Influence of Tillage and Lime on Nutrition of Soybeans Doublecropped with Wheat

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Introduction

No-till is a viable option for doublecropping soybeans after wheat. However, the value of occasional tillage for the incorporation of fertilizer and lime remains unclear. The objectives of this study were to compare the nutritional status and yield of soybean in a no-till system, where all fertilizer and lime were surface applied, with those of soybeans grown following three alternative tillage techniques. The present paper discusses the relationship between selected soil chemical properties, soybean leaflet nutrient concentrations, and soybean yield.

Materials and Methods

Four tillage systems were evaluated on an Olivier silt loam (Aquic Fragiudalf, fine-silty, mixed, thermic) on the same plots in Baton Rouge, LA from 1980 through 1987. The tillage systems studied were: no-till, disk only, moldboard plow plus disk, and subsoil plus disk (Table 1). Fertilizer was broadcast at 20-60-60 (N-P_2O_5-K_2O) lb/acre prior to seedbed smoothing and before soybean planting each year and again at the same rate prior to disking or no-till planting of wheat. Wheat was topdressed with 80 to 100 Ib N/acre each February. In June 1984, tillage plots were split with and without an application of 2 tons of dolomitic limestone/acre. No treatment was cultivated in any year. Thus, the no-till treatment received no pre- or post-plant tillage and all fertilizer and lime were surface applied by broadcasting.

Tillage was performed or glyphosate was applied at 1 Ib a.i./acre (on no-till plots) in late May after combining wheat and spreading straw, and Centennial soybean seed treated with Vitavax-MR® was planted at 50 Ib/acre in early June of each year. Weeds were controlled with a preemergence application of 3 lb a.i. alachlor/acre plus 6 oz a.i. metribuzin/acre. In 1986 and 1987, 7 oz metribuzin + chlorimuron ethyl (10 oz Canopy) per acre plus alachlor were applied. If needed, hand weeding or post-directed, over-the-top, and spot-treatment herbicide applications were used to achieve excellent weed control.

Soil samples were obtained each year in late February or early March and analyzed by the Louisiana Soil Testing Laboratory (Brupbacher et al., 1968). Elemental composition of the most recently expanded central trifoliolate leaflets (excluding petiol) at the R1 growth stage was determined during 1986. DRIS (diagnosis and recommendation integrated system) indices were determined for N, P, K, Ca, and Mg using the norms published by Hallmark (1987). DRIS indices identify nutritional imbalances by comparing element ratios to their ratios in high-yielding populations (Sumner, 1979).

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Results

Soybean Yield

From 1980 through 1983, tillage system caused no significant differences in soybean yield (data not presented). Similarly, during 1984 and 1985, neither tillage system nor lime application altered soybean yield and all treatments averaged between 35 and 41 bu/acre (Table 2). During 1986 and 1987, however, lime significantly increased soybean yield. This increase in yield was accompanied by a later date of soybean leaf drop in limed plots.

In 1986, a significant interaction was obtained between tillage system and lime application; lime increased yields of no-till and moldboard treatments, but did not increase yields

Table 1. Management practices of tillage systems evaluated for wheat-soybean doublecropping, 1980-1987. Olivier silt loam, Baton Rouge, LA.

Tillage system	Management for soybeans	Management for wheat
No-till	Spray, fertilize, plant*	Spray, fertilize, drill
Disk only	Disk, fertilize, disk, plant	Disk, fertilize, do-all, drill
Moldboard	Plow, fertilize, disk, plant	Disk, fertilize, do-all, drill
Subsoil and disk	In-row subsoil, disk', fertilize, disk, plant*	Disk, fertilize, do-all, drill

*30-inch row spacing

of disk only or subsoil plus disk treatments. Although lime increased seeds per plant and weight per seed of all treatments, limed plots of the disked and subsoil plus disk treatments had fewer plants per foot of row, and plants were shorter throughout the growing season. Such symptoms were not observed in any tillage-lime treatment in 1987, and lime significantly increased average soybean yield over all tillage treatments (Table 2). Yield increases in 1987 associated with lime resulted from an increase in stand density of no-till soybeans while increases, in both seed weight and number, were responsible for higher yields in other tillage systems.

