# INTERACTIONS OF NITROGEN FERTILIZER, COTTON SEEDING RATE, AND LATE SEASON INSECTICIDE FOR TARNISHED PLANT BUG CONTROL IN MIDSOUTH COTTON

**T.G. Teague**
**Arkansas State University/ University of Arkansas System Division of Agriculture**
**Jonesboro, AR**
**A.J. Baker**
**A. Mann**
**University of Arkansas System Division of Agriculture**
**Jonesboro, AR**
**N.R. Benson**
**University of Arkansas System Division of Agriculture**
**Osceola, AR**
**J. Nowlin**
**Arkansas State University**
**Jonesboro, AR**

## Abstract

Cotton producers typically reduce nitrogen (N) fertilizer application rates in cotton in rotation with peanut to improve fertilizer efficiency and reduce costs. Fertilizer management decisions can affect insect pest pressure as well as plant tolerance or compensation capacity. We initiated a multifactor field study in northeast Arkansas in 2020 to explore opportunities to reduce N fertilizer inputs in a cotton – peanut rotation. The study included an evaluation of how reductions in N fertilizer might affect the need for late season crop protection from infestations of tarnished plant bug (*Lygus lineolaris* (Palisot de Beauvois)). Cotton seeding rate also was included in the multifactor study to validate this option for reducing input costs. There were 4 fertilizer treatments, 2 seeding rates, and 2 late season insecticide regimes, with treatments arranged in a 4*2*2 factorial experiment with 3 replications. Planting, fertilizer and insecticide applications were made using the cooperating producer's commercial-scale equipment. Fertilizer treatments were: 1) base 80 lbs N /ac; 2) base 80 lbs N /ac+ foliar fertilizer (71 days after planting (DAP)); 3) base 80 lbs/ac+ sidedress 40 lb/ac (60 DAP); and 4) base 80 lbs/ac+ sidedress 40 lbs + foliar fertilizer (60 and 71 DAP, respectively). Seeding rates were either 27,512 or 41,267 seeds per acre (2 or 3 seeds per ft of row on 38-inch row spacing). The final insecticide application for tarnished plant bug infestations (termination timing) was either at physiological cutout (NAWF=5), or insect pest control was extended out to the Extension recommended termination timing of cutout + 250 DD60s. There was extensive in-season pest and plant monitoring. Yield was assessed using yield monitor data, and treatment effects were evaluated relative to different soil texture classifications based on soil electrical conductivity ($EC_a$) in the spatially variable field. Soil ECa was used as a proxy for soil texture, and soil textures in the field were categorized as either coarse sand ($<9 mSm^{-1}$) or loamy sand ($\geq 9 mSm^{-1}$) based on Veris Soil Surveyor measurements (shallow); ca. 46% of the field was categorized in the coarse sand classification.

There were no significant yield effects from either seeding rate or the foliar fertilizer application. Yield response to the sidedress fertilizer application was dependent on both insect control practices and soil texture. If Extension recommended insect control termination timing was followed, then there was no significant response to the additional sidedress fertilizer. The lowest N application rate was sufficient. If insect control was terminated earlier than recommended in loamy sand field areas, there was no yield penalty from plant bug infestations if plants received the sidedress application. If insect control was terminated earlier than recommended in coarse sand field areas, there were lower lint yields, and lowest overall yields were observed for plants that received only the base 80N. Plant compensation capacity and plant tolerance to feeding damage likely was reduced with lower N application rates in coarse sand field areas. Overall, results from this first-year study showed that if recommended late season pest management guidelines were followed, there was no penalty for reduced N fertilizer application rates in cotton following peanut. When this practice was coupled with reduced seeding rate, production inputs were reduced by ~$50/acre. Future research with peanut-cotton rotations will include expanded evaluations of soil sampling, plant nutrition, herbivore interactions, and opportunities for site-specific management.

## Introduction

Peanut production has expanded in Arkansas and Missouri cotton production areas, and the rotation is often credited with increasing soil nitrogen (N) because of biological N fixation by the legume. Extension recommendations from other peanut-producing states suggest that producers reduce their standard N fertilization rates, or ***apply N credits***, for crops planted after peanut (Crozier et al. 2010, Caddel et al 2012). These credits typically range from 20 to 60 lbs N/ac based on background levels of soil nutrient availability which should be determined using appropriate soil sampling protocols and techniques. If N credits can be adopted without yield or quality reductions, then fertilizer input costs can be reduced, and the risk of over fertilization can be reduced. Efficient N fertilizer management is important not only because of fertilizer costs, but also because excess soil N can result in cotton maturity delays, often making defoliation more expensive. In the midsouth, a late crop can have greater late season weather risks which can reduce yield and fiber quality. Delayed crop maturity can lead to increased late-season insect pest pressure, particularly from tarnished plant bug, *Lygus lineolaris*. More bugs typically means more costly insecticides for crop protection. An important cultural control tactic in cotton IPM is judicious use of N fertilizer.

