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ORIGINAL RESEARCH ARTICLE

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Effects of rotation of cotton (*Gossypium hirsutum* L.) and soybean [*Glycine max* (L.) Merr.] crops on soil fertility in Elizabeth, Mississippi, USA

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ABSTRACT

The effects of cotton (*Gossypium hirsutum* L.): soybean [*Glycine max* (L.) Merr.] rotation on the soil fertility levels are limited. An irrigated soybean: cotton rotation experiment was conducted from 2012 through 2015 near Elizabeth, Mississippi, USA. The crop rotation sequences were included continuous cotton (CCCC), continuous soybean (SSSS), cotton-soybean-cotton-soybean (CSCS), cotton-soybean-soybean-cotton (CSSC), soybean-cotton-cotton-soybean (SCCS), soybean-cotton-soybean-cotton (SCSC). The crop rotation sequences were followed continuous soybean, continuous cotton, cotton followed by soybean, soybean followed by cotton, soybean followed by two years of cotton, and cotton followed by two years of soybean. A weed control treatment of a non-glyphosate post-emergence vs. glyphosate post emergence was used in both crops. Soil samples taken prior to planting each year and in 2016 showed no differences in cation exchange capacity, organic matter, pH, or macro nutrient levels among the rotations, over the five sampling periods nor weed control methods used for either crop.

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INTRODUCTION

In general, crop rotations are well documented for their economic and agronomic benefits to producers and the soil they till. Crop rotations are known to aid in pest management (weed, insect and diseases), reduce soil erosion, maintain soil organic matter (OM), provide biologically fixed nitrogen (N) when legumes are part of the rotation scheme, and manage overall nutritional levels (Singer and Bauer, 2009; Arnold Bruns, 2017). Rotations involving the use of legumes, with few exceptions, have shown gains in economic yields of successive non-leguminous crops due to residual N fixed through symbiosis of the legume crop and a *Rhizobium* species of bacteria (Tisdale and Nelson, 1975).

Reports on rotation experiments of cotton with soybean are not as numerous as with other crops. Inconsistent yield responses of cotton yields following soybean have been reported in some studies (Bryson *et al.*, 2011: Davis *et al.*, 2003; Rochester *et al.*, 2001). Rochester *et al.* (2001), did report that N fixed by soybean partially fulfilled the N requirements of a succeeding cotton crop. Pettigrew *et al.* (2016) recently concluded that cotton demonstrated a yield increase following soybean that was likely due to increased levels of soil N through fixation from the previous soybean crop or an alteration of soil microbial populations favorable to the succeeding cotton crop. The objective of this part of the above mentioned experiment (Pettigrew *et al.*, 2016) was to determine if changes in the availability of most nutrients occurred as the rotation experiment progressed.

MATERIALS AND METHODS

The four years cotton: soybean rotation experiment was conducted during the growing seasons of 2012, 2013, 2014 and 2015 at a site 1.0 km north of Elizabeth, Mississippi, USA on land leased by the USDA-ARS Crop Production Systems Research Unit at Stoneville, MS. The site was a Dundee silty loam (fine-silty, mixed active, themic Typic Ochraqualf). The previous crop produced at the site prior to initiating the study was corn

(*Zea mays* L.). The experimental design was a randomized complete block with a split-plot arrangement of treatments replicated six times. Whole plots were two herbicidal weed control methods, glyphosate based and conventional herbicidal weed control. For both glyphosate based and conventional systems in cotton, fluometuron at 1.12 kg ai ha^{-1} and pendimethalin at1.12 kg ai ha-1 were applied pre-emergence. In glyphosate based cotton, glyphosate at 0.87 kg ae ha^{-1} were applied both early and late post-emergence according to labeled recommendations. For the conventional based system in cotton, pyrithiobac at 107 g ai ha^{-1} was applied early post-emergence followed by trifloxysulfuron at 11.7 g ai ha^{-1} plus prometryn at 1.33 kg ai ha^{-1} or trifloxysulfuron alone at 7.7 g ai ha^{-1} applied late post-emergence. Also plots were cultivated on an as needed-basis. In both glyphosate and conventional based weed control systems in soybean, the pre-emergence herbicides *S*-metolachlor at 1.12 kg ai ha^{-1} and pendimethalin at 1.12 kg ai ha^{-1} were applied. In the glyphosate based system, glyphosate at 0.87 kg ae ha-1 was applied as an early post-emergence treatment followed by second application in early reproductive growth of the crop. In the conventional based system for soybean, *S*-metolachlor at 1.21 kg ai ha^{-1}plus fomesafen 0.27 kg ai ha^{-1} were applied early post-emergence followed by chlorimuron at 13.2 g ai ha^{-1} applied as at early reproductive growth.

