Impact of Cotton Rotation and Tillage Intensity at Varying Phosphorus Fertility on Certain Sorghum Insects and Grain Yield

J.E. Matocha, C.F. Chilcutt, M.P. Richardson, and S.G. Vacek

Texas Agricultural Experiment Station, Corpus Christi, TX 78406. USA.

Corresponding author's e-mail: j-matocha@tamu.edu

ABSTRACT

With depressed grain prices and rising production input costs, grain sorghum [Sorghum bicolor (L.) Moench] producers are challenged to utilize alternate production methods to improve profitability. This study was initiated to extrapolate results of earlier small-plot research on cropping systems/tillage and soil fertility to larger field scale plots and further evaluate cultural and soil management practices for profitable production of grain sorghum. Objectives of this research include investigations of fossil fuel saving tillage practices, possible yield enhancing crop rotations and varying levels of fertilizer P and micronutrients, Fe and Zn, on grain sorghum production. The influence of these cultural management practices on certain sorghum insects was also evaluated. The experimental site was a Clareville clay loam (hyperthermic, Pachic Argiustoll) located west of Robstown, TX at the Perry Foundation. Conventional tillage (7-8 tillage trips; 6-10" tillage depth) was compared with minimum tillage (3-4 trips; 3" maximum depth) under both continuous sorghum cropping and a sorghum: cotton (Gossypium hirsutum L.) yearly rotation. The major blocks, cropping systems, and sub-blocks, tillage systems were evaluated at three P fertilization rates. Micronutrients, Fe and Zn, were included at the high P rate in the minimum tilled (MT) treatment. First year results for sorghum following cotton compared to sorghum following sorghum showed a 30 percent grain yield increase when averaged across all tillage and fertilizer variables. With severe moisture stress in the second year, the rotation benefit decreased to a statistically non-significant 13 percent. Early season plant growth differences in favor of reduced tillage failed to translate into final grain yield differences due to moisture stress prior to physiological maturity. Although sorghum head insect counts varied due to treatment, conclusive evidence of treatment effect is not offered at this time without additional data collection. Data collection for all parameters will continue for at least two years since changes in soil quality require many years to reach equilibrium and influence crop productivity.

KEYWORDS

Sorghum bicolor (L.) Moench, Tillage intensity, Cotton rotation, Phosphorus fertility, Insects.

INTRODUCTION

Improved crop yields and reduced production costs are vital to increased profitability in grain sorghum [Sorghum bicolor (L.) Moench] production in the South. Crop rotation and tillage management can have significant impact on soil quality parameters and subsequent crop yields. Changes in both soil chemical and physical properties require many years to reach near equilibrium and, therefore, long-term studies are needed to properly evaluate the effects of rotation and changing tillage systems on soil quality. Small plot research (Matocha and Stearman, 1989) showed substantial enhancement in crop yields due to crop rotation. Reduction in tillage in the Southeast USA (Motta, *et al.*, 2000) and the Southwest USA (Cripps and Matocha, 1987; Matocha *et al.*, 1998) has been shown to improve soil chemical and physical quality parameters.

Other work (Matocha and Sorenson, 1987; Matocha *et al.* 1987) has shown that fertilization techniques can affect crop yields under conservation tillage systems. Also, grain sorghum appears to respond better to certain forms of phosphate fertilizer than other sources (McCray and Matocha, 1988). Changes in soil microbial populations have been noted due to fertilization and sorghum cropping sequences (Barber and Matocha, 1994).

In the past, use of alternative tillage systems such as minimum and no-till has been slow in adoption in the Southwest but recent interest has expanded. The objective of our research was to evaluate the influence of a cotton: sorghum rotation compared to continuous sorghum on grain head insects numbers and final grain yields under conservation tillage and varying P fertilization.

IN E. van Santen (ed.) 2002. Making Conservation Tillage Conventional: Building a Future on 25 Years of Research. Proc. of 25th Annual Southern Conservation Tillage Conference for Sustainable Agriculture. Auburn, AL 24-26 June 2002. Special Report no. 1. Alabama Agric. Expt. Stn. and Auburn University, AL 36849. USA.

