Soybean Relative Yield as Affected by Cropping Sequences and Conservation Tillage

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ABSTRACT

Tillage and cropping sequence studies were conducted on a Hartsells fine sandy loam from 1981 to 1984 to determine the influence of tillage systems and crop rotation on soybean relative yields. The tillage systems were conventional, strip-tillage, and no-tillage. Crop rotation was continuous soybeans, corn-soybeans (full season), corn-wheat-soybeans (double-cropped soybeans). In 1982 through 1984, conventional tillage with continuous soybeans resulted in lower soybean yields than strip-tillage or no-tillage. Corn-soybean rotation consistently resulted in higher soybean yields than continuous soybeans. Double-cropped soybean yields were reduced by 10% when compared to full season soybeans, but wheat yields associated with double-cropped soybeans ranged from 3000 to 3900 kg/ha. The buildup of soybean cyst nematodes (continuous soybean with conventional tillage) appears to have a greater effect on soybean yields than soil compaction, soil nutrient levels, or rainfall distribution.

Introduction

Conservation tillage is a system of managing crop residue on the soil surface with minimum or no tillage. Goals of conservation tillage are to leave enough plant residue on the soil surface for control of water and wind erosion, to reduce energy requirements; and to conserve soil water (5). Although the use of crop residues on the soil surface has been widely practiced for many years, additional information is needed on the influence of tillage systems on physical, chemical, and biological soil environment, and on crop production. With the development of effective chemical weed control and suitable planting equipment, the potential for conservation tillage systems has increased. During the past several years, research in tillage systems has been expanded to include crop rotation and cropping systems. The purpose of this study, which was established in 1980, was to determine the influence of crop rotation and cropping systems on soybean yields.

Materials and Methods

Conventional tillage was compared to strip-tillage and no-tillage systems with soybeans, corn, and wheat on a Hartsells fine sandy loam (fine-loamy, siliceous, thermic, Typic Hapludults) soil. The strip-tillage consisted of planting corn and soybeans over 20 to 23 cm deep chisel slots (in-row chiseling); with no-tillage corn and soybeans were planted with a double-disk opener planter directly in the untilled soil surface. Row spacing was 90 cm for corn and 68 cm for soybeans. The soybean plots were 15 m long, with the center two rows harvested for yields.

Cropping sequences were continuous soybeans; continuous corn, corn-soybeans, and corn-wheat for grain-soybeans. Wheat was planted as winter cover on all plots including those not used for grain crop. The wheat was killed with an over-the-top application of paraquat 10 days before planting corn or soybeans. Planting dates ranged from 14 March to 1 April for corn, from 1 May to 10 May for full season soybeans, and 15 June to 1 July for double-cropped soybeans. Planting date for the double-cropped soybeans depended on soil moisture conditions when wheat was harvested.

Results and Discussion

The highest soybean yields in the first cycle occurred with continuous, full season soybeans in the strip- and no-tillage systems (Table 1). However, in the second, third, and fourth years, the no-tillage system rotated with corn resulted in the highest yields. The yields for this treatment were 45.2 bu/acre in 1981, 46.7 in 1982, 35.4 in 1983, and 44.2 in 1984. Yield averages for full season soybeans rotated with corn were 32.7, 41.8 and 42.9 bu/acre for conventional, strip, and no-tillage.

After 1981, yields of continuous soybeans grown with conventional tillage ranged from 29 to 88% as high as the no-tillage soybeans rotated with corn. With continuous full season soybeans, yield averages were 26.9, 36.4, and 41.7 bu/acre for conventional, strip-, and no-tillage. Yields of the double-cropped soybeans were lower each year than full-season soybeans rotated with corn. Yield averages for double-cropped soybeans were 35.9, 38.6, and 34.3 bu/acre for conventional, strip-, and no-tillage.

To determine the best rotation and tillage systems for consistent soybean production, these factors should be considered: soil nutrient levels, soil physical condition (compaction, tillage pans), climate (rainfall distribution) and change in soil microflora by tillage and rotation systems.