There have been no recent plant nutrition field studies in Arkansas with modern cotton varieties to examine changes in N fertility in a cotton–peanut rotation, and northeast Arkansas producers requested field studies to determine if N credits are warranted or if standard fertilizer practices should be maintained. In response, we initiated an on-farm study in 2020 to assess the general midsouth Extension guidance to reduce N fertilizer from standard 100 to 120 lbs N/ac down to 80 lbs N/ac in the year following peanut. Our multifactor experiment included a range (low to high) of production inputs including late season control of tarnished plant bug and cotton seeding rates. We included seeding rates in the study because transgenic seed is one of the costliest production inputs in US. Our previous field research findings have shown that reduced seeding rates are a viable option for reducing production costs (Benson et al., 2015, 2016, 2017; Teague et al 2019, 2020). Because of spatially heterogeneous soils in the northeast Arkansas production region, we considered variation of soil texture in our analysis as we evaluated cotton crop response to treatments. Information related to spatial variability could crop managers on potential options and practical utility of variable rate seeding, fertility, and/or pest control for site-specific management in order to reduce costs and improve profitability.

## Materials and Methods

The 2020 field study was conducted in a commercial field on Wildy Family Farms in Mississippi County, AR (35°52'31.73"N, 90°15'55.41"W). Soils at the field site were classified as Bruno-Crevasse complex (Sandy, mixed, thermic Typic Udifluvents). The plot plan is shown in
Figure 1. Plots were 150 ft long, 12 rows wide with at least 24 rows separating plots (Figure 2A). The study included 4 fertilizer treatments, 2 seeding rates, and 2 late season insecticide regimes arranged in a 4*2*2 factorial experimental design arranged in a RCB with 3 replications.

### Fertilizer

A base level of 80 lbs N per acre fertilizer was broadcast across the experiment 3 weeks after planting. Nitrogen treatments were: 1) base 80 lbs/ac, 2) base 80 lbs/ac+ foliar fertilizer (FF) (a commercial blend with N, K, B & S ), 3) base 80 lbs/ac+ sidedress 40 lb/ac (SD 40); 4) base 80 lbs/ac+ SD 40 + FF. Product descriptions and timing are listed in Table 1. All applications were made using the cooperating producer's equipment. Broadcast application of "sidedress" fertilizer was made with a commercial applicator with 22-row swath ((Figure 2B), and foliar fertilizer spray application was applied using a John Deere R3028 ExactApply high clearance sprayer with 36-row boom. Spray swaths for the fertilizer application were 18 rows wide with the 6-row harvest path for treatment yield assessments positioned in the center of the spray swath (Figure 2C).

### Seeding rate

Cotton cultivar Deltapine 1646 B2XF was planted 11 May at seeding rates of 2 and 3 per ft of row (38" row spacing).This would be equivalent to 27,512 or 41,267 seeds per acre. A 12-row variable rate planter was used. The base seeding rate for the entire field was 3 seeds per ft of row, and the lower rate was used only in the 12-row plot areas.

### Insecticide termination timing

The final insecticide application for tarnished plant bug (termination timing) was either at physiological cutout (NAWF=5), or 13 days later at approximately the Extension recommended termination timing of cutout + 250 DD60s. Prior to the final termination spray, the entire field had received blanket sprays through the season. The spray swath for the final termination application was 18 rows wide with the harvest path for yield assessments positioned in the center portion of the spray swath.

**Soil Samples & Soil Textural Classification**

In March 2020, our team collected soil samples across different soil textures. We used measurements of soil electrical conductivity ($EC_a$) as a proxy for soil texture. Spatial variability of soil texture within the field was the consequence of soil formation (alluvial soils), seismic activity associated with the New Madrid fault, and land leveling. Soil $EC_a$ measurements were made using from a Veris Soil Surveyor (Veristech.com) in early spring. Soil texture classes based on soil $EC_a$ Data (5m shallow) were stratified into two categories -- coarse sand (<9 mS m-1) and loamy sand (≥ 9mS m-1). The coarse sand category encompassed ~46% of the field (Figure 2). Class categories were based on previous experience at the farm site, analysis of historical yield, and plant monitoring data. Soil was collected to at 0 to 6 and 6 to 12 inch depths with through the field either in coarse sand or loamy sand sample sites (Table 2).

Replication (rep)
1
2
3

Fertilizer Treatment (fert)
1 80 N/ac
2 80 N/ac + Foliar Fertilizer
3 80 N/ac + SD (40N+S)
4 80 N/ac + SD (40N+S) + Foliar Fertilizer

Seeding Rates (sr)
1 3 seeds/ft
2 2 seeds/ft

Insecticide Termination (plant bug)
1 Early Termination (cutout)
2 Recommended (cutout+250HU)

Plots were 150 ft long and 22 rows wide

<--N

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| rep | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| fert | 1 | 4 | 1 | 2 | 3 | 4 | 2 | 3 | 1 | 2 | 3 | 4 |
| sr | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 2 | 1 | 1 | 2 | 1 |
| bug | 1 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 1 | 1 | 2 | 2 |
| plot | 104 | 108 | 112 | 116 | 204 | 208 | 212 | 216 | 304 | 308 | 312 | 316 |
| | | | | | | | | | | | | |
| | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| | 4 | 1 | 4 | 1 | 2 | 3 | 3 | 2 | 2 | 3 | 2 | 3 |
| | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 |
| | 2 | 1 | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 2 |
| | 103 | 107 | 111 | 115 | 203 | 207 | 211 | 215 | 303 | 307 | 311 | 315 |
| | | | | | | | | | | | | |
| | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| | 3 | 2 | 3 | 4 | 1 | 2 | 4 | 1 | 3 | 4 | 1 | 2 |
| | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 2 |
| | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 2 |
| | 102 | 106 | 110 | 114 | 202 | 206 | 210 | 214 | 302 | 306 | 310 | 314 |
| | | | | | | | | | | | | |
| | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| | 2 | 3 | 2 | 3 | 4 | 1 | 1 | 4 | 4 | 1 | 4 | 1 |
| | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 2 |
| | 1 | 2 | 2 | 1 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 1 |
| | 101 | 105 | 109 | 113 | 201 | 205 | 209 | 213 | 301 | 305 | 309 | 313 |

Figure 1. Field plan for 2020 fertilizer*seeding rate*insect control termination timing trial -- Manila, AR.

