The Influence of Nitrogen Fertilizer and Wheat-Straw Management on Double-Cropped Soybean Germination and Development

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RESEARCH PROBLEM

Many eastern Arkansas producers who typically grow soybean (*Glycine max* L.) in a wheat (*Triticum aestivum* L.)-soybean double-crop system choose to burn wheat residue immediately after harvest as a means of seedbed preparation. Burning residue adds a considerable amount of carbon dioxide (CO_2) to the atmosphere and prevents the return of much needed carbon (C) to the soil. Alternative wheat-residue management practices have the potential to be as, if not more, environmentally sound, economical, time-efficient, and productive as the traditional practice of burning wheat residue prior to growing a soybean crop. Alternative wheat-residue management practices may also improve the quality of the soil resource in the delta region of eastern Arkansas.

BACKGROUND

The Arkansas Agricultural Statistics Service estimated that approximately 3.0 million acres of soybean were planted in 2001 in Arkansas. The bulk of this area is in eastern Arkansas, and one-third of the soybean acreage are produced in a soybean-wheat double-crop production system. Benefits of this particular production system include: increased profits due to more efficiently used resources, reduced soil-water losses, and enhanced utilization of tillage methods that conserve soil, water, and energy (Sanford, 1982).

Though many farmers choose to burn wheat residue immediately after harvest as a simple means of seedbed preparation and to facilitate planting and pest control, burning residue is of little agronomic benefit (NeSmith et al., 1987). Burning adds CO_2 to the atmosphere and prevents the return of much needed C to the soil, and soil C and organic matter are at quite low levels in eastern-Arkansas soils. Returning organic materials to the soil would not only enhance soil quality but also would have positive environmental benefits. The positive results may include decreased erosion, prevention of agricultural runoff, and decreased amounts of CO_2 released to the atmosphere.

Despite the popularity of burning in eastern Arkansas, some farmers have adopted alternative post-wheat harvest operations. New and improved equipment has made planting more feasible in high-residue conditions; therefore, some farmers opt to plant into wheat stubble after conservation tillage (CT) or no-tillage (NT) field preparation methods. These methods are environmentally sound and have been proven to produce comparable yields while reducing production costs. As compared to CT, NT requires less labor and energy and decreases the need for certain machinery.

We hypothesized that reduced or no-tillage methods paired with non-burning of residue would result in similar soybean growth and development compared to conventional production system practices. The objective of this study was to evaluate the effect of various wheat residue-management practices on soybean growth and development.

PROCEDURES

Research was conducted on similar silt-loam Fragiudalfs in eastern Arkansas at the Pine Tree (PTBS) Branch and Cotton Branch (CBES) Experiment Stations. The previous crops grown were grain sorghum (*Sorghum bicolor* L.) and soybean at the PTBS and CBES, respectively. Prior to wheat planting, the plot area was disced twice followed by landplaning and field cultivation at the PTBS and disced twice followed by field cultivating at the CBES.

A split-strip plot was designed with six replications. The treatments evaluated were NT and CT, burning and non-burning wheat residue, and high and low wheat residue levels. All eight treatment combinations were included in the experimental design.

FIELD MANAGEMENT

Before wheat planting at the CBES, a 200 lb/acre broadcast application of 9-23-30 blended fertilizer was applied. In Fall 2001, the Coker 9663 wheat variety was drill seeded with a 6-inch row spacing at a rate of 98 lb/acre at the PTBS and 100 lb/acre at the CBES. In Spring 2002, 10- by 20-ft plots were established. In early March, all plots were fertilized with a 90 lb N/acre broadcast application of urea (46% N). To obtain different levels of aboveground wheat-residue production, twenty-four of the forty-eight plots were fertilized with an additional 90 lb N/acre as urea during the late-jointing stage.

Wheat was harvested in early June at both locations. A plot combine was used to collect the entire length of the middle 5 ft of each plot. After the wheat harvest, the burning treatment was imposed. After burning, the conventional tillage treatment was imposed, which included discing twice and seedbed smoothing.

