Tillage Variables for Peanut Production

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ABSTRACT

Effects of minimum tillage (MT) production techniques on peanut *(Arachis hypogaea* L.) root growth and yield were unknown. Field experiments were therefore conducted during 1984 near Williston and Marianna, FL and during 1985 near Williston and Jay, FL to evaluate effects of surface and subsurface tillage on peanut production. Soil types were a Zuber loamy sand (fine, mixed hyperthermic Ultic Hapludalf) at Williston, a Chipola sandy loam (loamy, siliceous, thermic Arenic Hapludult) at Marianna, and a Red Bay sandy loam (fine, loamy, siliceous, thermic Rhodic Paleudult) at Jay. The Sunrunner peanut cultivar was planted using a modified twin 23 cm row spacing and seeded at a rate of 140 kg/ha. Eight tillage systems that included combinations of conventional tillage, strip-tillage, and no-tillage with and without subsoiling or subsurface slitting were evaluated. Peanuts germinated and grew well except in no-tillage plots that received no subsurface tillage. Without surface or subsurface tillage there was not sufficient soil disturbance to insure proper seed-soil contact or seed cover. Generally, plots that received some degree of conventional tillage yielded better than plots with no surface preparation (4090 vs. 3760 kg/ha avg.). Minimum tillage plots yielded numerically less than conventional plots but in only a few cases were significant differences in yield noted. At most locations, minimum tillage plots that received no subsurface tillage developed a "lazy root syndrome" in which the few roots produced were quite shallow and grew near the soil surface. These treatments yielded less (3680 vs. 4010 kg/ha avg.) than those with conventional seedbed preparation or the minimum tillage treatments receiving subsurface tillage. Root strength and penetration measurements roughly reflect the same trends as peanut yields. The slit-tillage system resulted in peanut yields equal to or better than those obtained with chisel point subsoiling. Slitter wear and breakage problems were encountered but overall, the subsurface slit system appears to be a functional alternative to chisel point subsoiling.

Key Words: *Arachis hypogaea* L., slit-plant, subsoiling, reduced tillage, tillage comparisons, root strength measurements.

Throughout history, tillage has become accepted as a necessary requirement for production of most food crops. Many peanut *(Arachis hypogaea* L.) producers and researchers believe that tillage is necessary to reduce weed competition (3,13), disease incidence (1,2), and to provide soil conditions favorable for root growth (14). Traditionally, moldboard plowing has been done in late fall or early winter to insure the decomposition of existing plant residues. Little data exists on optimum depth of soil preparation in peanut production, but most soils are plowed 15 to 20 cm deep to allow for weed seed and disease propagule burial. Conventionally prepared peanut seedbeds are normally disked several weeks before planting to level fields and destroy weeds. A final disking just before planting is often used for incorporation of preplant herbicides. This method of land preparation has been termed "Deep turning; Non-Dirting" peanut culture by Boyle (1,2). It has been used since the early 1950's by most U.S. peanut producers because prior research (8,9,10) showed significant yield increases when this system was compared to less intensive tillage systems.

Traffic, plow, or genetic hard pans in Coastal Plain soils have made in-row subsoiling a popular tillage method for both conventional and minimum tillage (MT) production of agronomic crops. However, in-row subsoiling and other forms of deep tillage increase fuel costs and may slow planting operations (7). Use of a slit-plant system (6), may reduce energy and draft requirements of subsurface tillage as much as 40% compared to traditional in-row subsoiling. Furthermore, several new production methods have been introduced since the original work, comparing gradations in tillage from disking to moldboard plowing for the production of peanuts, was conducted in the mid-1950s (8,9,10).

Recent research devoted to MT production of many crops indicates that MT may offer several advantages over present production systems. These include 1) reduced wind and water erosion of the soil, 2) reduced energy requirements, 3) more flexible timing of planting and harvesting, and 4) more efficient water utilization (12,13). Copious amounts of research can be found dealing with the MT production of corn *(Zea mays* L.) and soybean *(Glycine max* (L.) Merr.), but only a few researchers have investigated MT production for peanuts (4,5). Also, there are little or no data evaluating effects of surface and/or subsurface tillage in no-tillage and conventional tillage systems for production of peanuts.

The objective of this study was to determine effects of various surface and subsurface tillage practices on root strength and peanut yield.

Materials and Methods

Field experiments were conducted during 1984 near Williston and Marianna, FL, and during 1985 near Williston and Jay, FL. Soil types were a Zuber loamy sand (fine, mixed, hyperthermic Ultic Hapludalf) at Williston, a Chipola loamy sand (loamy, siliceous, thermic Arenic Hapludult) at Marianna, and a Red Bay sandy loam (fine-loamy, siliceous, thermic Rhodic Paleudult) at Jay. Experimental areas at all locations were seeded with wheat *(Triticum aestivum* L.) in the fall prior to the initiation of experiments. All plots were sprayed with 1.12 kg ai/ha of glyphosate ((N-phosphonomethyl)glycine) approximately 2 weeks prior to peanut planting to kill the cover crop and existing weeds.