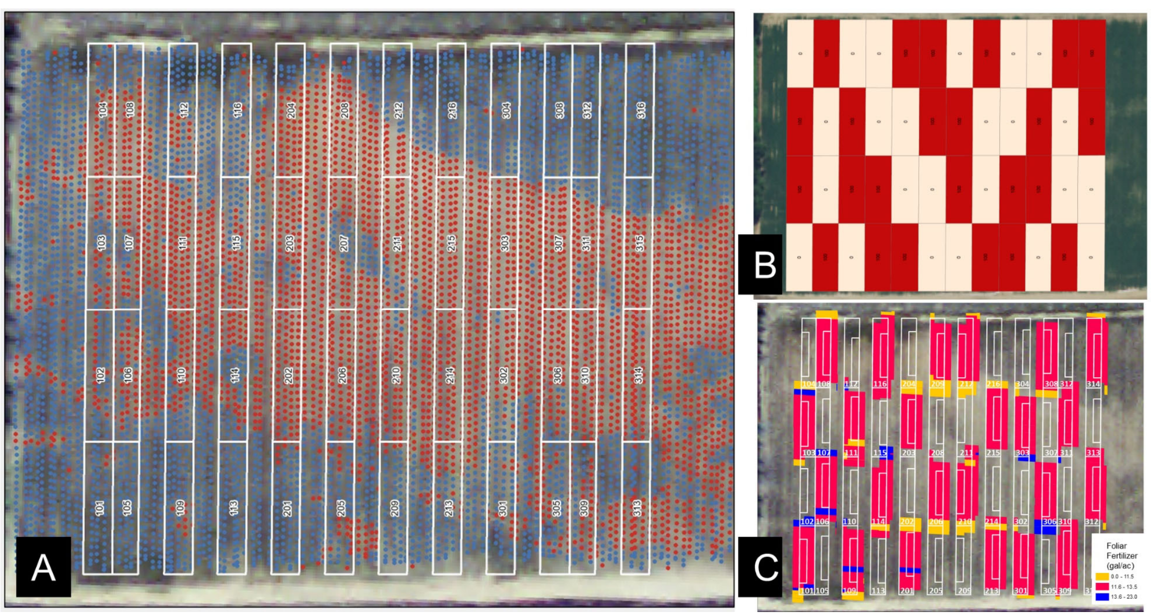


Figure 2. Three maps showing paths for measurements and treatments for the fertilizer*seeding rate*insect control termination trial: A) Soil $EC_a$ (shallow) map showing 12-row wide planter swaths for seeding rate treatments overlaid on a Soil $EC_a$ map showing spatial variation in soil texture. Soil texture classes were based on soil $EC_a$ data (5m shallow) stratified into two categories -- coarse sand (<9 mS $m^{-1}$) and loamy sand (≥ 9mS $m^{-1}$). B) Prescription map showing 22-row swaths for the sidedress (SD40) application. C) As-applied map for the foliar fertilizer application

showing the 18-row swath (similar 18-row swaths used for termination insecticide application). Also shown are the 6-row wide, 95 ft long, harvest assessment areas used in yield monitor data analysis.

Table 1. Dates of planting, fertilizer applications, irrigation, sampling, foliar insecticide application, and harvest for 2020 for the fertilizer*seeding rate*insect control termination trial -- Manila, AR.

| Operation | Date and description | Days after planting |
|---|---|---|
| Date of cotton planting | 11-May | 0 |
| Fertilizers | Base: 1-Jun -- all plots (broadcast) (80 units N (97.7 lbs of 80-0-0-10 S (76.87 lbs urea and 20.83 lbs ammonium sulfate)) | 21 |
| | Sidedress (SD): 10-July (granular broadcast) (131.4 lbs of 33.5-0-0-12S-1B (ammonium sulfate) | 60 |
| | Foliar Fertilizer (FF): 21-July-- (foliar broadcast spray) (Helena products: CoRoN® (10-0-10 plus 0.5% B) (1gal/ac) & Ele-Max Sulfur® (10-5-0 with 10% S) (32oz.ac) (Helena Agri-Enterprises, Collierville, TN) | 71 |
| Stand counts | 19-May, 26-May, 2-Jun, 8-Jun | 8, 15, 22, 26 |
| Thrips assessments | 2-Jun | 22 |
| *Lygus* sampling | 27-Jul, 3-Aug, 10-Aug, 14-Aug, 18-Aug, 25-Aug | 77, 84, 91, 95, 99 |
| COTMAN Sampling | 26-Jun, 30-Jun, 6-Jul, 13-Jul, 20-Jul, 27-Jul, 30-Jul, 3-Aug, 6-Aug, 10-Aug , 18-Aug | 46, 50, 56, 63, 70, 77, 80, 84, 87, 91, 99 |
| Foliar insecticides | 28-May, 12-Jun, 24-Jun, 9-Jul, 24-Jul, **11-Aug** (termination insecticides - acephate+lamba cyhalothrin) | 17, 32, 44, 59, 74, 92 |
| Furrow irrigation | 10-Jul, 21-Jul, 6-Aug, 13-Aug, 18-Aug, 26-Aug | 50, 27, 73, 80, 85, 93 |
| Harvest aids | 26-Sep, 3-Oct | 138, 145 |
| Machine harvest | | |

Stand counts to assess success of meeting seeding rate targets were made using line-transect sampling. Samplers counted plants per 3 ft in two transects across each 12- row plot at 8, 15, 22, and 26 DAP. Stand count data were compared to the seeding rate target.

