Cropping History, Commercial Inoculums, and Starter Fertilizer Effects On Soybean Growth and N Nutrition

Kevin A. Dillon and Jac J. Varco, Plant and Soil Sciences, Mississippi State University, Mississippi State, MS 39762

ABSTRACT

Planting soybean (*Glycine Max* L.) for the first time on soils with a history of cotton production raises questions about inoculation management. This greenhouse study evaluated the effects of previous cropping history of soybean or cotton only, starter fertilizer (10-34-0), and commercial inoculums ('Optimize 400' and 'Launcher Pro') on nodule production, growth, and N accumulation of soybean. Nodule counts were greatest at 42.3/plant with a history of soybean compared to 4.7/plant with a history of cotton. It appeared that commercial Rhizobium strains were ineffective against competing native Rhizobia in soybean soil as evidenced by their small size and dispersal throughout the root system as opposed to large nodules clustered at the base of the hypocotyl or upper radicle in the cotton soil. Soybean dry matter production was 0.58 g/plant on the cotton soil compared to 0.15 g/plant on the soybean soil. Starter fertilizer increased dry matter production from 0.31 g/plant to 0.41 g/plant averaged across soils. Total N accumulation was 1.82 mg/plant on the cotton soil and 0.5 mg/plant on the soybean soil. Starter fertilizer increased N accumulation 0.31 mg/plant. Native Rhizobium strains seemed more competitive than commercial inoculums in the soybean soil which had a pH of 5.2, but were not as effective in N_2-fixation. Inoculation was successful on the cotton soil where native strains were absent.

INTRODUCTION

- Due to an increase in planted soybean hectares with some planted on soils with only a history of cotton, 40 % of the soybean hectares in the mid-south are grown on coarser textured soils.
- Inoculation management has become critical in these situations due to a lack of effective *Rhizobium*.
- Total N requirements for soybean is met through available soil N pools and symbiotic N_2 fixation (Bezdicek et al., 1978; Bhangoo and Albritton 1976; Patterson and LaRue 1983).
- Effective inoculation with *Bradyrhizobium japonicum* is essential for N_2 fixation and economic production(Hiltbold et al., 1980).
- Two types of inoculants are available: seed-applied and soil-applied.
- Inoculum use has become increasingly popular due to improved inoculant technology, low cost of products, application ease, and increased input costs associated with nutrient management (De Bruin et al., 2010).
- Current recommendations suggest the use of inoculum if the field has no history of soybean in the past three to five years, has a soil pH <6.0, has low organic matter, or has been flooded for more than 1 week (Abendroth and Elmore 2006; Pedersen, 2004).
- The presence of nitrate-N in the soil has shown to interfere with the infection process and reduce or slow nodule formation, which limits N_2 fixation (Weber, 1966). However, if a soil is low in organic matter, applying pre-plant fertilizer N may encourage early season growth as well as N_2 fixation.
- Expanded hectares onto silty to sandy soils as opposed to predominantly clayey soils, has challenged soybean producers to introduce and manage rhizobial populations in a way that will result in increased N use efficiency and increases in grain yield.

OBJECTIVE

Evaluate the effects of previous cropping history of soybean or cotton only, starter fertilizer, and commercial inoculums on root nodulation, dry matter yield, and total N uptake of soybean (*Glycine max* L.).

MATERIALS & METHODS

- Greenhouse study, RCBD with four replicates, Mississippi State University, Starkville, MS.
- Eight treatments as follows:
  - Two commercial inoculants, 'Optimize 400' and 'Launcher Pro' compared to non-inoculated
  - With and without starter fertilizer 10-34-0 applied at 0.106 ml/pot (3.7 kg/ha)
  - Cropping history: continuous cotton vs. continuous soybean
- Soil collected from Delta Research and Extension Center, Stoneville, MS.
  - 1562 g of soil was placed in 15 cm plastic pots (Dillen Products, 15200 Madison Road, Middlefield, OH 44062-0738)

-Continuous soybean: Bosket fine sandy loam(Fine-loamy, mixed, active, thermic Mollic Hapludalf)

