 67, or 100% defoliation once during the R3 growth stage. An undefoliated control (UTC) was also included.

Effects of Planting Date on Defoliation

Objective 3. Evaluate the effects of planting date on defoliation. Tests were conducted during the 2015 and 2016 growing seasons at the R.R. Foil Plant Science Research Center at Starkville, MS and the Delta Research and Extension Center in Stoneville, MS, and additionally in 2016 at Lon Mann Cotton Research Station in Marianna, AR. Soybeans were planted every other week beginning in early April and ending in Mid-June for a total of 6 planting dates. Only the first 5 planting dates were harvested in the 2015 Stoneville test due to a poor plant stand in the last planting date. Each planting date contained a non-defoliated and 100% defoliated treatment for a total of 12 treatments with 6 replications. All defoliation events occurred when plants reached the V4 growth stage.

RESULTS AND DISCUSSION

Effects of Compounding Defoliation on Soybeans

In objective 1, both irrigated and nonirrigated locations did not yield lower than the check when defoliated 33 or 66%. Yield loss did occur, however, once defoliation levels reached 100% at V3 and V6 growth stages, and were independent of each other (Tables 1 and 2).

No interaction between defoliation levels was measured. Losses from single defoliation events in irrigated vegetative stage soybeans were consistent with studies conducted by Owen (2012). However, nonirrigated soybeans sustained greater damage when defoliated at V6 than indicated by Owen (2012). Increased yield loss from defoliation in the nonirrigated soybeans is due to the plants' reduced ability to compensate for the defoliation because of drought stress. Results suggest that multiple defoliation events in vegetative stage soybeans do not compound to further impact yields.

Table 1. Objective 1. Percentage yield compared to untreated check for irrigated soybeans

	V6 Defoliation			
	0	33%	66%	100%*
0	100%	94%	91%	83%
33%	101%	89%	85%	85%
66%	94%	92%	92%	84%
100%*	84%	81%	83%	76%

*Significantly different from the untreated check (P > 0.05)

Table 2. Objective 1. Percentage yield compared to untreated check for nonirrigated soybeans

		V6 Defoliation			
		0	33%	66%	100%*
V3 Defoliation	0	100%	82%	85%	64%
	33%	93%	88%	85%	64%
	66%	93%	82%	84%	68%
	100%*	72%	68%	63%	51%

*Significantly different from the untreated check (P > 0.05)

In objective 2, continuous defoliation at any level throughout the vegetative stage did not reduce yields significantly below the untreated control (Figure 1). Defoliation levels of 66 and 100% at R3 reduced yields below the check. Defoliation levels of 33 and 66% occurring season-long reduced yields below the untreated check as well. No season-long defoliation level reduced yield significantly below its respective R3 treatment. These results indicate that defoliation occurring prior to the R3 growth stage has very little, if any, additional impact on reproductive defoliation yield losses.

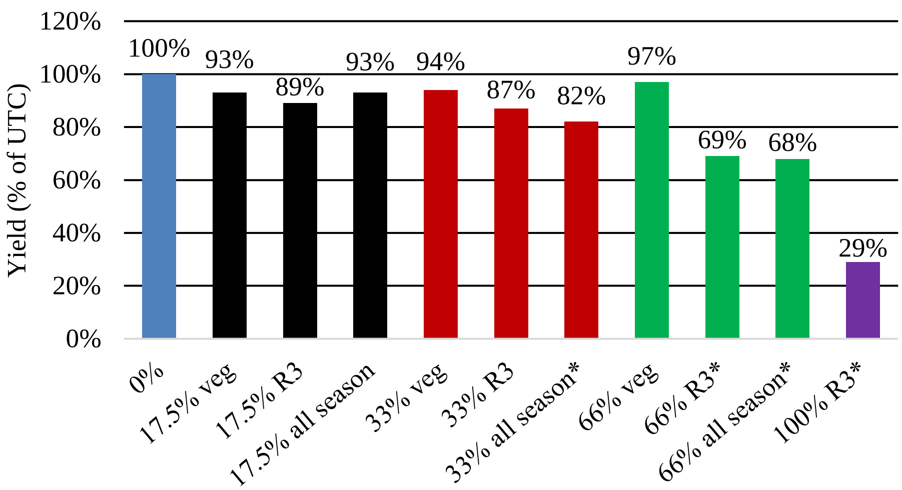

Figure 1. Objective 2. Percentage yield compared to untreated check
***Significantly different than the untreated check (P > 0.05)**