COTMAN plant monitoring activities were initiated at first square and included evaluations of plant main-stem nodal development, height, and first position square and boll retention using standard COTMAN® sampling protocols (Oosterhuis and Bourland 2008). Monitoring continued through the effective squaring and flowering periods. Efficient plant monitoring requires a standard with which to compare actual plant growth. In the COTMAN system, crop growth curves are generated from plant mapping data (counts of main-stem sympodial nodes and retention of first position fruiting forms) and consist of squaring nodes plotted against days after planting. Growth curves are compared to the COTMAN target development curve, a standard curve, which is assumed to represent an optimum combination of early maturity and high yield (Bourland et al 2008). The standard curve shows main stem squaring nodes through a season, ascending at a pace of one node each 2.7 days through first flower at 60 days after planting, and then descending to physiological cutout at 80 days. The rate of squaring node development after first flower declines in response to an increasing boll load. This post-flower decline in terminal growth is measured as NAWF (nodes above white flower). Physiological cutout was defined as the flowering date of the last effective boll population. Research in Arkansas has shown that the field or management unit is at physiological cutout when the sampled plant population reaches an average of NAWF = 5 (Oosterhuis and Bourland 2008).

Arthropod pests were monitored in weekly inspections. During stand counts, samplers scouted for cutworms (Lepidoptera: Noctuidae) and other seedling pests. Thrips (Thysanoptera: Thripidae) assessments were made 2 and 3 weeks after planting using whole plant alcohol washes with 10 plants collected per plot. Tarnished plant bugs were monitored weekly starting in the first week of squaring (~35 DAP) through physiological cutout (NAWF=5). Sampling included use of sweep nets (preflower) and drop cloths (full season).

Yield assessments were based on data collected from the cooperating producer's John Deere 7600 cotton picker equipped with calibrated yield monitor with GPS receiver to attain site-specific lint yield. Georeferenced data layers from the yield monitor and from Veris Soil Surveyor (5 m -shallow) were joined using ArcGIS (ESRI; ver10.7) to enable inclusion of soil texture as a covariate in yield analysis. A factorial structure was used for analysis of the yield monitor measured yield data with seeding rate, cover crop termination timing, and block effect; soil ECa classifications were used as a co-variate. Statistical analyses were performed using SAS 9.4 (SAS Institute). Analysis of variance was conducted using mixed model procedures (Proc Mixed). Mean comparisons were made using LSMEANS procedure with the Tukey adjustment ($P \leq 0.05$).

Fiber quality was evaluated using a 40-boll sample in treatment plots in field areas with loamy sand (40 bolls harvested throughout plants including both upper and lower canopy bolls). Samples were ginned on laboratory gin, and fiber set to the Texas Tech Fiber and Biopolymer Research Institute for HVI evaluations.

Table 2. Initial soil properties from soil sample depth of 0 to 6 inches and 6 to 12 inches with soil $EC_a$ directed sample site selection either in loamy sand or coarse sand categories. Nutrients were extracted from soils using Mehlic-3 reagent at the Universiy of Arkansas Soil Test Laboratory, Marianna, AR.

| | Soil texture category | Loamy sand | | Coarse sand | |
|---|---|---|---|---|---|
| | Soil sample depth (inches) | 0-6 | 6-12 | 0-6 | 6-12 |
| pH | | 6.5 | 6.3 | 7.0 | 6.7 |
| CEC | cmol/kg | 9 | 13 | 7 | 7 |
| P | mg kg$^{-1}$ | 52 | 27 | 53 | 38 |
| K | mg kg$^{-1}$ | 80 | 70 | 143 | 73 |
| Mg | mg kg$^{-1}$ | 208 | 292 | 132 | 153 |
| Ca | mg kg$^{-1}$ | 1032 | 1416 | 760 | 731 |
| S | mg kg$^{-1}$ | 6 | 9 | 4 | 4 |
| B | mg kg$^{-1}$ | 0.4 | 0.4 | 0.3 | 0.5 |
| Zn | mg kg$^{-1}$ | 17.7 | 4.0 | 13.3 | 3.9 |
| Mn | mg kg$^{-1}$ | 54 | 51 | 70 | 81 |
| Fe | mg kg$^{-1}$ | 202 | 226 | 156 | 177 |
| Cu | mg kg$^{-1}$ | 1.1 | 1.3 | 1.0 | 0.7 |

## Results

Rainfall amounts during the season were above average in May, June, July and early August (Table 3). The field was irrigated 7 times with applications in July and early August. Remnants of Hurricane Laura resulted in rainfall accumulations in late August after

Table 3. Monthly precipitation (inches) measured at the study site for the 2020 season compared with 30-year average for the county -- Manila, AR.

| Mean per month | 30-year Average | 2020 Rainfall | Departure |
|---|---|---|---|
| | ---------------------inches--------------------- | | |
| May | 5.37 | 6.55 | 1.18 |
| June | 3.99 | 4.26 | 0.27 |
| July | 4.04 | 2.06 | -1.98 |
| August | 2.36 | 5.25 | 2.89 |
| Total Season | 15.76 | 18.12 | 2.36 |

Plant stand density was measured in stand counts made weekly for 4 weeks starting at 8 DAP (Figure 3). Seeding rate treatments reached at least 90% of target stand by 14 DAP.