Soil Chemical Analysis

As expected, application of lime after wheat harvest in 1984 increased soil pH and Ca levels of samples obtained in March 1986. Tillage influenced the distribution of P, pH, and Ca with depth in the soil (Table 3). In the disked and subsoil plus disk treatments, lime increased soil pH from 5.2 to 6.4 and increased Ca levels to above 1,000 ppm throughout the 0 to 3-inch soil depth. In contrast, in the no-till treatment, lime increased pH in the top inch from 4.8 to 6.2 and raised Ca above 1,000 ppm; but pH remained less than 5.8 and Ca less than 1,000 ppm at depths below the top inch. In the moldboard treatment, pH values of 6.0 and Ca values around 970 were uniform throughout the 0 to 6-inch soil depth. Phosphorus concentrations were most stratified in the no-till plots and most uniform in the moldboard treatment.

Soybean Leaflet Analysis

Leaflet analyses (Table 4) did not reveal any nutrient deficiencies that could explain the stunting of disk only and subsoil plus disk soybean plants in 1986. DRIS indices indicated

Table 2. Yield of Centennial soybean doublecropped after wheat as influenced by tillage system and lime application, Baton Rouge, LA.

Year	Lime	No-till	Disk onlv	Moldboard and disk	Subsoil and disk	LSD* (0.05)
				bu/acre --------------		
1984	Lime	38	40	40	36	ns, ns
	No lime		36	35	35	ns, ns
1985	Lime	37	39	38	35	ns, ns
	No lime	41	39	39	39	ns, ns
1986	Lime	36	31	35	28	ns, 4
	No lime	31	31	24	28	8, 9
1987	Lime	43	42	43	44	ns, 2
	No lime	39	41	40	42	4. 5

*LSD values to separate specific means are listed in following order: tillage system means, lime treatment means, lime treatment within tillage, lime treatment between tillage systems. ns = not significantly different.

Table 3. Soil pH, Ca, and P values from soil tests conducted during March of 1986 as influenced by tillage every spring and a lime application made during May 1984, Baton Rouge, LA.

Depth (inches)	No-till		Disk only		Moldboard and disk		Subsoil and disk	
	Lime	No lime	Lime	No lime	Lime	No lime	Lime	No lime
				pH				
0-1	6.2	4.8	6.4	5.2	5.9	5.2	6.5	5.2
1-3	5.7	5.1	6.4	5.2	6.0	5.3	6.4	5.2
3-6	5.5	5.6	6.0	5.5	6.0	5.2	6.1	5.4
6-9	5.5	5.3	5.4	5.4	5.5	5.2	5.5	5.3
				Ca ppm)				
0-1	1,194	680	1,110	715	978	735	1.040	709
1-3	837	605	1,090	720	950	761	1,024	701
3-6	833	775	902	788	970	752	922	802
6-9	930	836	883	853	901	864	930	804
				P (ppm)				
0-1	162	163	110	107	69	79	78	74
1-3	82	71	95	103	71	69	77	73
3-6	20	23	31	30	41	42	34	35
6-9	10	15	12	14	21	21	13	15

N and Ca were the most limiting nutrients for all tillage systems in 1986 (Table 5). Phosphorus was not limiting in any tillage system, but this element was significantly higher in the no-till treatment than in other tillage systems (Table 4).

Discussion

The positive response of soybeans to lime resulted even though the seed was treated with molybdenum at planting each year. This response to lime is in accordance with the soil test interpretations given by Peevy (1972) that Ca levels below 1,000 ppm are considered low for Mississippi terrace soils with CEC of approximately 8 meq/100g. In contrast, soil test values for all other macro-nutrients were in the medium to high ranges given by Peevy (1972). Why the response of soybeans to lime was delayed until the third growing season after application, regardless of tillage, remains unclear.

