SOYBEAN NUTRIENT STATUS RESPONSE TO NO-TILLAGE VERSUS NO-TILLAGE PLUS SUBSOILING

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ABSTRACT

Nutrient supply is crucial to the proper development of the plant. This study was conducted to determine the effects of no-tillage (NT) without and plus subsoiling (NT + S) on the nutrient status of the soil and the soybean (Glvcine max plant at three reproductive stages R3, R6 and R8. Whole plant samples were taken from one square meter of treatment rows replicated three times. Whole plant samples were partitioned into root, stem, leaf, and pod parts. Soil samples were taken from the sample rows at depths of 0-2, 2-4, 4-6 and 6-12 inch. All plant tissue and soil samples were analyzed for N, P, K, Ca, Mg, Mn, Zn, Cu and Fe. There was a decline in content of mobile nutrients (N, P, K and Mg) for plants in both tillage methods from R3 to R8. There was a trend for nutrient content of most nutrients to be greater for NT+S soybean because of the generally higher dry matter and bean yield for this treatment. Whole plant and seed dry matter yields were 30% and 72% higher for NT + S compared to NT, respectively. Subsoiling not only gave higher dry matter yield but also resulted in greater uptake of plant nutrients from the soil.

INTRODUCTION

Tillage practices affect soil properties such as pH (Blevins et al., 1977) and organic matter (Gallaher, 1984). and may influence nutrient availability. Generally, soils under no-tillage (NT) have greater organic C and N concentrations (Gallaher, 1984; Wood et al., 1991). Above ground growth of soybean *(Glycine max* (L.) Merrill) was found to be a good indicator of root growth, with rooting depth about twice the plant height and about 50% of the roots concentrated in the upper 6 inch layer of soil under dry land conditions (Mayaki et al., 1976). The soybean plant has deep rooting and nutrient extraction capabilities (Al-Ithawi et al., 1980).

The objective of this experiment was to determine the effects of NT and no-tillage plus subsoiling (NT+S) on the nutrient status of the soil and the soybean plant at three reproductive stages R3, R6 and R8. Specifically, we were determining the nutrient content of the plant parts--roots, stems, leaves, pods and seeds–at each reproductive stage as affected by tillage method.

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MATERIALS AND METHODS

'Cook' soybean was sown in the summer of 1993 at the Green Acres Farm; the University of Florida, Agronomy Department's farm. The soil is an Arredondo loamy sand to sand (Grossarenic Paleudult) (Soil Survey Staff, 19841.

Treatments included NT+S (the Subsoiler was passed through the rows before the seeds were dropped into the soil) and NT in a randomized complete block design with three replications. Samples for nutrient analysis were taken at three reproductive (RI stages; R3, R6 and R8 (R3 is the beginning of pod formation with pods measuring 5-mm long at one of the four uppermost nodes on the main stem with a fully developed leaf, R6 stage is the stage at which a green seed fills the pod cavity at one of the four uppermost nodes on the main stem with a fully developed leaf and R8 is full maturity when 95% of the pods have reached their mature pod color) (Ferr and Caviness, 1977). Samples were taken from the healthy-looking one square meter of each treatment. The collected samples were separated into leaves (petioles remained on stems, and all leaves were collected as they were ready to drop and those remaining on the plant to ensure total leaf weights), stems, pods and roots. The samples were dried in a forced-air drier at 70°C, weighed on a Mettler PN2210 top-loading scale for DM, chopped, then ground using a Wiley Mill fitted with a 1-mm stainless steel screen, and were placed into plastic air-tight Whirl-pak bags.

Samples were dry ashed to determine the mineral concentrations and solutions were taken to the instruments (in the IFAS Extension Soil Testing Laboratory) for analysis. Readings were done for P (colorimetry) K (flame emission spectrophotometry), and Ca, Mg, Cu, Mn. Fe and Zn by atomic absorption spectrophotometry using a Perkin-Elmer (model 603) Atomic Absorption Spectrophotometer. The N concentration of the plant samples were determined by Micro-Kjeldahl techniques (Gallaher et al., 1975; Gallaher et al., 1976).

Soil samples were taken in the rows where the plant samples had been taken. A soil probe was inserted in the top 12 inches of the soil in about 12 places and the soil was mixed in small brown bags. The soil samples were air dried and sent to the IFAS Extension Soil Testing Laboratory to be analyzed by the double acid procedure (Mehlich, 1953). The pH was determined by electrode. Phosphorus was determined by colorimetry, K by flame emission and Ca, Mg, Cu, Mn, Fe, and Zn by atomic absorption spectrophotometry. Soil N concentration was analyzed by the same procedure used for plants except that 2.0 g of each sample were used without addition of glass boiling beads. Soil organic matter was determined using the potassium-Dichromate procedure (Walkley, 1947).