-Continuous cotton: Commerce fine sandy loam (Fine-silty, mixed, superactive, nonacid, thermic Fluvaquentic Endoaquepts)

- Potash was applied equivalent to 67.4 kg K_2O/ha (0.075g KCl/pot).
- Micronutrients - Frit-503G at a rate of 39.3 kg/ha (0.02625g/pot).
- Pioneer Hi-Bred 94B73 treated with following seed treatments:
  - *'Optimize 400'-* (EMD Crop BioScience) at 82.8 ml/45.4 kg seed
  - *'Launcher Pro'-* (Precision Laboratories) (ai: Launcher at 50.27 ml/22.68 kg seed; PBX at 11.83 ml/22.68 kg seed; ProSurge at 2.96 ml/ 22.68 kg seed) applied at 65.06 ml of solution/22.68 kg seed
- Aboveground biomass was harvested 28 days after emergence and oven-dried at 60 C and weighed to determine total dry matter (TDM).
- A dry combustion analyzer (Carlo Erba, Milan, Italy) was used to obtain % N and total N content per pot (mg/pot).
- Nodule counts on excavated roots were taken.
- Data collected was subjected to an ANOVA analysis using PROC GLM (SAS, 2001). Fisher's protected least significance difference (LSD) test at the 5% level of probability was used to determine mean separation. Interaction effects for the variables % N and nodule counts were subjected to analysis using PROC Mixed (SAS, 2001). Significant differences at a level of P = 0.05 are designated by differing letter groupings following each mean.

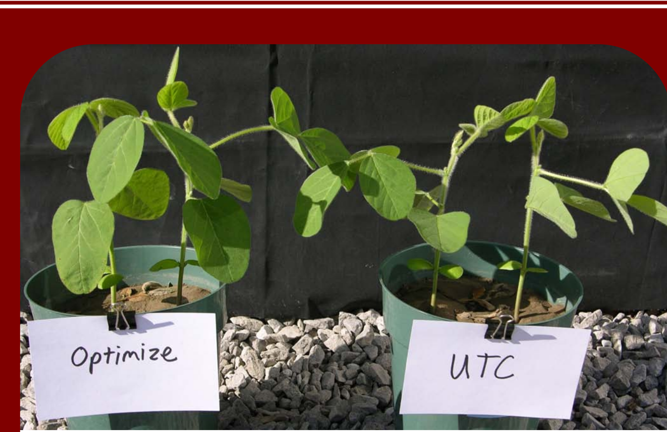

Figure 1. Optimize seed treatment vs. untreated on cotton production soil

Figure 2. Soil with solely soybean production (Bosket) vs. soil with solely cotton production (Commerce)

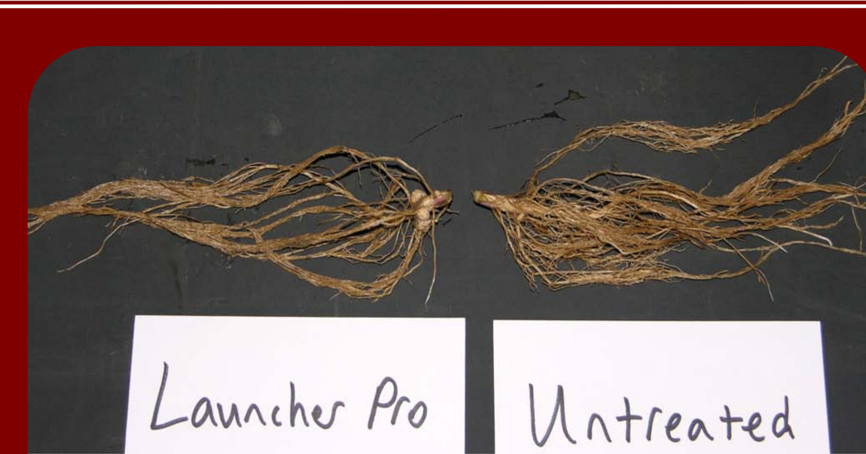

Figure 3. Launcher Pro seed treatment vs. untreated on soil with history of cotton production