Effects of Planting Date on Defoliation

Objective 3. The Starkville tests in 2015 and 2016 displayed trends that later-planted soybeans were more susceptible to yield loss from defoliation than earlier-planted beans, although differences were only found in 2016 (Figures 2 and 3). Results from Stoneville in 2015 and 2016 were not consistent with those found at Starkville in either year (Figures 4 and 5). Soybeans planted mid-season suffered slightly less yield loss than the earliest and latest planting dates, with the exception of the mid-June planting date in 2016. Arkansas 2016 was similar to Stoneville in that mid-April and early-May planning dates suffered the least amount of yield loss, although results were not significantly different (Figure 6).

Inconsistencies among locations are likely due to differences in weather, soil texture, and irrigation practices. Across all locations and years, trends indicate that mid-April and early-May planting dates suffer less yield loss than other planting dates, although the results are not significant. This is likely due to the plants' ability to rapidly compensate due to optimal weather conditions during the time of injury compared compared to the earliest planting date. When compared to later planting dates, these plants have an increased time to compensate for injury before the plant begins reproductive growth stages that have a greater impact on yields. Studies will be conducted in the future to further evaluate this effect and could potentially lead to a variable threshold that can be adjusted for planting date.

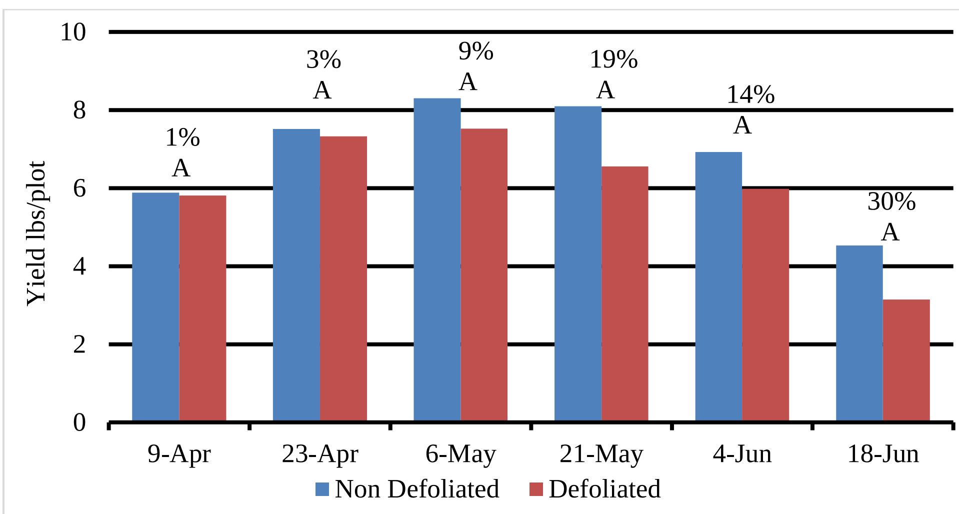

Figure 2. Starkville 2015 Objective 3. Yields and percentage yield reduction from defoliation at each planting date. Treatments with the same letter do not differ significantly (P > 0.05).