Experimental sites had natural infestations of Florida beggarweed *[Desmodium tortuosum* (SW.) DC.], smooth crabgrass *[Digitaria ischaemum* (Schreb.) Muhl.], and smallflower morningglory *[Jacquemontia tamnifolia* (L.) Griseb.]. Herbicide treatments applied to the entire test area for control of these weeds included oryzalin (4-(dipropylamino)-3, 5-dinitrobenzenesulfonamide) + glyphosate 1.12 + 1.12 kg ai/ha (preemergence), paraquat (1,1-dimethyl-4,4-bipyridiniumion) 0.14 kg ai/ha (ground cracking), and alachlor (2-chloro-N-(2,6-diethylphenyl)N-(methoxymethyl)acetamide) + dinoseb (2-(1-methylpropyl)-4, 6-dinitrophenol) + naptalam (2-[(1-naphth-

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alenylamino)carbonyl]benzoic acid) 3.36 + 1.12 + 2.24 kg ai/ha (early postemergence). Escaped weeds were hand pulled throughout the season in order to maintain weed free conditions. Soil fertilization and liming practices were in accordance with soil test recommendations of the University of Florida Soil Testing Laboratory.

In order to simulate wheat harvest and reduce stubble height, the test area was mowed before planting allowing the straw to scatter randomly over the plots. Strip-tilled seedbeds were prepared using a modified Brown-Harden Ro-till®[1] without planter units. The modified Ro-till® had a short subsoiler shank with an attachable slitter blade that penetrated the soil to a depth of approximately 40 cm. Fluted coulters were mounted on either side of the shank. The short subsoiler shank and slitter blade combination opened the soil breaking up plow pans beneath the row while fluted coulters smoothed the ripped soil and broke up large clods. 'Rolling crumblers' (barrel shaped devices that resemble a stalk cutter) were mounted immediately behind the fluted coulters to further smooth and shape the seedbed. No-tillage seedbeds were prepared using a KMC[2] no-tillage planter with actual planter units removed. The KMC unit has a single long subsoiler shank (40 cm) directly beneath the row that performed similarly to the Ro-Till® system. Small rubber tires on each side of the subsoiler shank pressed soil back into the subsoiler channel preparing a tilled area approximately 6 cm wide directly beneath the row. This minimum area of disturbed soil was compared to over 30 cm of disturbed soil prepared by the Ro-Till® system. Conventional seedbeds were prepared with a moldboard plow operated approximately 20 cm deep and followed by several diskings to further smooth the seedbed. A complete description of the eight tillage treatments are given in Table 1.

Table 1. Surface and subsurface tillage treatments.

Treatment Number	Surface tillage	Sub-surface tillage	Seed bed condition
1	Strip tillage[a]	Subsurface slit[b]	Stubble present[c]
2	Strip tillage	None[d]	Stubble present
3	Strip tillage	Subsurface slit	Conventional[e]
4	Strip tillage	None	Conventional
5	No-tillage[f]	Subsoiling[g]	Stubble present
6	No-tillage	None	Stubble present
7	No-tillage	Subsoiling	Conventional
8	No-tillage	None	Conventional

[a] Strip tillage--area approximately 30 cm tilled in row center area with modified Brown-Harden Ro-till®.

[b] Subsurface slit--Brown-Harden Ro-till® fitted with short subsoiler shank (24 cm) with 13 cm slitting bar attached directly beneath to penetrate through plow pan.

[c] Stubble present--upon final seed bed preparation for planting, wheat stubble is still present in plots except for area directly in row.

[d] None--no subsurface tillage.

[e] Conventional--seed bed prepared through mold board plowing and disking with either strip tillage or no-tillage planter unit used at seeding.

[f] No-tillage--area approximately 6 cm tilled directly in row with all other area undistrubed, unless employed in conventional plots.

[g] Subsoiling--KMC No-tillage planter fitted with subsoiler shanks penetrating approximately 36-40 cm into soil profile. Chisel type point 5 cm in width.

The Sunrunner (a runner type) peanut cultivar was planted in all studies at a seeding rate of 140 kg/ha in mid-May 1984 and mid to late May 1985. Planting was done in a separate operation due to equipment limitations for small plot work. The twin-row planting pattern was achieved using four twin-row planter (23 cm spacing) units mounted 76 cm apart (center-to-center) on a tool bar. Herbicides were applied with a tractor-mounted, compressed air sprayer set to deliver a diluent volume equivalent to 187 L/ha. Fungicide and insecticide applications were made as-needed throughout the season in accordance with accepted recommendations.