MATERIALS AND METHODS

This research was initiated in the fall of 1999 with yield data collected in years 2000 and 2001. The experimental site is located some nine miles west of Robstown, Texas, on a Clareville sandy clay loam soil. In this large field experiment, crop rotation was the main blocks and tillage treatments were evaluated as sub-blocks while soil fertility variables were considered as split-plots within each of the blocks. Each of the two tillage systems (conventional and minimum-till) was evaluated under continuous sorghum as well as a 1:1 cotton-sorghum rotation. A field at the Perry Foundation Farm (location described above) was selected which had been split into sorghum and cotton production with equal fertilizer application during the 1999 season. This allowed sorghum planting in the 2000 season on previous year's cotton land and a comparison with continuous sorghum on adjacent land in the same field and soil type.

The conventional tillage system (CT) involved 6-8 tillage operations per year (6-10" depth) and was compared with a minimum-till system (MT), which reduced tillage operations to 3-4 per year with tillage depth restricted to 3 inches or less.

Both tillage and crop rotation systems were evaluated at three levels of phosphorus (P) fertilizer (0, 20, 40 lbs P_2O_5 acre^{-1} in 2000; 0, 10, 20 lbs P_2O_5 acre^{-1} in 2001). In addition, the high P rate with the MT system was studied further with supplemental zinc (Zn) and iron (Fe) fertilization individually as well as both micronutrients in combination. Nitrogen (N) was blanketed to all treatments except the fertilizer control at a soil test recommended rate (80 lbs N acre-1) for 5500 lbs acre^{-1} grain yield. All fertilizer materials were applied as liquids in January 2000 and 2001, using a knifing mechanism that allowed banding to an approximate depth of three inches below and five inches to the side of seed placement. A randomized complete block design was utilized with three replications.

Gaucho insecticide treated grain sorghum hybrid, DK-52 (medium maturity) was planted on February 25, 2000, into seedbeds with marginal soil moisture. Seeding rate was 94,000 seed acre^{-1} in 30-inch rows. Each plot consisted of 12 rows with 250-foot row lengths.

Yield parameters for sorghum measured at harvest included grain moisture, bushel test weight and grain yield weight. Drought hastened maturity of the sorghum, which was harvested on June 23 using a grain combine, and weigh wagon.

Soil samples from selected areas in the experimental field were collected for chemical analyses prior to treatment initiation in 1999. Sampling will continue on a biennial schedule.

In the second year, crop rotation, soil fertility, and tillage treatments were studied at two seeding densities (approximately 60,000 and 75,000 seed acre-1). Both tillage systems and crop rotations were evaluated at reduced levels of P fertilizer during the 2001 season. These rates were reduced to 0, 10, and 20 lbs P_2O_5 acre^{-1} because of substantial carryover of P from the previous droughty season. As was the case in 2000 in the MT system, the high P rate was studied further with supplemental Zn and Fe fertilization individually, and in combination. Nitrogen (N) was blanketed to all treatments except the fertilizer control at the same rate used in 2000.

In the second year, planter-box insecticide treated grain sorghum hybrid, DK-52 (medium maturity) was planted in all treatments in March 2001, into seedbeds with marginal soil moisture.

Tillage and crop rotation effects on abundance of soil inhabiting insects such as southern corn rootworm, grubs and borers were assessed in both years by visual inspection of early damage to sorghum plants. Later, three insect samples were taken every other week over a 5-week period from May 15 to June 14, in both years. Samples were taken using the beat bucket method and consisted of 10 sorghum heads each. Insect data recorded included densities of headworm (*Helicoverpa zea*), rice stinkbug (*Oebalus pugnax*) and a total count of natural enemies, mainly predators. Most of the predators were ladybugs (*Scymnus* sp.), insidious flower bugs (*Orius insidiosis*), fire ants (*Solenopsis invicta*), green lacewings (*Chrysopa carnea*), damsel bugs (*Nabis* spp.), and spiders. Cocoons of one *Cotesia* parasitoid species were also observed.

Appropriate statistical analyses were performed on all collected field data. Sufficient yield response data is not available at this time so economic analyses for determining profitability of the production systems are not included in this paper.

