SOYBEAN ROOT RESISTANCE AS AFFECTED BY TILLAGE IN OLD TILLAGE STUDIES

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Introduction

Many scientists have observed that yields of soybean (Glycine max L. Merr.) tend to decrease beginning the second or third year of continuous no-tillage. The exact reason for this decrease has never been thoroughly defined. Some have proposed that conventional tillage is needed every second or third year to eliminate the problem. Another approach is to conventionally till the soil every year in the fall when establishing the small grain and to utilize no-tillage planting only for the summer crop when timing, incorporation of fertilizers, moisture conservation, and/or soil conservation are more important. While these and other manaqement practices help reduce or eliminate decreased yields over time with continuous no-tillage, the problem still needs to be defined so that other possible solutions may be found. The purpose of this research was to measure root resistance of soybeans as an indication of rooting patterns in relation to no-tillage and conventional tillage. Root resistance was measured by determining the maximum g/cm^2 required to pull soybean plants free from their attachment to the soil.

Materials and Methods

A single root resistant measurement consisted of selecting a 2324 cm^2 section at random in soybean plots. In this measurement area the number of soybean plants were counted for calculating the area per plant. Three side-by-side plants were then selected from the area at random, tied together near the base with a string which was attached to a killogram scale. A smooth and continuous force was then applied to the scale until the soybean plants were released from the *soil*. The maximum reading on the scale was recorded. Five selection sites and readings were taken in each individual treatment of a replication and averaged for the treatment-replication value. These readings were adjusted for population so that plant size would not be a confounding factor. An example of a root resistant calculation is as follows: 1) assume the number of plants in a 2324 cm^2 area was 8.2; 2) assume the field resistance for three plants was 15.2 kg; 3) the area per plant would be 2324 cm^2/8.2 plants = 283.4 cm^2 /plant; 4) the original g resistance per plant would be 15.2 kg X 1000 g/kg/3 plants = 5067 g/plant; 5) the corrected root resistance would be 5067 g/plant/283.4 cm^2/plant = 17.88 g/cm^2,

One experiment where measurements were made was an oat (Avena sativa)/soybean succession begun in 1974. Tillage treatments included 1) no-tillage plus subsoil, 2) no-tillage, 3) conventional tillage plus subsoil, and 4) conventional tillage. No-tillage treatments were imposed with an in-row subsoil no-tillage planter. Conventional plots were tilled to a depth of 25 cm with a rototiller and planted with the same planter. Root resistance measurements were begun in 1981 and will continue through 1984 at which tine the tillage treatments will have been maintained for eight years. Measurements were taken just prior to senescence except in 1983 when one measurement was taken 11 days prior to senescence and a second measurement was taken at senescence.

Measurements were made in a rye (Secale cereale L.)/soybean succession which began in 1975 and ended in 1983. This experiment had only two tillage variables until 1981 and included 1) no-tillage plus subsoil, and 2) no-tillage. In 1981 these treatments were split to include 1) continuous no-tillage plus subsoil, 2) imposed conventional tillage plus subsoil, 3) continuous no-tillage, and 4) imposed conventional tillage. Root resistance measurements were begun in this study in 1981 and continued through 1983. Heasurements were taken just prior to senescence of the soybeans except in 1983 when the measurement was taken about one week after senescence.

Root resistance measurements were also made in two other experiments with identical tillage variables in 1981 to observe first year mulching effects for soybean and peanut (Arachis hypopaea L.). Treatments in these studies included 1) no-tillage into rye straw residue, 1) no-tillage after rye straw removal, 3) conventional tillage incorporation of rye straw, and 4) conventional tillage after rye straw removal.

All experiments were conducted on an Arredondo fine sand (loamy, silicious, hyperthermic grossarenic Paleudults) and were in randomized complete block designs. Experiments were replicated four times. Analysis of variance was run using standard procedures and means tested using Duncans new multiple range test.