Data collected in this experiment was entered into a computer spreadsheet (Quattro pro 4.0.. 1987) for manipulation and transformations. Analysis of variance (ANOVA) of a randomized complete block design was computed with MSTAT (Version 4.0-C, 19871.

RESULTS AND DISCUSSION

Soil Analysis

Fertilizer recommendations from the IFAS Extension Soil Testing Laboratory at the University of Florida indicated that K and Ca were deficient whereas P and Mg were high among the macronutrients at all soil depths analyzed. The pH and O M of the soil decreased with depth (Table 1).

Diaanostic Leaf

The results from the diagnostic leaves revealed a deficiency of K among the macronutrients confirming what was observed in the soil. Manganese was high among the micronutrients and Cu was deficient based on sufficiency ranges of nutrients for soybean (Jones et al., 1991) (Table 2).

Table 1. Mehlich 1 extractible nutrients, pH and organic matter affected by depth and subsoil treatment in no-tillage soybean plots.

			Macronutrient				Micronutrient		
Soil Depth	pH	O M	P	K	Mg	Ca	Zn	Cu	Mn
---- in ----		- % -	---------------- ppm ---------------				------------ ppm ----------		
0 - 2	5.7	2.496	43h	21d	54h	607	1.10	0.09	2.31
2 - 4	5.3	1.716	57h	14d	43h	345	0.27	0.07	0.87
4 - 6	5.1	1.950	47h	11d	36h	255	0.19	0.06	0.78
6 - 12	4.7	1.248	33h	6d	12d	80	0.10	0.05	0.37
Subsoil'									
yes	5.1		45	16	25	211	0.29	0.06	1.57
No	5.2		49	14	27	334	0.35	0.07	0.96

*) Average of three replications
h) high
d) deficient

For future soybean production, application of 4,000 lb calcitic or dolomitic limestone/acre was recommended to adjust soil pH. A recommendation of 60 lb K/acre was also recommended for growing soybean.

Table 2. A comparison of the soybean table of interpretive nutrient values from Jones et al. 1991 and values from the diagnostic leaves.

	Jones et al. 1991			Diagnostic leaves	
Element	Low	Sufficient	High	No-tillage + Subsoiling	No-tillage
			%		
N	3.10-4.00	4.01-5.50	5.51-7.00	4.43 s	4.38 s
P	0.16-0.25	0.26-0.50	0.51-0.80	0.28 s	0.30 s
K	1.26-1.70	1.71-2.50	2.51-2.75	1.17 d	1.19 d
Ca	0.21-0.35	0.36-2.00	2.01-3.00	1.12 s	1.13 s
Mg	0.11-0.25	0.26-1.00	1.01-1.50	0.48 s	0.49 s
			ppm		
Mn	15-20	21-100	101-250	105 h	116 h
Zn	10-20	21-50	51-75	46 s	46 s
CU	5-9	10-30	31-50	6 d	6 d
Fe	31-50	51-350	350-500	113 s	120 s

s = sufficient; d = deficient; h = high

Nutrient Content Analysis

Whole plant macronutrient contents were higher at 105 days after planting (DAP) (Table 3). Whereas micronutrients were higher at 129 DAP, Fe was higher at 105 DAP (Table 4). There were no significant differences between tillage treatments on micronutrients. Nevertheless, macronutrients were affected by tillage. Contents of N, P, and Ca ($p=0.10$) and K and Mg ($p=0.05$) were significantly higher for NT+S compared to NT.

Drv Matter Analysis

Root, Stem, and leaf DM increased throughout the vegetative period and decreased after 105 DAP (after the onset of reproductive growth). Tillage treatments did not show any significant difference on roots. On the contrary, tillage affected stems ($p=0.10$) and leaves ($p=0.05$) with NT+S having larger values. Pods experienced an increase in DM at harvest time (129 DAP). The increase of DM in this new sink is reflected in the decrease in the DM of leaves and stems after vegetative growth. No-tillage plus subsoiling had higher whole plant DM ($p=0.05$). This was due to the good root development in NT+S plots supporting what Mayaki et al (1976) reported. Final seed yield was higher for NT+ S than NT ($p=0.05$) (Table 5). From the foregoing discussion, it is likely that the tillage differences observed with macronutrients did not result from differences in nutrient concentration but from differences in dry matter per unit area.

Table 3. Whole plant soybean (Glycine max L.) macronutrient content response to no-tillage treatment.