RESULTS AND DISCUSSION

First-Year Grain Yields

Yield levels for the first year (2000 season) were considered satisfactory especially since only 5.9 inches of precipitation were recorded for the period following planting through physiological maturity. This represents approximately 60% of the long-term average. Grain yields ranged from a high of 3522 to a low of 2290 lbs acre-1. Average yield for all 24 treatments was 3007 lbs acre-1. Sorghum grown in rotation with cotton averaged 3384 lbs acre^{-1} across tillage and fertility regimes while continuous sorghum produced average grain yields of 2605 lbs acre-1. This reflected a 30% increase in yield due specifically to crop rotation. The benefit from rotation appeared consistent within tillage systems and for most fertilizer rates.

As would be expected for the early phase of the project, yields remained largely unchanged due to tillage intensity. However, yield trends with continuous sorghum appeared lower for MT compared to CT at low P fertilizer rates. This effect was not evident when sorghum followed cotton. Additions of P fertilizer in general, either with or without micronutrients Zn and Fe had little effect on grain yields even though initial soil test levels measured medium.

Insect Evaluations

Damage to sorghum plants by soil inhabiting insects was monitored by visual inspection with no evidence of damage recorded in either year. Sorghum head insect counts were made at two dates (mid-May and June 1). Sorghum completed its blooming cycle during the first 7 days in May. Primary insects counted were headworms, rice stink bugs, and predators. At the mid-May insect count, data indicated only small and largely non-significant differences in numbers of all three insects due to tillage. However, in the early June counts, differences due to cropping system and fertilizer treatment became apparent. Stink bug numbers ranged from 0.33 to 21 per 10 heads. This was generally below what is considered the economic threshold so spraying was not initiated. However, the crop rotation effect produced substantial variation in numbers of stink bugs. Significantly greater numbers of stink bugs were recorded across most treatment variables in sorghum following cotton compared to continuous sorghum. However, insect counts two weeks later, June 1, showed large increases in headworms, stink bugs and predators. The headworm numbers were still below threshold levels, but stink bugs increased to an average range of 14 to 59 per 10 heads depending upon treatment variable and were above the economic threshold. Insecticide spraying for stink bugs was not required, however, because sorghum grain had just matured past the stage where stink bugs were no longer a yield affecting factor.

Second-Year Grain Yields

Grain yields for 2001 were drastically reduced by drought and approximated 33 percent of expected normal yields. Only 3.61 inches of precipitation were recorded for the period following planting through physiological maturity. This represents approximately 37% of the long-term average. Grain yields ranged from a high of 2025 to a low of 1108 lbs acre^{-1} with both extremes measured with the lower plant density. Average yields for the 24 treatments were 1482 and 1476 for the high and low plant densities, respectively. Sorghum grown in rotation with cotton averaged 1574 lbs acre^{-1} across tillage, fertility regimes and population treatments, while continuous sorghum produced average grain yields of 1384 lbs acre-1. or approximately 14% less than sorghum grown in rotation. The benefit from rotation appeared consistent within tillage systems and for most fertilizer rates. Further breakout of yields within the MT systems showed an approximate 430 lbs acre^{-1} (34%) increase from rotation at the higher plant populations.

Grain sorghum response to P fertilizer was variable with tillage intensity and cropping system. A statistically non-significant 320 lbs acre^{-1} grain yield increase was measured from 20 lbs P_2O_5 acre^{-1} in the MT and continuous sorghum system. However, sorghum following cotton produced 627 lbs acre^{-1} (significant at $P = 0.05$) more grain with P fertilizer and the CT tillage system. As P fertilizer rates increased, there appeared to be better response to rotation under CT as compared to the MT system. As was the case in the initial year of this study, no yield improvement was recorded from Fe and Zn fertilization.

Grain yields remained largely unchanged due to tillage variables, although moisture readings down to 24 inch depths showed a positive influence from MT earlier in the growing season. However, abnormally high air temperatures and essentially no rainfall during critical stages of plant growth resulted in severe drought stress which masked the earlier substantial plant growth response from the MT system and prevented manifestation of increases in final grain yields.