Rotation schemes were also assigned at random at the being of the experiment and remained in place during the duration of the study. The crop rotation sequences were as follows; continuous cotton (CCCC), continuous soybean (SSSS), cotton-soybean-cotton-soybean (CSCS), cotton-soybean-soybean-cotton (CSSC), soybean-cotton-cotton-soybean (SCCS), soybean-cotton-soybean-cotton (SCSC). During this experiment soil samples from each rotation scheme were acquired. These samples were approximately 1.0 kg and collected near the center of each sub-plot to a depth of approximately 15.0 cm. Sampling begin in 2012 and continued each spring before planting and the application of N fertilizer, with one final sampling in 2016 prior to spring tillage for a succeeding experiment. Each soil sample was then analyzed by the Agricultural Analytical Service Laboratory Pennsylvania State University, State College, PA for cation exchange capacity (CEC), pH, organic matter (OM), P, K, Ca, Mg, S, Zn and Cu concentration. Data were analyzed using the PROC MIXED of the Statistical Analysis System (SAS Institute, Cary, NC).

RESULTS AND DISCUSSION

The characteristics of soil after following different crop rotation schemes are presented in Table 1. During the present investigation, the results indicated that herbicide treatments showed no effect upon any of the soil chemical properties measured and as a result those data were combined. Significant difference was also not observed for any of the data collected across rotation schemes or years (Table 1). Among different crop rotation schemes *viz.*, continuous cotton (CCCC), continuous soybean (SSSS), cotton-soybean-cotton-soybean (CSCS), cotton-soybean -soybean-cotton (CSSC), soybean-cotton-cotton-soybean (SCCS), soybean-cotton-soybean-cotton (SCSC), the higher values of CEC (15.2cmol/kg), OM (1.47%), P (40.1%), K (250.6%), Ca (2219.5%), S (8.8mg/kg) and Cu (3.44mg/kg) were recorded with SCSC crop rotation scheme while the higher value of Mg (424mg/kg) was observed with SSSS. Zn (3.6mg/kg) was noted higher with CSSC rotation scheme. There were no any change in pH was recorded with all these crop rotation schemes (Table 1). All variables fluctuated slightly but not consistently nor great enough to demonstrate a statistically significant trend. As stated in a previous report by Pettigrew *et al.* (2016) some improvement in lint yield of cotton was observed following soybean in one yr. and those plants were significantly taller and had more chlorophyll than those plants in the continuous cotton system. No such differences were observed in any of the soybean crops produced in the experiment (data not shown, in review). These data demonstrate no effect, positive or negative, to soil fertility levels in cotton: soybean rotations that may be used in the lower Mississippi River Valley.

Table 1. Soil fertility levels of a Dundee silty loam over five years in a six scheme cotton (C) soybean (S) rotation system.

Rotation†	CEC cmol/kg	OM %	pH	P	K	Ca	Mg mg/kg	S	Zn	Cu
CCCC	14.9	1.39	7.1	40	241.4	2175	418	8.5	3.1	3.03
CSCS	14.8	1.41	7.1	36.5	240.7	2152.1	414	8.5	3.1	3.02
CSSC	14.9	1.46	7.1	39	249	2154.9	414.4	8.5	3.6	3.36
SCCS	14.9	1.41	7.1	38.1	241.4	2156.3	414.4	8.5	3.3	3.07
SCSC	15.2	1.47	7.1	40.1	250.6	2219.5	423.1	8.8	3.5	3.44
SSSS	15	1.45	7	1.45	240.4	2166.9	424	8.8	3.5	3.08
Year‡										
2012	15.5	1.48	7	36.1	268.3	2222.6	438	10.7	3.5	3.18
2013	15.1	1.48	6.9	31.5	238.9	2160.6	415.8	8.6	3.4	3.04
2014	15.5	1.48	7.1	35.1	253.4	2283.7	437.4	8.2	3.4	3.75
2015	14.9	1.39	7.1	38.6	237	2170.7	404.9	7	2.8	2.91
2016	13.9	1.32	7.3	49.5	211.9	2016.2	393.8	8.6	3.6	2.94

†Means of 5 yrs, 2 herbicide treatments (glyphosate vs. non-glyphosate products), and 6 replications. No statistically significantly differences were observed. ‡Means of 6 cotton: soybean rotation schemes, 2 herbicide treatments (glyphosate vs. non-glyphosate products), and 6 replications. No statistically significant differences were observed.

Conclusion

This investigation concluded that crop rotation sequences were included continuous soybean, continuous cotton, cotton followed by soybean, soybean followed by cotton, soybean followed by two years of cotton, and cotton followed by two years of soybean. A weed control treatment of a non-glyphosate post-emergence vs. glyphosate post-emergence was used in both crops. Soil samples taken prior to planting each year and in 2016 showed no differences in cation exchange capacity, organic matter, pH, or macro nutrient levels among the rotations, over the five sampling periods nor weed control methods used for either crop.

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The trades names are used in this publication are solely for the purpose of providing specific information. Mention of a trade name, propriety product, or specific equipment does not constitute a guarantee or warranty by the USDA-ARS and does not imply approval of the named product to exclusion of other similar products.

Conflict of interest

The authors declare there are no conflicts of interest.

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