Results and Discussion

Subsoiling in either no-tillage or conventional tillage resulted in greater root resistance than nonsubsoiling treatments (Tables 1 and 2). The traditional no-tillage treatment had the least root resistance in almost all cases, followed closely by conventional tillage.

Visual observation of soybean roots in no-tillage without subsoiling showed that roots were confined to the upper few centimeters of soil in close association with the previous oat or rye residues. Observations support the idea that, since small grain residue mulch conserves moisture and degrades rapidly under Florida conditions, more water and nutrients are available near the soil surface for the no-tillage soybeans. This favorable environment near the soil surface would favor root growth in the upper few centimeters. The mulching study (Table 3) supoorts this idea because root resistance for both soybeans and peanuts were lowest in mulch treatments.

In 1976, when the experiments in Tables 1 and 2 were begun, one of the objectives was to determine if the recently invented no-tillage in-row subsoil planter would alleviate the yield decline problem for no-tillage soybeans. Root resistance data and visual observations indicate that roots are stimulated to grow to deeper depths as well as proliferate near the surface under the small grain mulch in the no-tillage plus subsoil plots. Root resistance for no-tillage in-row subsoil were equal in almost all cases to root resistance measuredin conventional tillage in-row subsoiling.

These data show that crop residues play a Major role in distribution and location of roots. No-tillage in-row subsoiling can allow direct seeding without tillage over a longer period than traditional no-tillage planting of soybeans based on root resistance data in this report. It is proposed that crop residues acting as a mulch in no-tillage soybeans causes roots to grow nearer the soil surface because of additional water, lower soil temperatures, and slower release of plant nutrients. Root resistance data from this researcl; supports this idea. Because of this soil surface root gowing habit under mulching conditions, few roots would be deep in the soil profile and plants could he adversely affected during periods of drought stress. This rooting habit under no-tillage is Likely part of the reason that soybean yields decrease after the second or third year of continuous no-tillage. Since research studies have shown yield responses to no-tillage in-row subsoil planting under these conditions, the use of this type of no-tillage equipment would result in roots utilizing the surface benefits of the mulch as well as encouraging deeper rooting habits in order to better maintain the plants during drought stress.

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Table 1. Soybean Root Resistance in an oat-soybean double cropping system.

Tillage	Year				Average
	1981	1982	1983-1	1983-2	
	g/cm^2				
No-Tillage Sub.	10.00a	17.53a	13.96 b	9.52b	12.75a
No-Tillage	5.21b	11.28b	10.91c	6.99c	8.60c
Conv-Tillage Sub.	9.26a	17.85a	16.35a	10.47ab	13.48a
Conv-Tillage	9.95a	12.57b	12.61 b	11.36a	11.62b

Conv is conventional. Sub is subsoil. Values in columns not followed by the same letter are significantly different at the 0.05 level of probability according to Duncans new multiple range test.

Table 2. Soybean root resistance in a rye-soybean double cropping system.

Tillage	Year			Average
	1981	1982	1983	
	g/cm^2			
No-tillage Sub.	9.26 a	9.75 a	6.28 ab	8.43 a
No-tillaee	6.15 b	6.92 b	5.32b	6.13 b
Conv-tillage Sub.	7.95 a	10.68 a	8.43 a	9.33 a
Conv-tillage	7.89 a	5.53 b	6.58 a	7.00 b

Conv is conventional. Sub is subsoil. Values in columns not followed by the same letter are significantly different at the 0.05 level of probability according to Duncans new multiple range test.

Table 3. Soybean and peanut root resistance in double cropping systems with rye for grain in 1381.

Tillage	crop	
	Soybean	Peanut
	g/cm^2	
No-tillage plus rye straw	5.85 b	7.44 b
No-tillage minus rye straw	4.89 b	10.97a
Conv-tillage plus rye straw	6.21a	9.73ab
Conv-tillage minus rye straw	6.88a	12.81a

Conv is conventional. Values in columns not followed by the same letter are significantly different at the 0.05 level of probability according to Duncans new multiple range test.