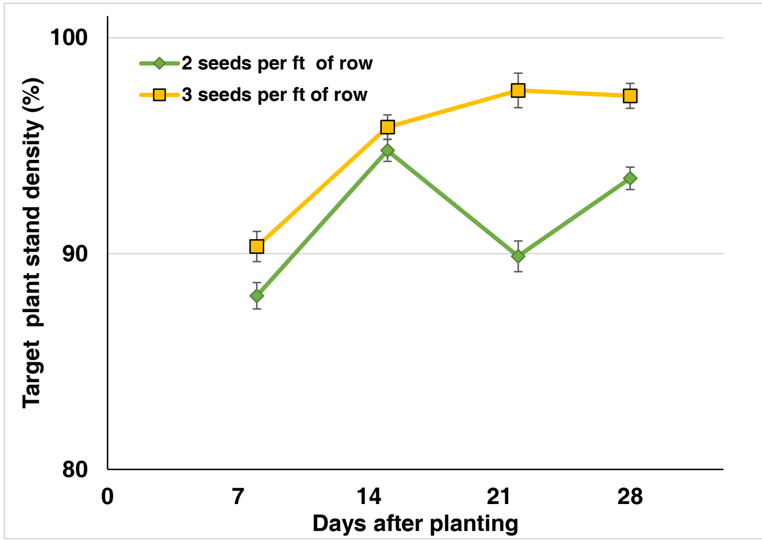


Figure 3. Mean (±SEM) plant stand density as a percentage of target stand (2 or 3 seeds per ft of row) for seeding rate effects measured in two, 3-ft transects across the 12-rows plots on 8, 15, 22, and 29 days after planting – 2020 Manila, AR.

COTMAN growth curves reflected good growing conditions after planting. The pace of pre-flower main-stem sympodial nodal development (squaring nodes) tracked the standard COTMAN Target Development Curve (Figure 4). First flowers were observed at 60 DAP. COTMAN plant monitoring results showed that first position square shed was at low levels through cutout. Square retention on 1st position, main-stem sympodia during the week of first flowers ranged from 95 to 99%, indicating very low levels of tarnished plant bug feeding activity (data not shown). Results from plant monitoring indicated that, on average, plants reached physiological cutout (NAWF=5) by 82 to 85 DAP (Figure 4) for fertilizer treatment main effects. There were no significant interactions and no statistical differences in days to cutout noted with either fertilizers or seeding rate effects.

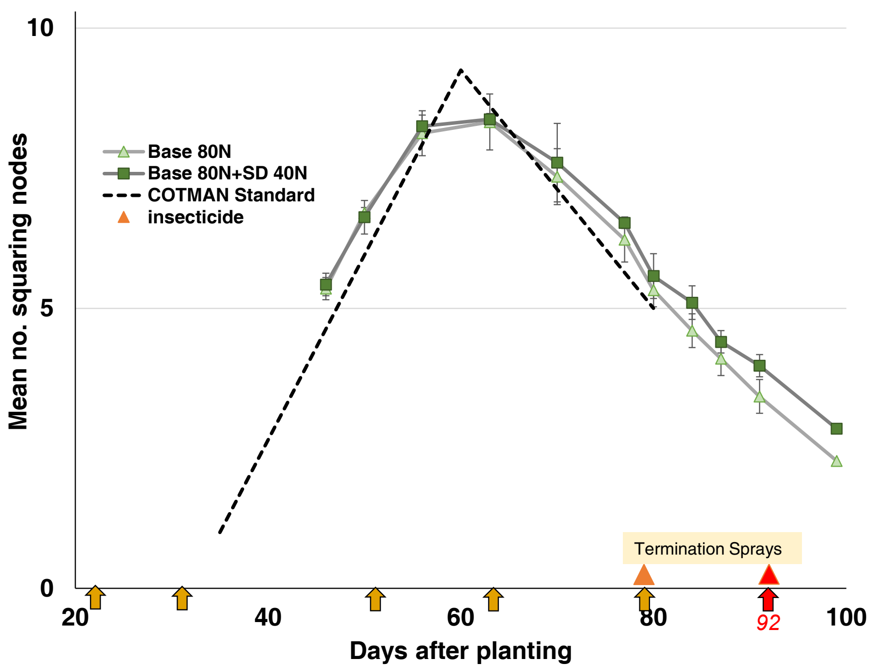


Figure 4. COTMAN target development curve (Standard) and actual growth curves for fertilizer treatment main effects showing the base 80 lbs N/ac and base 80 N lbs + sidedress (SD) 40 lbs N/ac effects. Also shown are dates of in-season insecticide blanket applications in the study field including the timing of the termination sprays, either 79 or 92 days after planting.

