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Long-Term Effects of Three Tillage Systems on Peanut Grade, Yield, and Stem Rot Development[1]

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ABSTRACT

Field studies were conducted from 1987 to 1996 to evaluate the effects of long-term no-tillage, reduced-tillage, or full-tillage systems on peanut grade, yield, and stem rot (*Sclerotium rolfsii*) disease development. In 3 of 10 yr the full-tillage system outyielded the no-tillage system while the reduced tillage system resulted in yield increase over no-tillage systems in 2 yr. Reduced-tillage plots had a higher incidence of stem rot than full-or no-tillage in 4 of 10 yr. In 3 of 10 yr, peanut grade (%TSMK) was lower in no-tillage than full-tillage plots. The reduced tillage system has shown promise for use in Texas for peanut. However, no-tillage peanut systems have never produced yield and quality comparable to full-tillage systems.

Key Words: Full-tillage, groundnut, no-tillage, reduced-tillage.

In south Texas, growers typically use full-tillage peanut production systems that include preparation of a slightly raised seedbed with no plant residue on the surface. These operations can require considerable fuel, labor, and time. With current peanut prices, it would be beneficial to reduce the costs of production. The use of conservation (reduced) tillage systems to reduce production costs may be effective if yield and grade are not altered.

Conservation tillage systems consist of planting in an unprepared seedbed, with undisturbed crop residue left on the soil surface, or planting in a narrow strip or band which disturbs less than 30% of the soil surface and crop residue (ASAE, 1990). The use of minimum-tillage or reduced-tillage practices in other crops such as corn, grain sorghum, soybeans or wheat has reduced production costs, soil erosion, and water runoff (Jones *et al.*, 1968; Fink and Wesley, 1974; Mutchler and Greer, 1984; Izaurralde *et al.*, 1986; Deibert, 1989).

Unger and co-workers (1977) noted that the presence of crop residue on the soil surface nearly eliminated erosion problems. Musick *et al.* (1975) reported that a heavy mulch comprised of wheat straw could increase soil water storage 6 cm during an 11-mo fallow. They reported that the extra soil water increased subsequent grain sorghum yield by 1120 kg/ha.

Although conservation tillage has been used in other crops for over 30 yr, only during the past 20 yr has interest developed for its use in peanut production (Boswell and Grichar, 1981; Grichar and Boswell, 1987; Wright and Porter, 1991, 1995; Grichar and Smith, 1992). Concerns about increased disease and insect problems, weed control, potential problems in digging and combining, and crop residue effects on crop yield and grade have resulted in a slow development of conservation tillage systems (Wright and Porter, 1985, 1995; Grichar and Boswell, 1987).

Cheshire *et al.* (1985) compared full- and no-tillage production practices for peanut in Georgia. Yields and seed quality were reported to be significantly higher for no-tillage peanut than in full-tilled peanut where soil moisture was adequate. Levels of soil insects and incidence of stem rot caused by *Sclerotium rolfsii* Sacc. were similar for the two tillage methods. Grichar and Boswell (1987) reported difficulty in controlling broadleaf weeds and annual grasses which caused problems in digging the no-tilled treatment compared to the full-tilled treatment. In these studies, pod yields and crop values were significantly less for the no-tilled peanut as compared to the full-tilled peanut; but the percentage of sound mature kernels was similar for tillage systems 2 out of 4 yr (Grichar and Boswell, 1987).

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Colvin *et al.* (1988) observed that pod yields in Florida were similar for minimum- or full-tillage systems in 1983 and higher for minimum-tillage than full-tillage in 1984. Grade factors were not different for the full- and minimum-tillage systems. Hartzog and Adams (1989) conducted 17 on-farm reduced-tillage experiments in Alabama between 1982 and 1986. Pod yields for the reduced-tillage systems increased at three sites, decreased at five sites, and were not different at nine sites when compared to full-tillage systems. Grade factors, weed control, and disease severity were not influenced by reduced-tillage.