Soybeans were planted on 17 and 18 June at the PTBS and CBES, respectively. The glyphosate-resistant Pioneer 35B82 soybean variety of maturity group 5.3 was planted at a seeding rate of 89 lb/acre at the PTBS and 42 lb/acre at the CBES. A higher seeding rate was needed at the PTBS because of low soil-moisture conditions at the time of planting. Soybeans were planted using a no-till drill at both locations with a row spacing of 7.5 inches. Plots at the PTBS were sprinkle-irrigated about 10 d after planting to insure adequate stands. Plots were further irrigated by flooding at the PTBS three times throughout the growing season. Plots at the CBES were furrow-irrigated three times throughout the season. Weeds and insects were controlled using University of Arkansas Cooperative Extension Service recommendations.

Following wheat harvest and residue burning, but prior to cultivation and soybean planting, aboveground wheat-residue levels were measured by cutting and collecting the residue within a 2.7-sq. ft. metal frame. The residue sample was subsequently oven dried at 158°F (70°C) for 48 hrs and weighed to express the residue level on a lb/acre basis.

Stand counts (i.e., plant population) were obtained at 8 and 30 d after planting by averaging the number of soybean plants within two 3.3-ft (1-m) sections of row in opposite corners of the plots. Vegetative growth stages were determined 30 d after planting using a soybean growth-staging system (Anonymous, 2000), which is based on the number of fully developed trifoliates above the first node. Leaf area index (LAI) was measured in the soybeans 86 d after planting using a LI-COR LAI-2000 plant canopy analyzer (Li-Cor, Inc., Lincoln, NE; Wells and Norman, 1991).

Soil temperature at a 1-inch depth was measured periodically throughout the growing season with a probe thermometer. Volumetric soil moisture content was also measured periodically throughout the soybean growing season in the 0- to 2.5-inch depth range using a Theta Probe, which records dielectric voltage readings and converts them to volumetric water contents using a soil-specific calibration equation.

Treatment effects (i.e., tillage, burning, and residue level) and their interactions were determined by analysis of variance using SAS software (SAS 8.1, SAS Institute, Cary, NC).

RESULTS AND DISCUSSION

Wheat-Residue Level

Despite the addition of N at 90 and 180 lb N/acre to achieve two different amounts of aboveground wheat residue, the N-fertilization rate (i.e., low versus high) did not significantly affect the amount of wheat residue that remained on the soil surface following wheat harvest. The low-residue-level treatment averaged 3,496 (± standard error = 328) lb/acre of wheat residue, while the high-residue-level treatment averaged 2906 (±212) lbs/acre of wheat residue.

Soybean Seedling Populations

Neither tillage nor wheat-residue level significantly affected soybean stand counts (i.e., plant population) by 8 d after planting at either location. However, burning significantly affected ($P = 0.031$) soybean populations at the CBES (Fig. 1a), but not at the PTBS (Fig. 1b). Soybean populations averaged 46,748 (±4,250) and 23,374 (±2,125) plants/acre for the burned and non-burned treatments, respectively, at the CBES and averaged 53,122 (±8,500) and 61,622 (±12,749) plants/acre for the burned and non-burned treatments, respectively, at the PTBS. Neither soil temperature nor moisture (data not shown) differed significantly in the burn treatments at either location to explain differences in soybean population 8 d after planting.

By 30 d after planting, there was still a significant burning effect (P = 0.022) at the CBES, where the soybean population averaged 59,497 (±6,375) and 40,373 (±2,125) plants/acre for the burn and no-burn treatments, respectively (Fig. 1a), but not at the PTBS (Fig. 1b). However, there was a significant tillage effect (P = 0.029) at the PTBS, where the soybean population averaged 282,612 (±21,249) and 78,621 (±10,624) plants/acre for NT and CT, respectively, but not at the CBES. Wheat-residue level did not affect soybean populations 30 d after planting at either location.