Figure 4. Optimize seed treatment vs. untreated on soil with history of cotton production

RESULTS

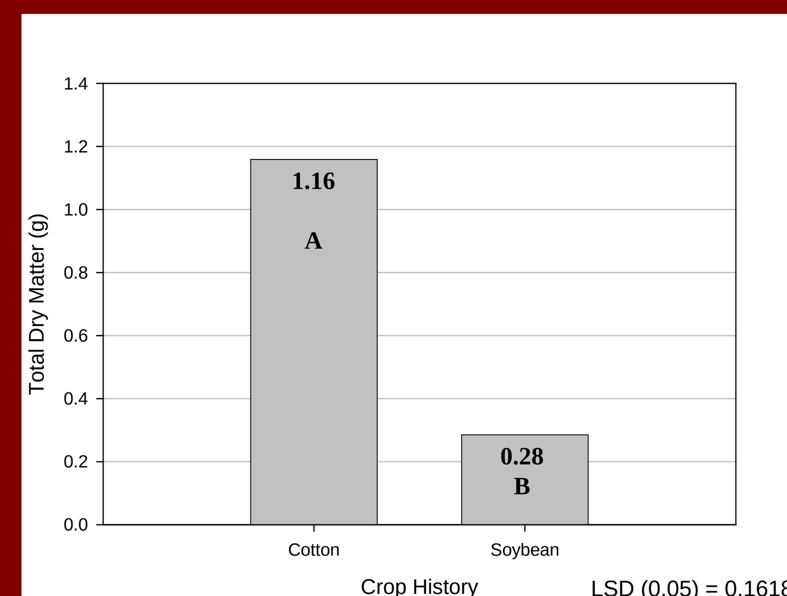

Figure 5. Total Dry Matter (TDM) (g) as affected by Cropping History (P < .0001)

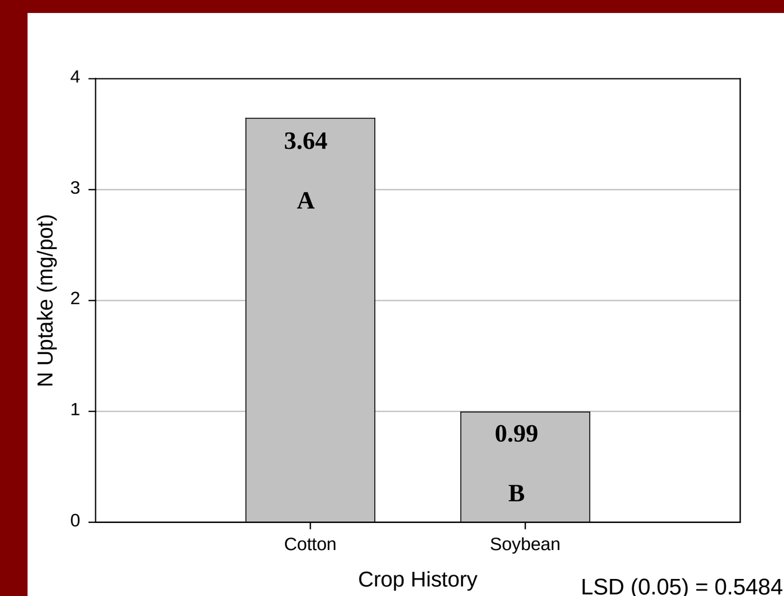

Figure 6. Uptake N (mg/pot) as affected by Cropping History (P <.0001)