Table 4. Mean no. days from planting to physiological cutout (NAWF=5) for fertilizer main effects plus heat unit accumulation from cutout to the time of the final insecticide termination spray and defoliation.

| Fertilizer treatment | Days to NAWF=5 | Date of cutout | Heat units from NAWF=5 Final Termination | Heat units from NAWF=5 Defoliation |
|---|---|---|---|---|
| | (days) | | (DD60s) | |
| Base 80 N/ac | 83 | 2 Aug | 177 | 858 |
| Base 80 N + Sidedress 40N | 85 | 4 Aug | 141 | 822 |

Tarnished plant bug management guidelines set by the University of Arkansas Extension (Studebaker et al 2020) suggest that action threshold increase at the time of cutout. Plant bugs were controlled season-long with blanket insecticide applications. Plant bug infestation levels began to increase after the cutout termination application made at 79 DAP, and by 90 DAP had exceeded the post-cutout action threshold. Results from late season drop cloth samples show reductions in insect counts in the late application on 91 DAP (Figure 5).

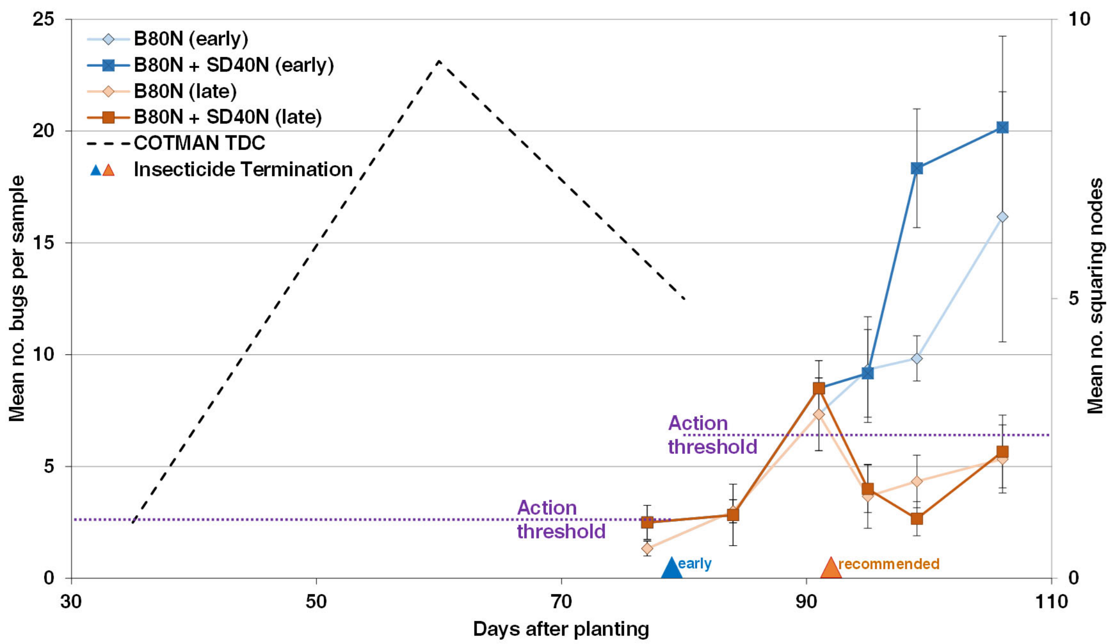


Figure 5. Mean (±SEM) no. tarnished plant bug (*Lygus*) observed per drop cloth sample from late season shown in relation to the COTMAN target development curve (TDC) showing timing of the cutout termination spray at 79 days after planting (DAP) and recommended, insecticide termination timing at 92 DAP for the base 80 lbs N/ac (B80N), and base 80N + sidedress 40 lbs/ac (B80N+SD40N) treatments in the 2020 fertilizer*seeding rate*insect control termination timing trial; Manila, AR.

**Yields**

There were no significant yield differences associated with seeding rate effects or the foliar fertilizer application. Yield data were re-analyzed without seeding rate treatments and with fertilizer effects combined to consider two fertilizer treatments – Base 80N and Base 80N+SD40N. Mean yields ranged from 1408 to 1605 lbs lint/acre (Figure 6). There was a significant fertilizer * termination * soil texture interaction ($P$=0.001) with yield response to fertilizer dependent on insect control termination timing and soil texture. If recommended insecticide termination timing was followed, there were no differences among treatments. The Base 80N application rate was sufficient to produce high yields, and there was no benefit to the additional sidedress of 40lbs N (total 120 lbs for the crop). With an early insecticide termination at cutout (NAWF=5), tarnished plant bug numbers rose to 3X threshold before the effective boll population was safe. Yield of early termination plants that received the sidedress application, and that were growing in loamy sand was similar to those that received the additional insecticide spray at 91 DAP. If insect control was terminated earlier than recommended in coarse sand field areas, there were lower lint yields, and lowest overall yields were observed for plants that received only the base 80N. Plant compensation capacity and plant tolerance to feeding damage likely was reduced with lower N application rates in coarse sand field areas.