Results comparing the effectiveness of various tillage experiments on crop production have been reported (Jones *et al.*, 1968; Fink and Wesley, 1974; Mutchler and Greer, 1984; Izaurralde *et al.*, 1986; Deibert, 1989). These reports, however, generally have been limited by the brief time period over which the experiments have been conducted. Van Doren *et al.* (1976) published results detailing the changes in corn (*Zea mays* L.) grain yield associated with the application of continuous no-tillage on four soil types after 12 yr of observation. They concluded that corn grain yields were remarkably insensitive to tillage over a wide range of soil types, cropping systems, climate, and duration so long as equal plant densities and adequate weed control was maintained. Dick and Van Doren (1985) reported that the long-term application of no-tillage crop production affected corn, soybean, and oat yields differently on different soil types. On a well-drained sloping soil, yields were greater under no-tillage than under full-tillage treatments. On a poorly drained soil, yields were decreased under no-tillage systems, particularly where a corn-corn rotation was maintained.

No information is available on the long-term effects of long-term reduced or no-tillage systems on the yield, grade, and disease development in peanut. The objectives of this study were to assess the long-term effects of various tillage systems on peanut production and stem rot development.

Materials and Methods

Tests were conducted from 1987 to 1996 on plots at the Texas Agricultural Experiment Station near Yoakum. The soil was a Tremona loamy fine sand (thermic Aquic Arenic Palenstalfs) with a pH of 7.0 to 7.3 and less than 1% organic matter. Prior to the initiation of this study, the test site had been planted in continuous peanuts under a full-tillage system for at least 15 yr and was known to have moderate to high levels of stem rot caused by *S. rolfsii*. The area selected for the study was lower than the rest of the area and stayed water-logged longer than other areas of the field under heavy rainfall conditions.

Tillage systems included reduced-tilled, no-tilled, and full-tilled. Annual rye grass (*Lolium multiflorum* Lam.) or wheat (*Triticum aestivuum* L.) was planted in the fall in each tillage system of the test area. Under full-tillage, the cover crop was shredded with a tractor-driven shredder, soil was turned with a moldboard plow to a depth of 25 cm and was then disked and bedded with disk bedders. The beds were leveled to planting height and treated with preplant incorporated herbicides prior to seeding.

In the reduced-tillage system, the small grain was mowed to a height of approximately 25 cm to simulate harvest. Paraquat (Starfire 1.5E) at 0.34 kg/ha was applied the same day as land preparation to kill the small grain cover crop and any existing weeds. Seedbeds were prepared with a Ro-Till unit (Bush-Hog, Inc. Selma, AL) which tilled a 36- to 40-cm-wide planting strip on 91-cm centers. The Ro-Till unit consisted of a subsoil shank which penetrated the soil to a depth of approximately 40 cm. Twin sets of fluted coulters were mounted on either side of these shanks. The subsoiler shank opened the soil and distributed (or broke up) any plowpan beneath the row. The fluted coulters smoothed the soil and broke up any large clods. Rolling crumblers mounted immediately behind the fluted coulters further smoothed and shaped the seedbed and incorporated pendimethalin (Prowl 3.3E).

In the no-tillage system, the small grain was shredded to a height of 25 cm, paraquat was applied, and peanuts were seeded directly into the grain stubble. Planting depth in each tillage system was approximately 3 to 5 cm.

A tank mix of either pendimethalin at 1.12 kg/ha or ethalfluralin (Sonalan HFP) at 1.25 kg/ha in combination with either imazethapyr (Pursuit 2AS) at 0.07 kg/ha or metolachlor (Dual 8E) at 1.7 kg/ha was preplant incorporated 7 cm deep with a power tiller in the full-tillage system and applied preemergence in reduced and no tillage systems after seeding. Sethoxydim (Poast Plus 1.0E) at 0.22 kg/ha and 2,4-DB (Butyrac 1.5 EC) at 0.28 kg/ha were applied postemergence during the growing season to control Texas panicum (*Panicum texanum* Buckl.) and Palmer amaranth (*Amaranthus palmeri* S. Wats.), respectively.

Tillage treatments were arranged in a randomized complete block design with 8 by 12.2-m long rows spaced 0.9 m apart with four replications. All data was taken from the middle four rows. A pair of buffer rows was located between each tillage system to reduce plot interference. Chlorothalonil (Bravo 720) was used on a scheduled spray throughout the growing season to control leaf spot.

Plots were seeded during the first 3 wk of May in each year of the study and plots were dug 140 to 148 d after planting. After digging, the number of 31-cm long row segments with symptoms of stem rot or signs of infection by *S. rolfsii* were counted (Rodriguez-Kabana *et al.*, 1975). *Sclerotium rolfsii* was isolated from diseased pods in the laboratory to verify the presence of the pathogen.