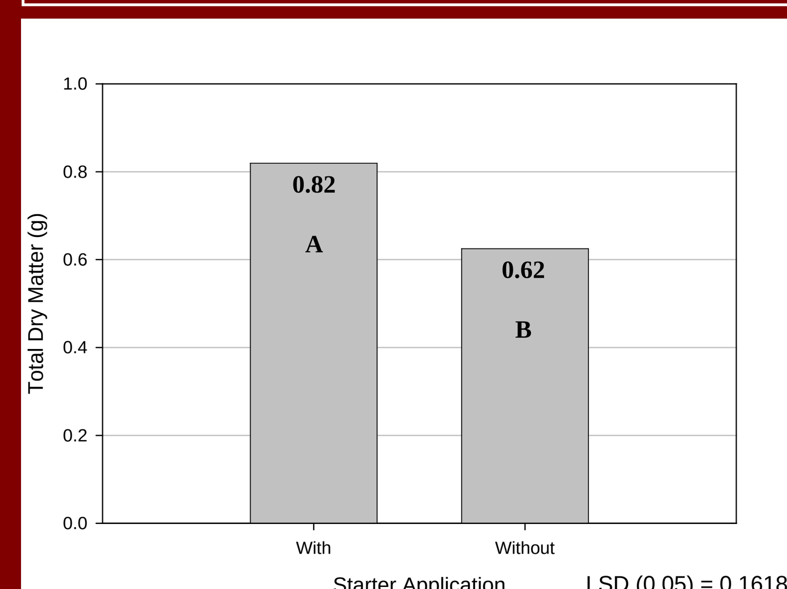

Figure 7. Total Dry Matter (TDM) (g) as affected by Starter Fertilizer (P = 0.02)

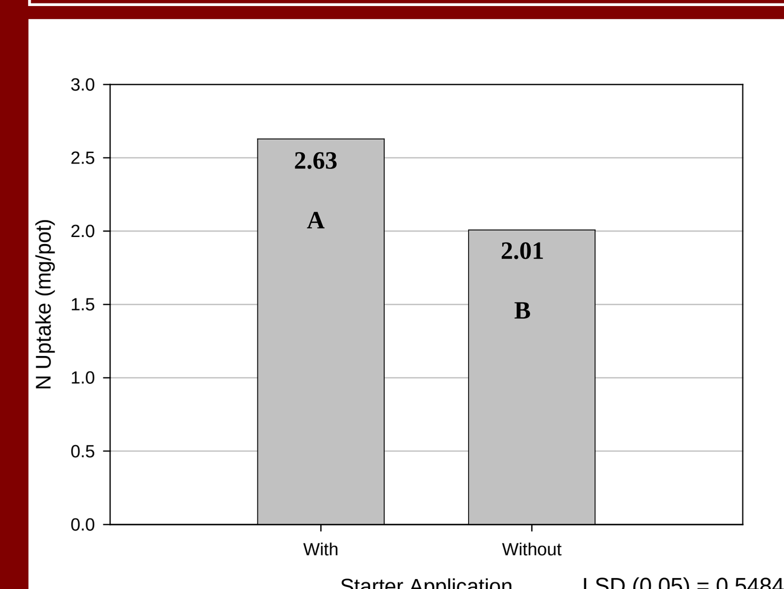

Figure 8. Uptake N (mg/pot) as affected by Starter Fertilizer (P = 0.03)

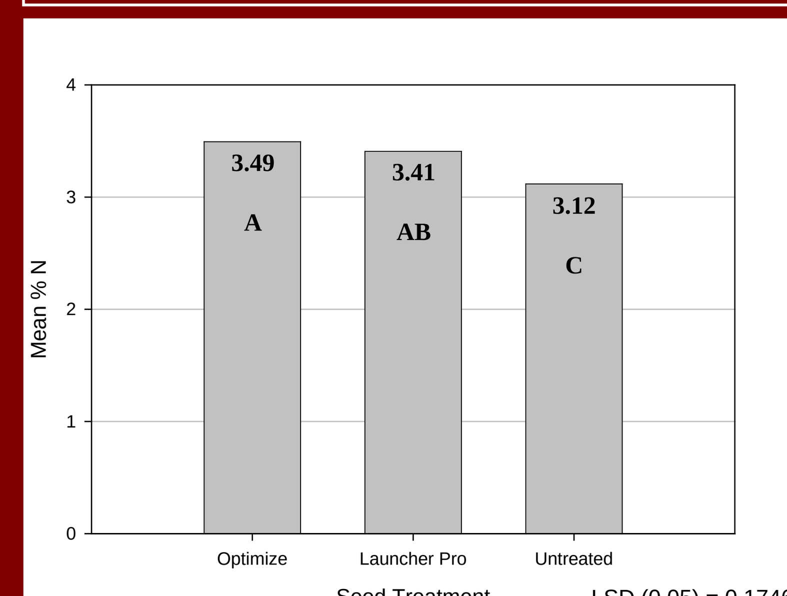

Figure 9. Percent N as affected by Seed Treatment (P = 0.001)