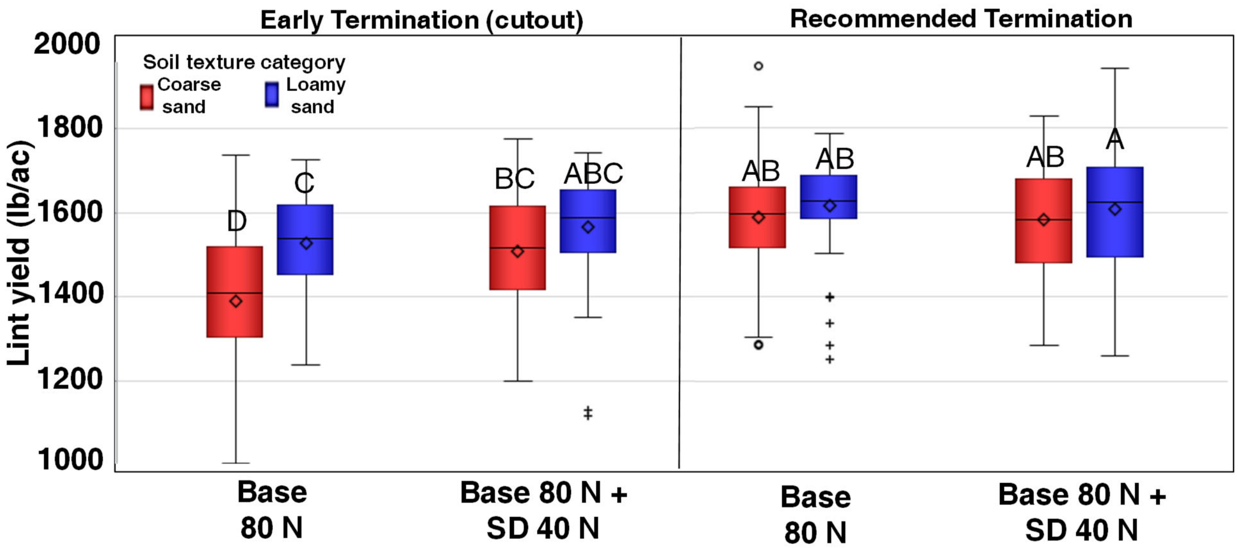


Figure 6. Yield monitor measured yields for plants in coarse sand and loamy sand areas of the field with either 80 N or 80 N +40N (sidedress) in early insect control termination (cutout) or recommended termination timing treatment; Manila, AR. Boxes represent 50% quartile; diamonds within the box depict means, and the line is the median value.

Fiber Quality assessments (HVI) from 40 boll hand-picked samples indicated no significant differences in boll weight or fiber quality parameters associated with fertilizer or seeding rate treatments. Fiber quality was impacted by insect control termination timing with reductions noted in fiber elongation with early insect control termination (Table 5).

Table 5. Mean boll size and fiber quality assessments (HVI[a]) for 40-boll collections showing insect control main effects -- 2020, Manila, AR.

| Termination timing | Boll weight *g* | Micronaire *unit* | Length *in.* | Uniformity *UI* | Strength *g/tex* | Elongation |
|---|---|---|---|---|---|---|
| Early (cutout) | 4.60 | 4.55 | 1.30 | 84.27 | 29.80 | 7.02 |
| Recommended | 4.68 | 4.48 | 1.29 | 84.78 | 28.98 | 7.30 |
| *P>F* | *0.61* | *0.70* | *0.47* | *0.10* | *0.11* | *0.03* |

[a] HVI assessments made at the Fiber & Biopolymer Research Institute, Texas Tech University, Lubbock.

## Discussion

This on-farm field trial provided an opportunity to evaluate an array of practices that could allow growers to reduce their input costs without sacrificing economic yield. One of the most expensive cotton production inputs is treated, transgenic seed. Our 2020 study included comparing crop production with seeding rates of 2 or 3 seeds/ft of row with 38-inch row spacing. Results showed no differences in yield between seeding rates; however, production costs were reduced by $32.40 /acre with the lower rate (Table 6). These findings are similar to those reported from our previous 6 years of on-farm research also using producer equipment on similar soils (Benson et al., 2015, 2016, 2017; Teague et al 2019, 2020). Higher seeding rates may be appropriate where soils may be prone to crusting or in management systems that include planting into non-terminated (green), winter cover crops, but our data indicate that a seeding rate of 2 compared to 3 seeds per ft of row is a cost-saving management choice for cotton production in the sandy soils typical much of the midsouth.

One benefit associated with a cotton-peanut rotation is the potential reduction in N fertilizer expenses for subsequent cotton crops. Even though cotton research in Alabama suggests that residue from peanut crop may contribute 20 to 30 pounds N per acre to the following cotton crop (Adams et al., 1994), results from other studies in Alabama and Florida suggest that assumed N credits are unsupported (Meso et al 2007; Jani et al 2020). Yield levels vary from year to year in the humid southeast and midsouth cotton production systems, and there are sometimes unpredictable crop responses to N fertilizer depending on growing conditions, independent of crop yield potential (Crozier et al. 2010). In our 2020 study, we used base N fertilizer application of 80 lb/ac which was ca. 20 lb/ac less than the standard practice on the cooperating farm. The base rate of 80 units of N resulted in high yields across variable soils. We observed no benefit to a sidedress application of N if Extension-recommended insecticide termination timing was followed; however, if insect control was terminated earlier than recommended, there was a yield penalty depending on N fertilizer and soil texture. In the coarse sand areas of the field (46% of commercial field), there were lower yields with early termination. We measured no yield reductions in loamy sand areas if a split application of N fertilizer applied at 1$^{st}$ flower. The foliar fertilizer application had no effect on yield regardless of plant protection or soil texture.