Soil nutrient levels are easily monitored by soil test to eliminate them as limiting factors in soybean yields. Each fall nutrients were applied to all plots to maintain high levels of P and K; however, fertilizer was applied on an individual plot basis since differing amounts of P and K were removed, depending on tillage and crop rotation. Nitrogen (90 lb/acre) was applied to wheat for cover and wheat for grain.

High soil strength and low soil oxygen are two important factors restricting root growth in soil with compactible layers. Conservation tillage systems eliminated these limiting factors. With conventional tillage, soybean rooting was restricted to a soil volume of 15 cm or the Ap layer. The restricted rooting depth was also verified by taking soil penetrometer measurements under the row in June 1983 (Table 2). Soil strength was less than 1 Pascal at the 40-cm depth for the strip-tillage system. The energy for penetration of the no-tillage system was reduced only at the 0- to 15-cm depth, and increased from the 15- to 60-cm soil depths. Thus, under conditions of low rainfall during critical moisture periods, increased soil strength could have an adverse effect on soybean yields by restricting root growth and water removal to the soil volume above the hardpan.

Tillage systems that enhance water infiltration and/or reduce evaporation have a better chance of maintaining adequate soil water during periods of drought stress. In 1982-1984, poor rainfall distribution (Fig. 1) resulted in periods of drought stress of 14 days or more. However, soybean yields did not appear to be affected in the tillage systems that maintained some residue on the soil surface (strip-tillage and no-tillage). The moisture conserving advantage of the mulch may have been one of the primary factors responsible for higher yields with conservation tillage than with conventional tillage in 1982-1984.

After 4 years of continuous soybeans, yield in 1983 with conventional tillage was only 10 bu/acre. The soybean plants were stunted in late August and began to defoliate prematurely (1,2,3,4). Observation of the soybean roots and soil samples collected in late August suggested a nematode infestation. In 1984 high populatons of soybean cyst nematodes were found in soil samples from continuous soybean-conventional tillage.

In summary, soybean yields in this conservation tillage study were influenced by rainfall distribution, soil physical conditions, and change in the soil microflora. Effects of rainfall distribution can only be controlled by supplemental irrigation, while the adverse effects of soil compaction can be controlled to some extent by maintaining some plant residue on the soi surface to enhance water infiltration and reduce evaporation losses. Nematode populations can be kept in check by growing corn or some other grass in rota ion with soybeans; however, the greatest increase in soybean yields due to rota ion was more evident when grown with some form of conservation tillage system.

Literature Cited

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Table 1. Effects of tillage and crop rotation on soybean relative yields for 1981 through 1984 at Crossville, Alabama

Tillage systems	Relative yield of soybeans (% of standard)"			
	1981	1982	1983	1984
	Continuous soybean			
Conventional	88	65	29	63
Strip-tillage	114	88	66	67
No-tillage	127	89	93	79
	Soybeans-corn rotation			
Conventional	81	89	70	63
Strip-tillage	94	98	94	100
No-tillage	100*	100*	100*	100"
	Wheat-soybeans-corn			
Conventional	96	91	81	66
Strip-tillage	94	92	79	92
No-tillage	71	88	77	82

* Yields for standard were 45.2 bu/acre in 1981; 46.7 in 1982; 35.4 in 1983; and 44.2 in 1984.

Table 2. Effects of conservation tillage systems on soil strength at Crossville, Alabama in 1983.