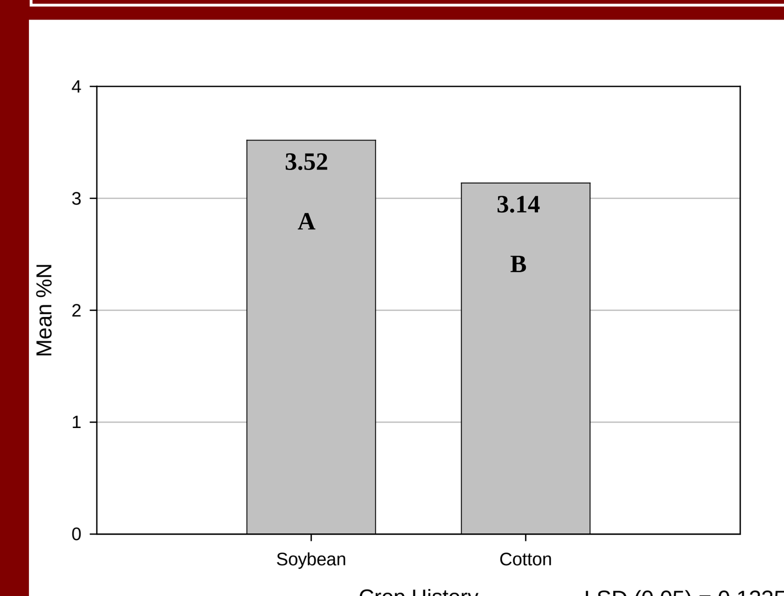

Figure 10. Percent N as affected by Cropping History (P < .0001)

Table 1. Soil Test Results

			Extractable Nutrient Levels (kg/ha)								cmolc/kg					% Base Saturation			
Soil Series	Crop History	%OM	P	K	Ca	Mg	Zn	S	Na	pH	H	K	Ca	Mg	Total	H	K	Ca	Mg
Bosket	Soybean	0.69	23.3	84.0	491.1	94.5	1.1	18.2	14.2	5.2	2	0.59	6.68	2.14	11.41	17.53	5.17	58.55	18.76
Commerce	Cotton	0.95	22.8	65.3	367.2	63.9	1.6	25.2	10.7	6.3	1.3	0.46	4.99	1.45	8.2	15.85	5.61	60.85	17.68