Our producer collaborators at Wildy Family Farms have a long history (>25 years) of using NAWF-based crop termination guides. The practice allows them to save money by eliminating unnecessary insecticide applications in late season when the last effective boll population is no longer susceptible to feeding damage. Our 2020 research findings support the general guidelines for insect control termination timing of NAWF=5+250 HU for tarnished plant bug. Overall, results from this first-year study showed that if recommended late season pest management guidelines were followed, there was no penalty for reduced N fertilizer application rates in cotton following peanut. When this practice was coupled with reduced seeding rate, production inputs were reduced by ~$50/acre. Future research involving cotton-peanut rotation will include expanded plant nutrition evaluations including decision-making for site selection for soil sampling and consideration of site-specific management for N fertility. Research will also include study of plant tolerance across spatially variable fields.

Table 6. Seed costs for treated, transgenic seed used in the 2020 seeding rate trial (based on cooperating producer costs in spring 2020[a]).

| Seeding rate (per ft of row, | No. seeds (per acre) | Seed cost ($ per acre) |
|---|---|---|
| 2 | 27,512 | $65 |
| 3 | 41,267 | $97 |

[a] Cotton seed costs were based on 50 lb bag cost of $530, with 225,000 seeds per bag, and an estimated cost per seed of $0.0024.

## Acknowledgements

Special thanks to cooperating producers and staff at Wildy Family Farms, Manila, Arkansas, for their continuing support of applied cotton research. This project was supported through Cotton Incorporated Core, the University of Arkansas System Division of Agriculture (USDA NIFA project ARK02355), and Arkansas State University.

## References

Adams, J. F., C.C. Mitchell, and H.H. Bryant. 1994. Soil test fertilizer recommendations for Alabama crops. Alabama Agriculture Experiment Station, Agronomy and Soils Department Series. No. 178.

Benson, N.R., D.K. Morris, and T.G. Teague. 2015. Effects of irrigation timing and seeding rate on the maturity and yield of cotton grown in a northeast Arkansas field. pp. 91-97 In: Derrick M. Oosterhuis (Ed.), Summaries of Arkansas Cotton Research 2014, Arkansas Agricultural Experiment Station Research Series 625.

Benson, N.R., A.M. Mann, D.K. Morris, and T.G. Teague. 2016. Seeding rate decisions and impacts on spatial yield variability in Northeast Arkansas cotton pp. 25-30 In: Derrick M. Oosterhuis (Ed.), Summaries of Arkansas Cotton Research 2015, Arkansas Agricultural Experiment Station Research Series 635.

Benson, N.R., A.M. Mann, and T.G. Teague. 2017. Cultivar selection, seeding rate, and irrigation timing effects on yield of NE Arkansas cotton. pp. 89-96 In: F.M. Bourland (Ed.), Summaries of Arkansas Cotton Research 2016, Arkansas Agribourcultural Experiment Station Research Series.

Bourland, F.M., D.M. Oosterhuis, N.P. Tugwell, M.J. Cochran and D.M. Danforth. 2008. Interpretation of crop growth patterns generated by COTMAN. *In:* D.M. Oosterhuis and F.M. Bourland (Eds). COTMAN Crop Management

System. U. of Ark Agric. Exp. Sta., Fayetteville, AR. http://cotman.org/Doc.php accessed 10 January 2019.

Caddel, J., D. Redfean, H. Zang, J. Edwards, S. Deng. 2012. Forage legumes and nitrogen production. Oklahoma Cooperative Extension Service PSS-2590-6.

Crozier, C.R., Hardy, D.H., Kissel, D. E., J.L. Oldham, S. Phillips, L. Sonson. 2010. Research-based soil testing and recommendations for cotton on coastal plain soils. Southern Cooperative Series Bulletin no. 410 ISBN 1-58161-410-1.

Jani, A.D, M.J. Mulvaney, J.E. Erickson, R.G. Leon, C.W. Wood, D.L. Rowland, H.A. Enloe. 2020. Peanut nitrogen credits to winter wheat are negligible under conservation tillage management in the southeastern USA. Field Crops Research 249(2020) 107739.

Meso, B., K.S. Balkcom, C.W. Wood, and J.G. Adams. 2007. Nitrogen contribution of peanut residue to cotton in a conservation tillage system. 30:115301165.

Oosterhuis D.M. and F.M. Bourland. 2008. (eds.) COTMAN Crop Management System, University of Arkansas Agricultural Experiment Station, Fayetteville, AR. pp. 107.

Studebaker, G., Bateman, N, J. Davis, J.D. Hopkins, B. Thrash, J. Lee, K. Loftin, G. Lorenz., P. Spradley, N. Joshi, J. Zawislak, A. Cato, and T.G. Teague. 2021. Insecticide recommendations for Arkansas – MP 144. University of Arkansas System Division of Agriculture. https://www.uaex.edu/publications/mp-144.aspx

Teague, T.G. 2016. Plant-insect interactions and cotton development. Pp. 27-65 *In:* J. Snider and D.M. Oosterhuis (Eds.), Linking Physiology to Management. Cotton Foundation Reference Book Series Number Nine. The Cotton Foundation. Cordova, TN, USA.

Teague, T.G., N.R. Benson, K.D. Wilson, and A.M.H. Mann 2018. Seeding rate, cultivar selection and winter cover crop effects on maturity and yield of cotton pp. 98-107 In: F.M. Bourland (Ed.), Summaries of Arkansas Cotton Research 2017, Arkansas Agricultural Experiment Station Research Series 652.