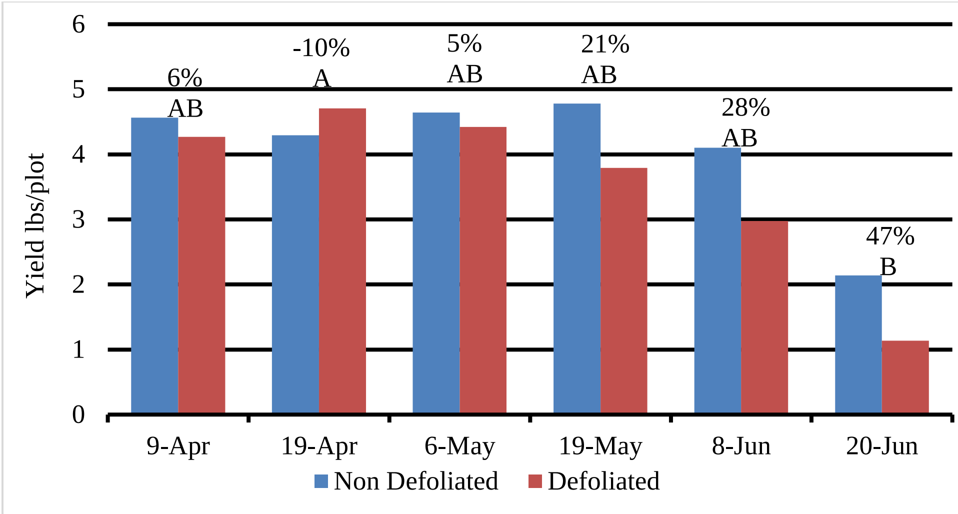

Figure 3. Starkville 2016 Objective 3. Yields and percentage yield reduction from defoliation at each planting date. Treatments with the same letter do not differ significantly (P > 0.05).

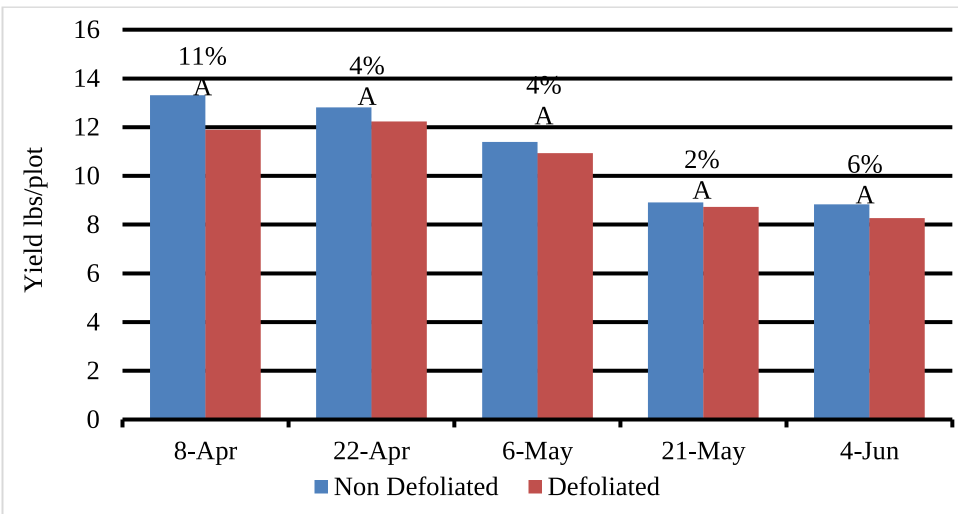

Figure 4. Stoneville 2015 Objective 3. Yields and percentage yield reduction from defoliation at each planting date. Treatments with the same letter do not differ significantly (P > 0.05).

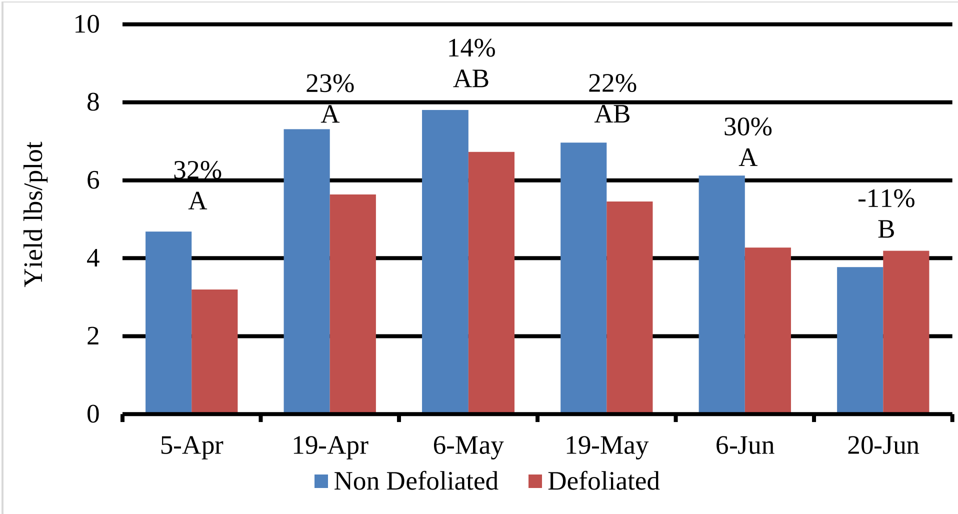

Figure 5. Stoneville 2016 Objective 3. Yields and percentage yield reduction from defoliation at each planting date. Treatments with the same letter do not differ significantly (P > 0.05).