Vegetative Growth Stages

Soybean growth and development through the vegetative growth stages varied by location. At the CBES, the soybean crop was at a significantly more advanced vegetative growth stage in the NT versus CT (P = 0.013), no-burn versus burn (P = 0.007), and low-residue versus high residue level (P = 0.008) treatments (Fig. 2). There were significant residue level × tillage (P = 0.041), residue level × burn (P = 0.044), and residue level × tillage × burn (P = 0.025) interactions at the CBES. In contrast, there were no significant treatment effects or treatment interactions on soybean vegetative growth stages at the PTBS. There were also no consistent trends in soil temperature and/or moisture (data not shown) within 30 d after planting to suggest that significant treatment differences in soybean vegetative growth stages at the CBES were related to treatment-induced differences in soil temperature or moisture.

Leaf Area Index

By 86 d after planting, any treatment effects on soybean growth and development throughout the growing season should have either manifested themselves or the soybean crop should have adjusted to the imposed treatments and compensated for early-season differences to mask late-season treatment differences in soybean growth and development. Despite early-season differences in soybean populations and vegetative growth stages at the CBES, there were no treatment effects on LAI 86 d after planting (Fig. 3). Mean LAI ranged from 3.25 (±0.2) to 3.80 (±0.2) $m^2 m^{-2}$ across all treatments at the CBES. In contrast, tillage (P = <0.001), burning (P = 0.008), and wheat-residue level (P = 0.013) significantly affected soybean LAI at the PTBS despite fewer early-season differences in growth and development at the PTBS compared to the CBES. In addition, there was a significant (P = 0.009) tillage × residue level interaction. Effects on soybean LAI indicate that the treatments alone or in some combination affected the canopy architecture, which influences light interception and photosynthesis and may or may not ultimately affect soybean yield.

PRACTICAL APPLICATIONS

Soybean growth and development response to imposed residue management treatments varied between study locations, but a few generalities were apparent. Tillage and residue burning affected soybean plant populations, but wheat-residue level did not. Tillage, residue burning, and wheat-residue level all affected soybean vegetative growth stage and LAI. After a single wheat-soybean cropping cycle, enough evidence exists to suggest that alternative wheat-residue management practices affect soybean growth and development equally, and in some cases more positively, when compared to the common practice of burning wheat residue followed by conventional tillage prior to sowing the subsequent soybean crop.

ACKNOWLEDGMENTS

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LITERATURE CITED

Anonymous. 2000. Arkansas soybean handbook. University of Arkansas Cooperative Extension Service Misc. Publ. 197.

NeSmith, D.S., W.L. Hargrove, D.E. Radcliffe, E.W. Tollner, and H.H. Arioglu. 1987. Tillage and residue management effects on properties of an Ultisol and double-cropped soybean production. Agron. J. 79:570-576.

Sanford, J.O. 1982. Straw and tillage management practices in soybean-wheat double-cropping. Agron. J. 74:1032-1035.

Wells, J.M. and J.M. Norman. 1991. Instrument for indirect measurement of canopy architecture. Agron. J. 83:818-825.