Days After Planting	R Stage	No-Tillage plus subsoil Yes	No	Mean	CV(%)
		------------- lb/acre -------------			
			Nitrogen		
84	3	120.8	76.4	98.5 b	20.16
105	6	174.2	149.4	161.8 a	
129	8	177.8	134.1	155.9 a	
Mean		157.5	120.0 +		
LSD				54.2	
			Phosphorous		
84	3	13.68	8.19	10.93 b	22.65
105	6	20.41	17.44	18.93 a	
129	8	18.18	14.18	16.18 a	
Mean		17.43	13.27 +		
LSD				4.63	
			Potassium		
84	3	83.0	43.0	63.0 b	28.30
105	6	115.3	84.6	100.0 a	
129	8	101.6	77.3	89.5 ab	
Mean		99.9	67.5 •		
LSD				31.7	
			Calcium		
84	3	38.69	23.26	30.97 b	18.98
105	6	47.55	39.61	43.06 a	
129	8	42.93	33.17	38.05 ab	
Mean		43.06	32.01 +		
LSD				9.48	
			Magnesium		
84	3	20.14	13.06	16.60 b	21.90
105	6	26.91	23.29	25.10 a	
129	8	26.10	19.05	22.58 ab	
Mean		24.39	18.46 *		
LSD				6.25	

Values in columns among Days After Planting for each nutrient followed by the same letter are not significantly different at the 5 % level of probability according to LSD test. Values in rows between tillage with * and + are significantly different at the 5 % and 10 % level of probability, respectively.

Table 4. Whole plant soybean (Glvcine max L.) micronutrient content response to no-tillage treatment.

Days After Planting	R Stage	No-Tillage plus subsoil Yes	No	Mean	CV(%)
		----------b/acre----------			
			Manganese		
84	3	0.329	0.228	0.279 a	21.72
105	6	0.381	0.287	0.334 a	
129	8	0.379	0.315	0.347 a	
Mean		0.363	0.277 NS		
LSD				NS	
			Zinc		
84	3	0.182	0.121	0.151 b	31.93
105	6	0.278	0.250	0.264 ab	
129	8	0.347	0.325	0.336 a	
Mean		0.269	0.231 NS		
LSD				0.170	
			Copper		
84	3	0.025	0.017	0.021 a	21.08
105	6	0.027	0.026	0.027 a	
129	8	0.032	0.024	0.031 a	
Mean		0.029	0.022 NS		
LSD				NS	
			Iron		
84	3	0.646	0.594	0.619 a	27.90
105	6	0.822	0.949	0.886 a	
129	8	0.796	0.606	0.701 a	
Mean		0.755	0.717 NS		
LSD				NS	

Values in columns among Days After Planting for each element followed by the same letter are not significantly different at the 5 % level of probability according to LSD test. Values in rows between tillage with NS = not significant at the 5 % level of probability.

Table 5. Dry matter weight of soybean (Glycine max L.) plant part, response to no-tillage treatment.

Days After Planting	R Stage	No-Tillage plus subsoil Yes	No		Mean	CV(%)
		----------------------- lb/acre	-----------------------			
			Roots			
84	3	714.7	472.6		593.6 b	22.59
105	6	946.1	990.6		968.3 a	
129	8	704.0	572.3		636.4 b	
Mean		788.5	678.2	NS		
LSD					219.8	
			Stems			
84	3	2848.0	1668.8		2258.4 ab	18.98
105	6	3008.2	2497.3		2752.8 a	
129	8	1945.5	1771.1		1858.3 b	
Mean		2600.6	1979.4	•		
LSD					578.5	
			Leaves			
84	3	1599.3	1057.3		1328.8 a	16.79
105	6	1462.3	1174.8		1318.1 a	
129	8	939.8	867.8		903.3 b	
Mean		1334.1	1033.3	+		
LSD					264.3	
			Pods			
84	3	358.7	237.6		298.2 c	35.11
105	6	1818.3	1417.8		1618.0 b	
129	8	2993.1	2091.5		2542.7 a	
Mean		1723.0	1248.7	+		
LSD					695.1	
			Whole plant			
84	3	5520.7	3438.1		4479.4 b	17.37
105	6	7235.7	6081.4		6658.1 a	
129	8	6583.3	5300.0		5941.6 a	
Mean		6446.3	4940.4	•		
LSD					1316.3	
			Seeds			
129		1937.5	1180.1	*	1558.4	

Values in columns among Days After Planting for each plant part followed by the same letter are not significantly different at the 5% level of probability according to LSD test. Values in rows between tillage with NS= not significant at the 5% level of probability. Values in rows between tillage with * and + are significantly different at the 5% and 10% level of probability, respectively.

CONCLUSIONS

To summarize we found that mobile macronutrient concentrations declined as the plants grew older. From the data it is likely that tillage treatments did not affect nutrient concentration but because of conditions for greater dry matter production NT+S resulted in greater nutrient contents for most macronutrients. Diagnostic leaf tissue was deficient in K. Low soil pH and low soil K was also found. Improved yield and plant nutrition of NT soybean could occur from application of 4000 lb calcitic or dolomitic limestone/acre and 60 lb K/acre for future soybean plantings, and the recommended tillage for these conditions is NT+S.

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