Plots were 3.0 x 7.7 m in size and treatments were arranged as a randomized complete block design with four replications. The center 1.5 m area of each plot was dug in mid-September of both years with a conventional digger-shaker-inverter. Peanuts were harvested with conventional equipment after three days of field drying. Peanut pod yields (adjusted to 7% moisture) and in two locations, root strength measurements were made using a standard scale mechanism and measuring force exerted (g/cm^2) to pull plants from the soil.

Root strength and yield data were subjected to analysis of variance and treatment means were tested for differences using an LSD test at the 0.05 level of probability.

Results and Discussion

Germination and Growth of Peanuts

Peanuts generally germinated well, but without surface or subsurface tillage (Trt. 6), stubble caused various degrees of planting problems at all locations. This occurred because the twin-row planter disturbed very little soil and often deposited seed directly on the surface with minimal soil covering the seed. Exposed seed were covered by hand, but this treatment still had somewhat poorer stands. Final yields were not drastically affected by lower stand, presumably because remaining plants were able to compensate for missing plants. Peanuts generally emerged more uniformly following moldboard plowing and harrowing, but this may have been expected because the planter was designed for a clean seedbed. Seedling disease ratings were not recorded, but among tillage treatments, no early season differences were apparent. There were also no differences among tillage treatments with respect to leaf spot *(Cercospora sp.)* or stem rot *(Sclerotium rolfsii* Sacc.). Although this test was not designed to measure such occurrences, it does raise the question of whether foliar and soilborne disease incidence can be assumed to be no worse in MT peanut production than in conventional culture.

Weed Control Differences

The entire experimental area received the same herbicide treatment, but weed emergence seemed to be correlated with tillage intensity. This factor was not measured, but general plot appearance suggested more uniform emergence of broadleaf weeds in treatments receiving conventional tillage (CT). Herbicides appeared to be more efficacious on grasses in CT plots than MT plots. Fewer weeds emerged in no-tillage plots than in strip-tillage plots. One reason that grasses were more of a problem in MT treatments than CT treatments was that broadleaf weed seed were never disturbed and given an opportunity to germinate. Shallower grass seed may have escaped control due to interception of herbicide material by wheat straw or other surface organic matter in no-tillage treatments. This hypothesis is suggested because when rain occurred within two days of herbicide application grass control in MT plots was not less than for CT treatments.

Tillage treatment effects

Tillage effects are presented by location and year because of significant location by year interactions.

Marianna 1984. The 1984 growing season near

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Marianna was very dry and as a result, yields for all treatments were suppressed (Table 2). Planting was delayed at this location due to lack of rainfall or irrigation and tillage equipment did not penetrate the soil as deep as at other locations. Lack of adequate soil penetration and overall dry conditions resulted in slow growth during the first 45 days of the season.

Table 2. Peanut yield as affected by tillage system, location, and year.

	Location and Year					
Treatment* Number	Marianna 1984	Williston 1984	Jay 1985	Williston 1985A	Williston 1985B	Avg.
	Peanut pod yield (kg/ha)#					
1	2560	4160	4280	5000	4040	4000
2	2540	3700	4520	3880	4240	3780
3	3390	4940	5060	4510	3780	4330
4	2060	4800	4400	4710	3900	3970
5	2690	4300	4370	3560	3550	3690
6	2240	3550	4200	4040	3920	3590
7	2440	4660	4830	4360	3780	4010
8	2090	4650	5020	4420	4020	4050
LSD .05	697	897	620	707	NS	

* For treatment description refer to Table 1.

Unfavorable growing conditions resulted in few differences in peanut growth and yield (Table 2). One exception was for Treatment 3 (strip-tillage with a subsurface slit beneath a conventionally prepared seedbed) (Table 1) which yielded significantly better than other treatments. The conventionally prepared seedbed allowed good lateral root development into a well prepared upper level soil environment. In addition, the subsurface slit allowed the peanut tap root to penetrate subsurface soil layers and extract water and nutrients from greater depths. This treatment was superior to Treatment 7 which utilized a standard subsoiler chisel foot. Larger channels created by the subsoiler chisel tended to be closed very quickly by subsequent machinery traffic and plants could utilize the opened channel for only a short time after planting. Elkins, et. al (7) have pointed out that the wider chisel subsoiler feet will often also cause undesirable surface and subsurface soil mixing which can be detrimental to plant root growth.