The positive response of soybeans to lime and the interpretation of soil test results by Peevy are both consistent with the DRIS diagnosis that Ca and N were the most limiting elements. The Ca imbalance may act directly on the physiology of the soybean plant, or it may affect the associated rhizobia. The earlier leaf senescence in unlimed plots is consistent with the interpretation that the response of soybeans to lime is mediated through an increased plant-N status.

The stunting of soybean plants observed in 1986 on disked only and subsoil plus disk treatments, which was due to shortened internode lengths, is consistent with the activity of the herbicide chlorimuron ethyl. This herbicide is known to have greater activity in higher pH environments. Conditions were quite wet after planting in 1986. The combination of wet weather and soil pH above 6.4 in the top 3 inches may have been critical in the expression of herbicide injury. Depth of incorporation of lime may need to be considered when making herbicide recommendations, and detailed soil pH determinations may be warranted under some circumstances. Further research is needed.

A thorough economic analysis is needed before a recommendation among the various tillage systems can be made. Weed control was more difficult in the no-till treatments. However, planting of the no-till treatments frequently was delayed until weather and equipment availability allowed tillage operations on other treatments to be completed. Adopting a common planting date in this study allowed a fairer comparison of soybean growth as influenced by the physical environments created by tillage, but eliminated the timeliness advantage of no-till planting.

Table 4. Element concentrations of soybean leaflets at the R1 growth stage as influenced by tillage and lime application, Baton Rouge. LA. 1986.

Element	No-till		Disk only		Moldboard and disk		Subsoil and disk	
	Lime	No lime	Lime	No lime	Lime	No lime	Lime	No lime
	(%)							
N	5.4	5.3	5.2	4.9	5.2	4.9	5.3	5.0
P	0.63	0.62	0.59	0.60	0.60	0.56	0.58	0.59
K	2.43	2.28	2.37	2.33	2.26	2.28	2.36	2.34
Ca	0.80	0.70	0.86	0.74	0.80	0.76	0.86	0.84
Mg	0.49	0.46	0.48	0.47	0.48	0.48	0.50	0.50
S	0.37	0.35	0.38	0.35	0.35	0.33	0.36	0.36
	(ppm)							
Fe	94	88	106	88	98	83	116	92
Mn	101	272	91	158	99	198	88	149
Zn	65	67	66	68	64	67	62	69
Cu	14	14	13	14	14	14	13	14
B	42	48	41	50	42	52	40	50

Table 5. DRIS indices of soybean leaflets sampled at the R1 growth stage as influenced by tillage and lime application, Baton Rouge, LA, 1986.

DRIS index	No-till		Disk only		Moldboard and disk		Subsoil and disk	
	Lime	No lime	Lime	No lime	Lime	No lime	Lime	No lime
N	−0.6	−0.4	−0.8	−0.9	−0.7	−1.0	−0.6	−1.0
P	3.3	3.4	2.6	3.1	3.2	2.7	2.8	3.0
K	0.2	0.1	0.1	0.2	−0.1	0.1	0.1	0.1
Ca	−2.3	−2.9	−1.7	−2.4	−2.2	−2.2	−1.9	−2.0
Mg	1.1	1.1	1.1	1.2	1.1	1.4	1.3	1.3
Dry matter	−1.7	-1.3	−1.5	−1.3	-1.5	−1.2	−1.6	-1.5

Conclusion

Incorporation of fertilizer and lime with tillage did not increase the yield nor improve the nutritional status of soybeans compared with continuous no-till planting. After 8 years of continuous no-till, soybean yields were equal and leaflet P concentrations were higher in no-till than in other treatments. Ca and N were the most limiting elements with all tillage systems, but response to lime was as great for no-till as for any tillage system. Neither deep tillage (moldboard or subsoiling) nor shallow mixing were needed on this soil in order to maintain soybean productivity when weeds were controlled by other means.

Literature Cited

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