Peanuts were allowed to air dry in the field 4-6 d prior to harvesting individual plots with a combine. The pods were dried to 10% moisture and then cleaned. Grades were determined from a 200-g pod sample from each plot following procedures described by the Federal-State Inspection Service (USDA, 1986). All data were subjected to analysis of variance and means were separated with Fisher's Protected LSD Test at $P = 0.05$ where appropriate. There were significant year by tillage system interactions for stem rot, yield and grade. Consequently, these data are presented by year.

Results and Discussion

Disease Development. Incidence of stem rot ranged from less than 5 to greater than 18 symptomatic row segments/plot (Fig. 1). In 1993, disease incidence was low due to a series of abnormally cold days during the last few weeks of October which slowed disease development and also resulted in premature digging of the plots.

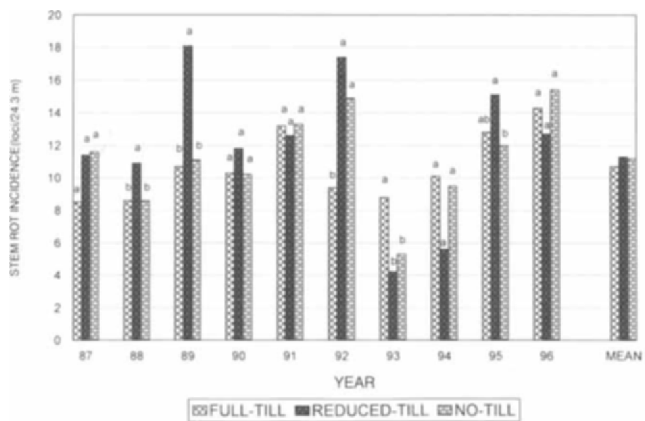

Fig. 1. Incidence of stem rot as influenced by tillage systems over a 10-yr period (the same letter at the top of vertical bars within a year indicates values are not significantly different at P = 0.05 according to Fisher's Protected LSD Test).

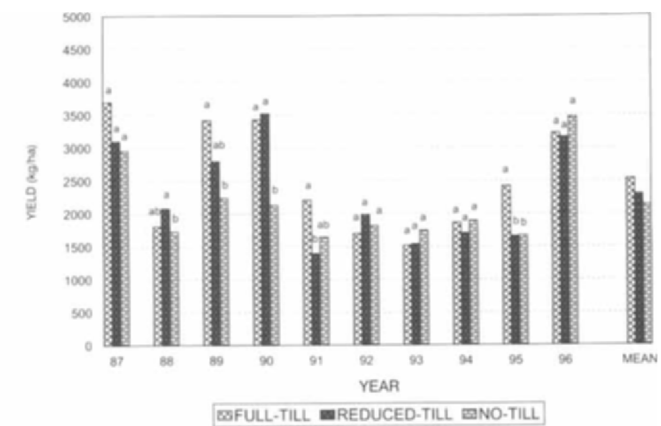

Fig 2. Peanut yield as influenced by tillage system over a 10-yr period (the same letter at the top of vertical bars within a year indicates values are not significantly different at P = 0.05 according to Fisher's Protected LSD Test).

In 5 of the 10 yr there were no differences in disease incidence between any of the tillage systems (Fig. 1). In the remaining 5 yr where differences occurred, only in 1992 did the no-tillage plots result in a higher incidence of stem rot than the full-tillage plots. In 2 of the 5 yr, the reduced-tillage plots resulted in higher disease incidence than either full-tillage or the no-tillage plots.

Mean disease incidence over years did not show an increase in disease incidence in any of the systems where crop residue was left on the soil surface (Fig. 1). Increases in stem rot also have not been observed in studies by others that evaluated reduced tillage systems for peanut production (Grichar and Boswell, 1987; Colvin and Brecke, 1988; Colvin *et al.*, 1988). In earlier work, Boswell and Grichar (1981) reported stem rot to be a major problem in reduced-tillage systems in Texas; however, later results indicated no differences in disease development among tillage systems (Grichar and Boswell, 1987; Grichar and Smith, 1991, 1992).