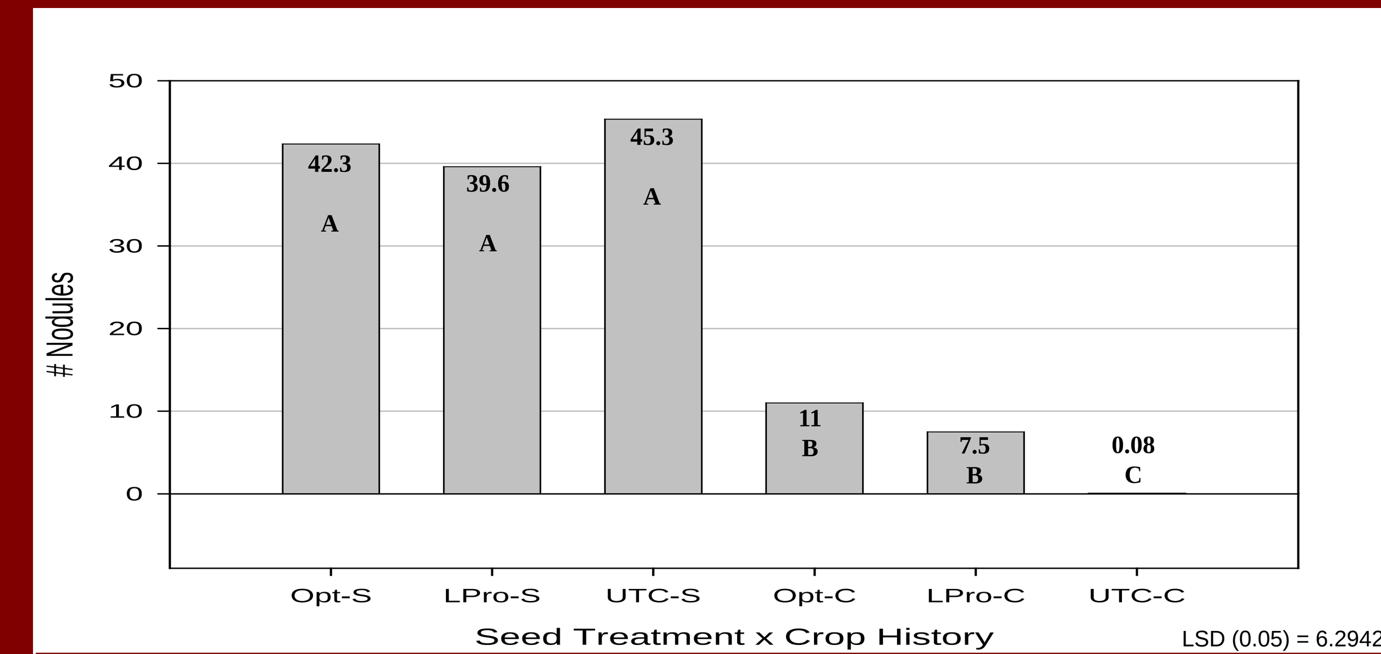

Figure 11. Nodule Count as affected by an Interaction of Seed Treatment and Crop History(P = 0.0056) S=Soybean Crop History; C=Cotton Crop History