Tillage systems	Soil depth (cm)			
	15	30	45	60
	Pascal 10 x10^{6}			
Conventional	0.75	1.18	1.73	1.93
Strip-tillage	0.29	0.59	0.89	1.41
No-tillage	0.51	1.00	1.62	1.15

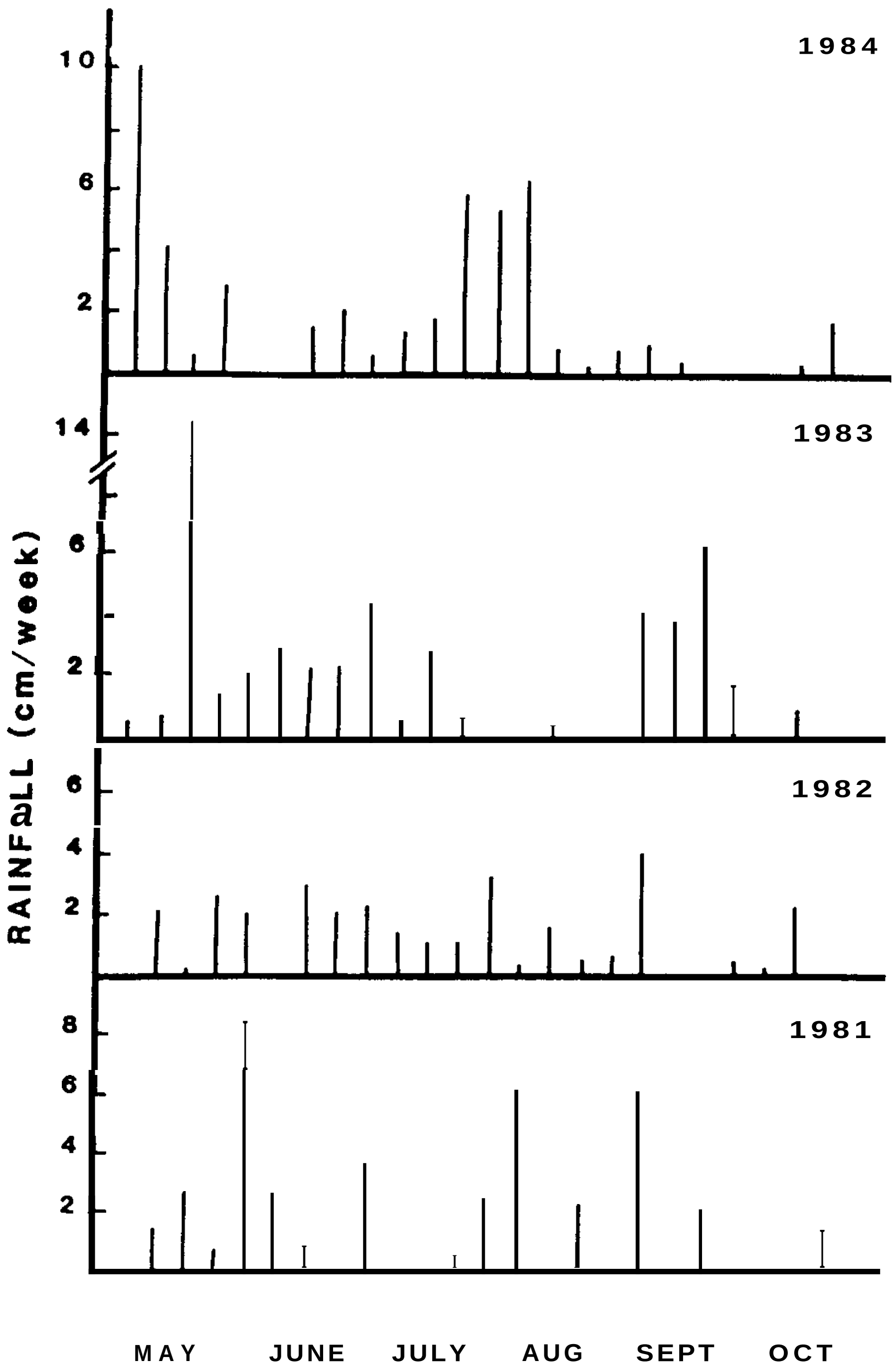

Figure 1. Rainfall in cm/week at Sand Mountain Substation for 1981 through 1984 for the soybean growing season.