Peanut Yield. Peanut yields ranged from 1514 to 3696 kg/ha. Only in 1996 did the no-tillage plots outyield the full-tillage plots while in 3 of the 10 yr, the full tillage-plots outyielded the no-tillage plots (Fig. 2).

Early research in the United States and Canada showed that no-tillage or reduced-tillage wheat yielded less than for full land preparation (Locke and Mathews, 1953; Luebs, 1962). Recent research associated reduced wheat stands under reduced- or no-tillage practices with phytotoxic effects from crop residues (Cochran *et al.*, 1977). Poor seed placement also has been linked to heavy residue conditions and to increased soil bulk density (Lindwall and Anderson, 1977). In most peanut-growing areas, there should not be an increase in soil bulk density. In early work, Grichar and Boswell (1987) reported difficulty with soil compaction in the reduced tillage treatments. However, the digging of peanut at maturity should result in some soil movement and a reduction in compaction problems.

Peanut Grade. Peanut grades were below normal in many instances (Fig. 3). Grades in the 60's were common with a few in the 50's, regardless of tillage system. In four of the 10 yr, tillage systems had an effect on grade. In 3 of those 4 yr, the full-tillage plots produced a higher grade than no-tillage while in 1 yr the no-tillage and full-tillage treatments resulted in a better grade than reduced-tillage.

Varnell *et al.* (1976) found that compared to full-tillage, no-tillage culture reduced peanut quality by 62%. They attributed the poor performance in no-tillage to a compacted planting zone resulting in shallow planting and increased weed competition. Wright and Porter (1991) reported that tillage systems had an inconsistent effect on grade. Other researchers have not reported an effect of tillage practices on grade (Colvin and Brecke, 1988; Hartzog and Adams, 1989; Sholar *et al.*, 1993).

When averaged over the 10-yr period, the full-tillage plots produced almost a 3% grade increase over the no-tillage plots. This may be due in part to delayed emergence which was observed in many of the no-tillage plots (pers. observation). The delayed germination may be attributed to several factors. Allelopathy, the influence of one plant on another through the production of chemi-

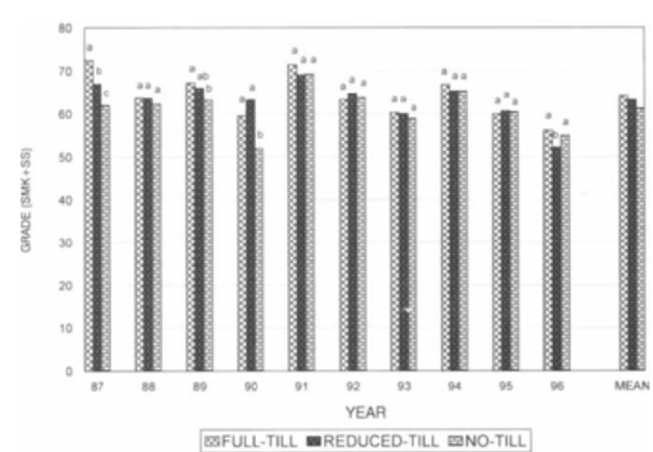

Fig. 3. Peanut grade (SMK+SS) as influenced by tillage system over a 10-yr period (the same letter at the top of vertical bars within a year indicates values are not significantly different at P = 0.05 according to Fisher's Protected LSD Test).

cals that escape into the environment (Hicks *et al.*, 1989), may be involved. Crop and weed residues can result in decreased stand establishment and growth of succeeding crops (Rice, 1984; Putnam and Weston, 1986).

Patrick and Koch (1958) determined that the greatest toxicity was associated with crop residues decomposing under saturated soil conditions. Corn performed poorly when planted into stubble mulch of white sweet clover (*Melilotus alba* Medixus) or wheat straw (Rice, 1984). Barnes and Putnam (1986) studied the influence of rye (*Secale cereale* L.) residue placement in soil on germination of various plant species. As distance between residue and seed increased, phytotoxicity decreased. Hicks *et al.* (1989) reported that major reductions in cotton (*Gossypium hirsutum* L.) emergence only occurred when surface residues were present in the seedbed.

In conclusion, continuous no-tillage and reduced-tillage systems did not result in increased levels of stem rot when compared with full-tillage systems. However, peanut yields were periodically better under full-tillage. Lower peanut grades observed under reduced- or no-tillage systems may be the result of delayed peanut emergence.

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