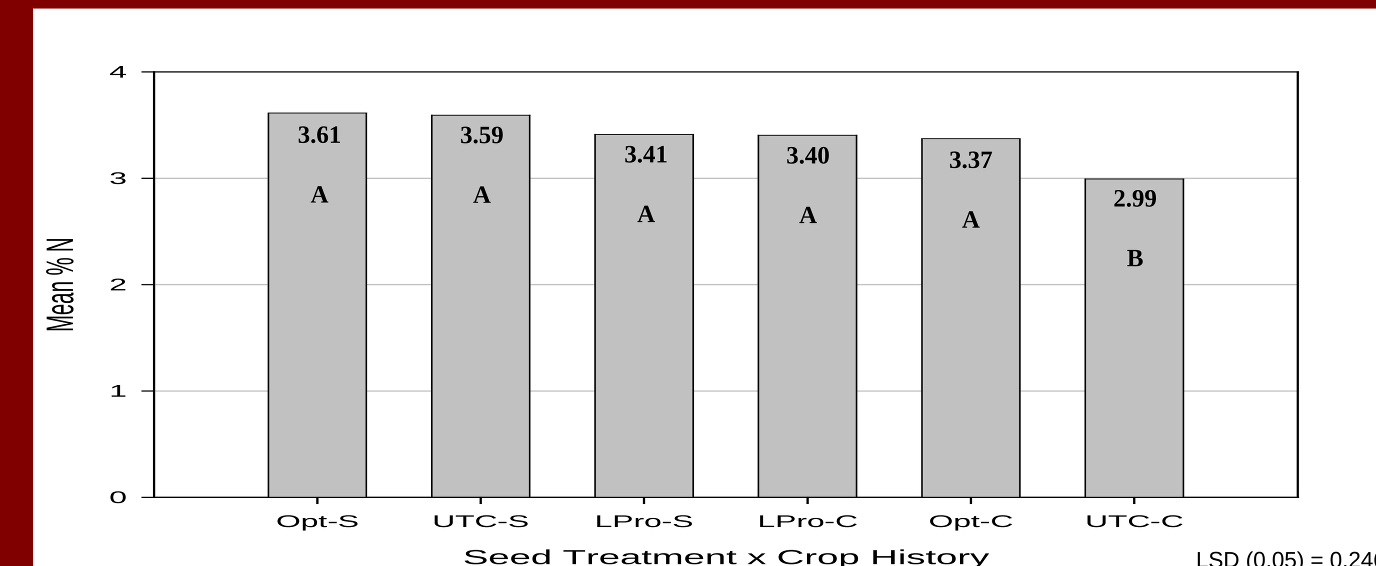

Figure 12. Percent N as affected by an Interaction of Seed Treatment and Crop History (P = 0.0056) S=Soybean Crop History; C=Cotton Crop History

DISCUSSION

- Nodulation with cropping history of cotton appeared solely attributable to the commercial inoculums.
- Following cotton, 'Optimize' performed better than 'Launcher Pro', but not significantly.
- With a history of soybean production, nodule number was significantly greater than with history of cotton. However, significantly greater TDM and Total N Uptake occurred on cotton soil compared to the soybean soil.
- Soil with history of soybean appeared to be most dependent on native *Rhizobium.*
- Soybean soil resulted in greater tissue N% but growth was lower.
- Total N Uptake and TDM were highest in soybean grown on cotton soil. This suggest greater effectiveness of commercial *Rhizobium* strains in fixing N compared to acid tolerant strains which likely dominated in the soybean soil. It is likely that the acid pH of 5.2 on the soybean soil severely limited their effectiveness and that native acid tolerant strains were more viable inoculants.
- When starter fertilizer was applied, N uptake and TDM significantly increased.
- With today's ever changing crop markets, increases in input and production cost, the application of a seed inoculant should be utilized by producers to increase yields of soybean.
- Further research is needed to analyze different types and brands of inoculums. Future research should investigate the effects of soil pH on effectiveness and competiveness of commercial inoculums to native strains which may be tolerant of soil acidity.

LITERATURE CITED

Abendroth, L., and R. Elmore. 2006. Soybean inoculation: Applying the facts to your field. NebGuide G1622. Univ. of Nebraska, Lincoln

Bezdicek, D.F., D.W. Evans, B. Abede, and R.W. Witters. 1978. Evaluation of peat and granular inoculums for soybean yield and N fixation under irrigation. Agron. J. 70:865-868.

Bhangoo, M.S. and D.J. Albritton. 1976. Nodulating and non-nodulating Lee soybean isolines response to applied nitrogen. Agron. J. 68:642-645.

De Bruin, J.L., P. Pedersen, S.P. Conley, J.M. Gaska, S.L. Naeve, J.E. Kurle, R.W. Elmore, L.J. Giesler, and L.J. Abendroth. 2010. Probability of yield response to inoculants in fields with a history of soybean. Crop Sci. 50:265-272.

Hiltbold, A.E., D.L. Thurlow, and H.D. Skipper. 1980. Evaluation of commercial soybean inoculants by various techniques. Agron. J. 72:675-682.

Patterson, T.G., and T.A. LaRue. 1983. Nitrogen fixation by soybean: Seasonal and cultivar effects and comparisons of estimates. Crop Sci. 23:488-492.

Pedersen, P. 2004. Do we really need to inoculate our fields? p. 23-25. In Proc. 2004 Integrated Crop Management Conf., Ames, IA. 1-2 Dec. 2004. Iowa State Univ., Ames.

Weber, C.R. 1966. Nodulating and nonnodulating soybean isolines. II. Response to applied nitrogen and modified soil conditions. Agron. J. 58:46-49.

ACKNOWLEDGEMENTS

The authors would like to express sincere appreciation to Dr. Trey Koger, Dr. Timothy Walker, Mr. Brewer Blessit, and the Mississippi Soybean Promotion Board for their assistance and funding of this research.