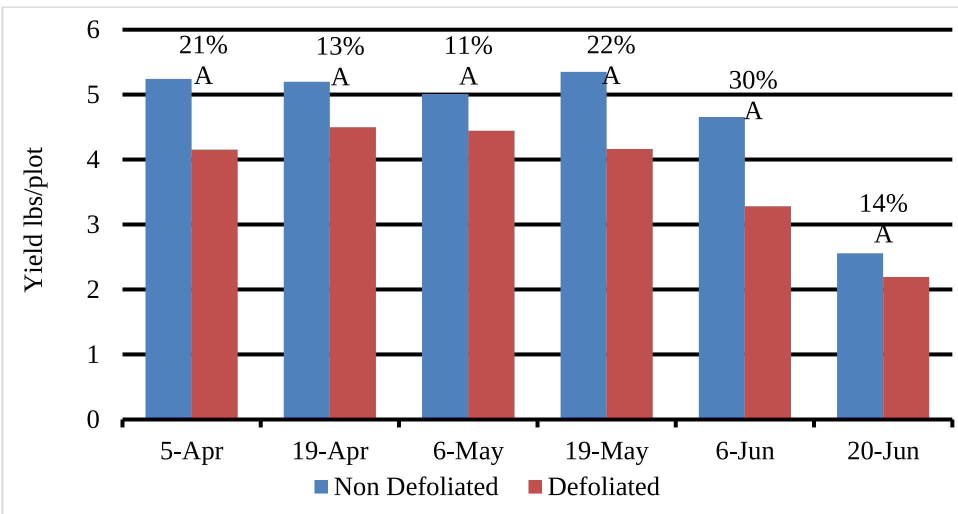

Figure 6. Arkansas 2016 Objective 3. Yields and percentage yield reduction from defoliation at each planting date. Treatments with the same letter do not differ significantly (P > 0.05).

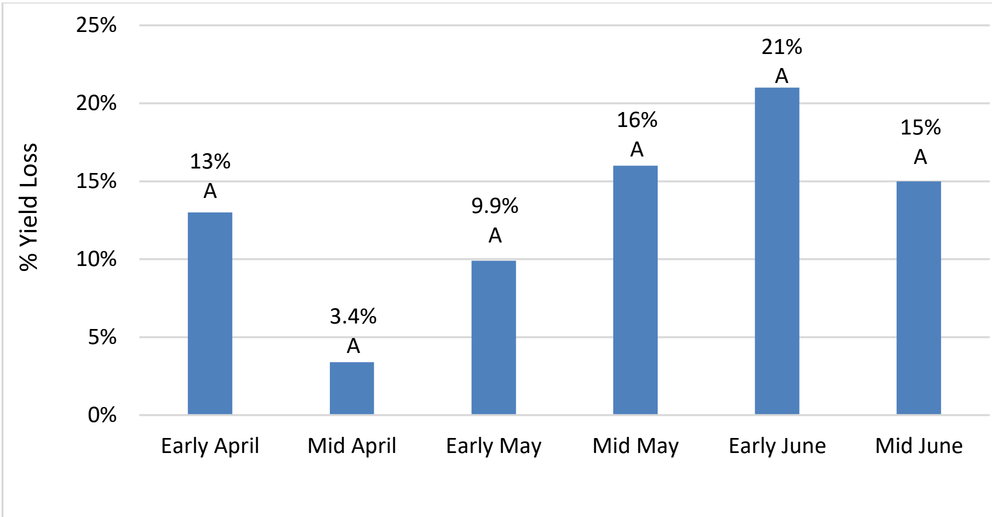

Figure 7. Objective 3. Yield loss from defoliation compared to the check for each planting date across all locations and years. Treatments with the same letter did not differ significantly (P > 0.05).

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