Williston 1984. At the Williston location, treatments receiving conventional tillage either with or without subsurface tillage were superior to other treatments. Treatments 3, 4, 7 and 8 were significantly better than Treatments 2 and 6 (Table 2). Treatments 2 and 6 received no form of subsurface tillage and only minimal surface tillage. Treatments 1 and 5 were minimum tillage treatments as well but each received subsurface tillage with either a slitter (Treatment 1) or subsoiler chisel (Treatment 5). With only a small surface area tilled, Treatments 2 and 6 apparently developed a "lazy root system." The force required to pull plants from the soil (Table 3) suggested that roots grew near the soil surface but did not branch out into the subsoil. Treatments 3, 4, 7 and 8 yielded the greatest numerically, but yields for systems 1 and 5 were not significantly different.

Table 3. Force required to pull plants from the soil as affected by tillage treatment.

	Location and years	
Treatment* Number	Williston 1984	Williston 1985A
	------- (g/cm^2 root resistance)# -----	
1	12.27 ab	12.95 ab
2	12.58 ab	10.62 ab
3	17.55 a	12.22 ab
4	12.83 ab	9.65 b
5	14.60 ab	14.98 a
6	10.68 b	13.35 ab
7	11.98 ab	14.18 ab
8	15.98 ab	13.40 ab

* For treatment description, refer to Table 1.

\# Means followed by different letters within a column are significantly different according to Duncan's multiple range test (P = 0.05).

Jay 1985. The soil at Jay, a Red Bay sandy loam, was the finest textured of all locations and resulted in fewer observed tillage differences. Treatments 3 and 8 had the highest numerical yield, but they were not significantly higher than most of the other treatments (Table 2). They did yield significantly more than Treatment 6 (no surface or subsurface tillage with stubble present) probably because of a poorly developed root system as pointed out earlier. It was noted that system 3 which received subsurface slitting, and Treatment 8 which received no subsurface tillage were statistically equivalent in peanut yield. Several factors could have prevented yield differences from developing. First, this soil type was much less sandy than in the other locations and the layer of clay accumulation was closer to the soil surface. Therefore, this soil had a better water-holding capacity and did not tend to form soil hard pans as readily as sandier soils underlain by a deeper clay layer. In addition, soil moisture at Jay in 1985 was adequate due to ample rain fall and supplemental irrigation.

Results at Jay, FL suggest that with adequate moisture and finer textured soil, subsurface tillage may be of little importance as long as the surface is friable. This observation also supports popular belief among growers and equipment manufacturers[3,4] that subsurface tillage will generally not increase yields on many finer textured midwestern soils, provided these soils are periodically moldboard plowed.

Williston 1985A. Tillage comparisons near Williston in 1985 were made at two different locations. Location A was in an area that was previously cropped with peanuts and soybeans. Treatment 1 (Strip tillage, subsurface slit with stubble present) had the highest numerical yield. Yields from Treatments 3, 4, 7, and 8, which had some degree of conventional tillage, were statistically equivalent (Table 2) to Treatment 1. Treatments 2, 5, and 6 yielded significantly less than Treatment 2 but with the exception of Treatment 5 they did not have any form of subsurface tillage. Treatment 5 yields were presumably poor because of planter and stand problems that were experienced with this system. However, by mid-season, plants had filled in skips and a full plant canopy was established. Root strength (Table 3) was highest for Treatment 5, possibly because less plant to plant competition for light, water, and nutrients allowed these plants to produce better root systems. Plants in this treatment did not produce as many mature nuts as more optimally spaced plants in other treatments. Few other signficiant trends can be evidenced from yield or root strength data between treatments.

Williston 1985B. The second Williston location in 1985 was established in an area where bahiagrass *(Paspalum notatum* Flugge) pasture was grown for the previous 8 years. Yield data showed no differences between tillage treatments (Table 2). This is supported by many years of grower experiences showing that peanuts following bahiagrass will consistently yield much better than any other rotational crop[5]

Norden *et al.* (11) reported that significant increases in peanut yield were noted after only one year in bahiagrass sod because bahiagrass roots tend to open up many macro and micro pores up to depths of 1 M in the soil profile (6,12). This condition allows subsequent crops roots to grow unimpeded. As a result, optimum conditions for peanut root growth had already been established throughout the experimental area and no yield differences were detected regardless of tillage system.

Overall Conclusions

This research confirms that for maximum peanut growth and yield there is no substitute for a friable seedbed. Yields were generally higher with surface tillage than without, suggesting that some surface tillage is needed for high peanut yields. Subsurface tillage was very important, especially in extremely dry years, and on sandy soils that are underlain by hard pans and which have low water holding capacity. Data suggests that proper planting apparatus, coupled with subsoiling or subsurface slitting, can provide a viable option for MT peanut production. Furthermore, MT peanut production may be advantageous on marginal soils or soils high in erodibility. This research supports previous findings of Elkins *et al.* (7) that slit-tillage systems provided equal to superior yields over standard chisel point subsoiling techniques. However, substantial problems were encountered with slitter wear and breakage in rocky soils. This suggests that further materials and engineering work are needed to develop this conservation tillage system.

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