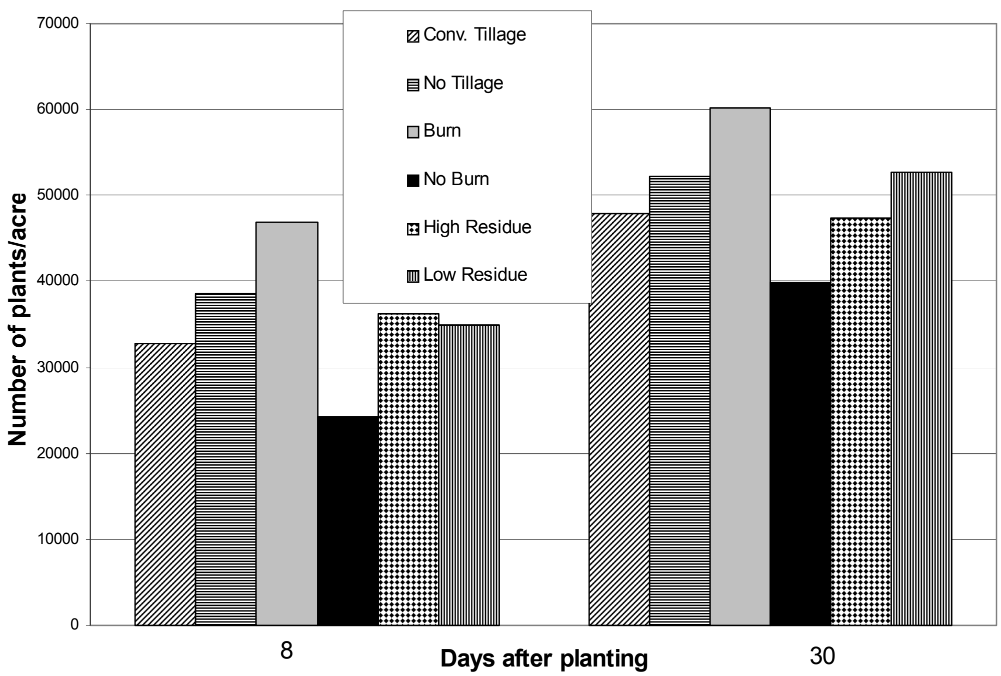

Fig. 1a. Standcounts at 8 and 30 days after planting, Cotton Branch Station.

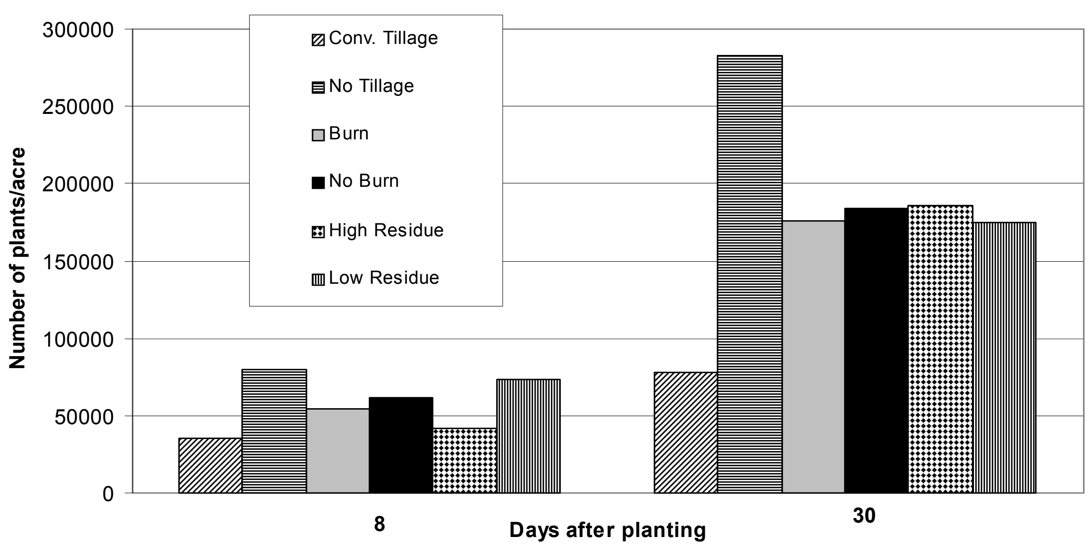

Fig. 1b. Standcounts at 8 and 30 days after planting, Pine Tree Station.