Insect Evaluations

As was described for the first year, damage to sorghum plants by soil inhabiting insects was monitored by visual inspection with no evidence of damage recorded. Headworms were only present during the first two sampling periods, with average densities per head during sampling period 1 (0.87) being significantly greater than sampling period 2 or 3 (0.10 and 0, respectively). Although tillage had no effect on headworm densities, rotation and fertilizer treatment did significantly affect headworm densities, but only during sampling period one. During sampling period 1, headworm densities were greater on sorghum planted in rotation with cotton (1.07 per plant), than for continuously planted sorghum (0.67 per plant). A significant interaction between tillage and fertilizer treatments on headworm numbers was also measured at this time. In CT plots, there were significantly less headworms in the N + 0 P treatment than in the 0 N-0 P, N + 10 lbs P, or N + 20 lbs P treatments.

Rice stinkbugs were only significantly affected by fertilizer treatments in MT plots, and this affect was different depending on the type of rotation. In the sorghum: cotton rotation plot the no N-no P treatment had significantly more rice stinkbugs than did the N + 20 lbs P treatment or the N + 20 lbs. P + zinc treatment. Generally, there appeared to be a trend of fewer rice stinkbugs with increasing rates of P fertilization.

The only variable that significantly affected predator density was tillage. Natural enemy density (4.94 per head) was greater in the CT system than in the MT treatment (4.00 per head). Also, there was no significant correlation between predator density and either headworm or rice stinkbug densities.

CONCLUSIONS

The first two years of this research project have demonstrated that rotation of grain sorghum with cotton in alternate years can influence grain productivity and profitability. Rotation improved profits by $24.00 per acre in the first year. Drought stress conditions especially in the second season may have suppressed treatment response. Reduced tillage had shown to be a large factor in early season growth of sorghum due to treatment effect on improved soil moisture in the second year, but severe drought in late season prevented changes in final grain yields. Although this research appears to suggest a relationship between sorghum headworm/rice stinkbug pressures and crop rotation and P fertilization, additional studies are needed for conclusive evidence of this association. Additional years of treatment evaluations are needed before conclusive economic evidence of profit maximizing levels of tillage/rotation/fertility can be developed.

ACKNOWLEDGMENT

Funding for this research is provided in part by a Sorghum PROFIT Initiative from the Texas State Legislature. Authors wish to thank Andy Perry and the Perry Foundation trustees for providing land and equipment for conducting this experiment.
We also thank S.L. Livingston, Joe Oelschlegel, Amanda Headley, and C.J. Correa for assistance with the project.

LITERATURE CITED

Barber, K.L. and J.E. Matocha, 1994. Rotational cropping sequence and fertilization effects on soil microbial populations. Int. Sorghum Millets Newsletter, Vol. 35, p. 126.

Cripps, R.W., and J.E. Matocha. 1987. Effect of different tillage practices on surface reside and soil physical properties. p. 84. *IN* Proc. Southern Region No-Till Conference, College Station, TX, p. 84.

Matocha, J.E., and G.K. Stearman. 1989. Reduced inputs for dryland grain sorghum under semi-arid conditions. pp. 115-116. *IN* Proc. 16th Grain Sorghum Research and Utilization Conference, Lubbock, TX. Feb. 18-22.

Matocha, J.E., P.S. Branick and Fred Hopper. 1987. Fertilization of cotton under reduced tillage conditions. pp. 484-486. *IN* Proc. Beltwide Cotton Producers Research Conference, Dallas, TX.

Matocha, J.E., T.L. Provin, and S.G. Vacek. 1999. Soil Chemcal Properties as Influenced by Tillage Intensities. Presentation at Annual Meetings of American Society of Agronomy, Crop Science Society, and Soil Science Society of America. Salt Lake City, Utah. October 31 - November 4, 1999. Agronomy Abstracts, p. 260.

Matocha, J.E., and D.R. Sorenson. 1987. Tillage Effects on Fertilizer Rate and Placement Requirements of Dryland Grain Sorghum. Proceedings of Southern Regional No-Till Conference, College Station, TX.

McCray, J.M. and J.E. Matocha. 1988. Effect of phosphorus fertilizer sources on dryland grain sorghum. Agronomy Abstracts. Anaheim, CA. November 27-December 2, 1988.

Motta, A.C.V., D.W. Reeves and J.T. Touchton. 2000. Long-term tillage system effects on chemical soil quality indicators in the southeastern coastal plain. pp. 114-120. *IN* Proc. of 23rd Annual Southern Conservation Tillage Conference for Sustainable Agriculture, Monroe, LA.