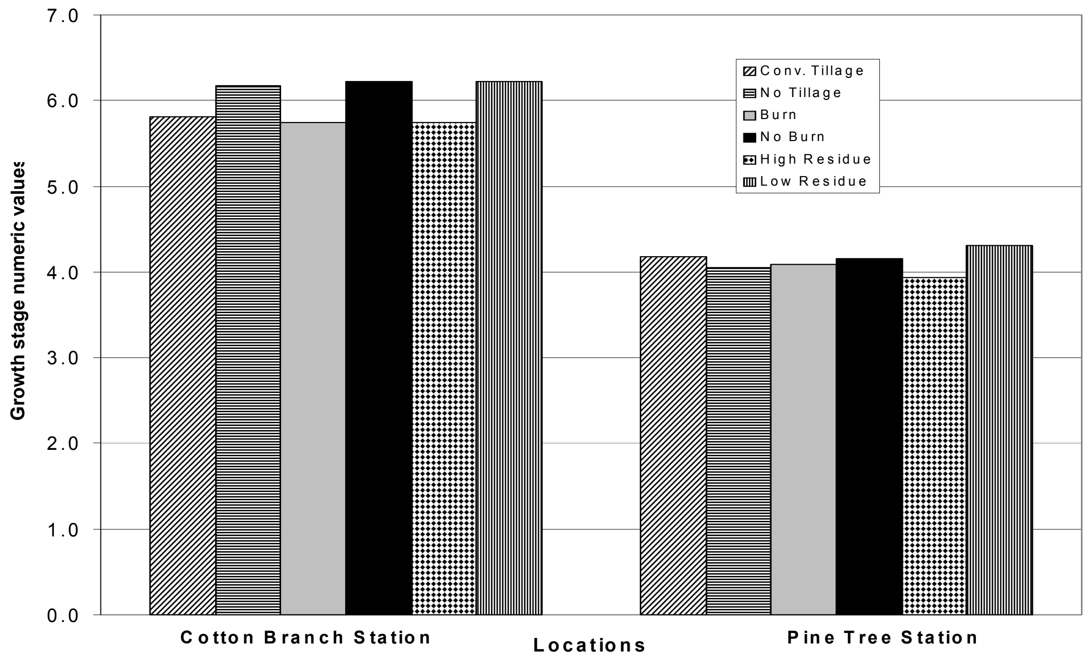

Fig. 2. Vegetative growth stages at 30 days after planting.

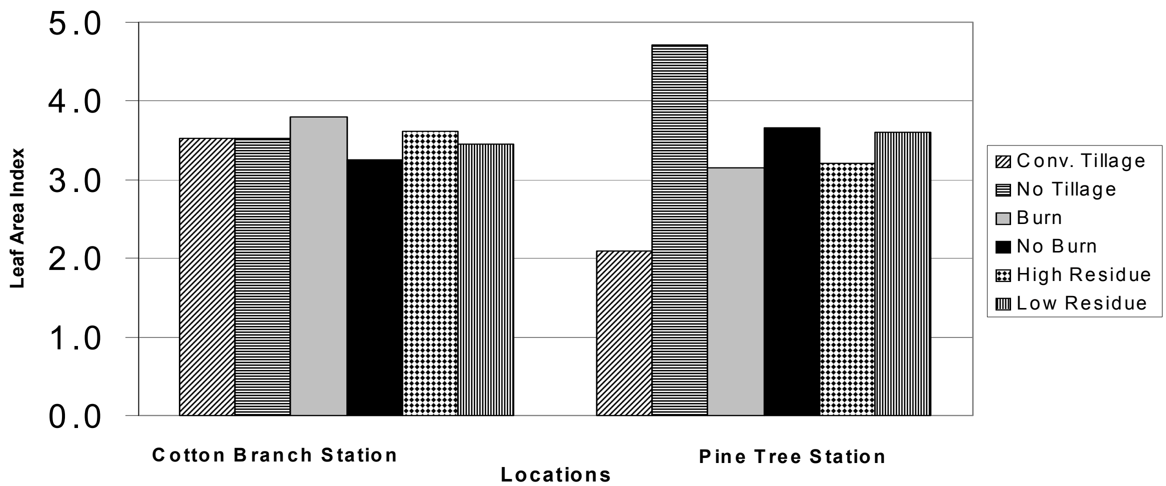

Fig. 3. Leaf area indices at 30 days after planting.