Fall-Bedding for Reduced Digging Losses and Improved Yield in Strip-Till Peanut

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ABSTRACT

Most peanut (*Arahcis hypogaea* L.) production occurs under highly intensive conventional tillage systems. With recent volatility in input prices, reducing tillage trips is a viable way of reducing production costs. However, growers can experience yield loss when switching from conventional tillage to strip-tillage in peanut on certain soil types due to the lack of an elevated bed at harvest time. Studies were conducted to compare standard strip-till with strip-till on two-row raised beds as well as rip and beds prepared in the fall. Comparisons were made on a coarse textured soil at Tifton, GA and a fine textured soil at Plains, GA. The three bed types, with and without wheat cover, were evaluated over two years at both locations. No effects of cover or interactions with bed type were present. At Plains, the rip and bed and raised bed reduced digging losses by 62 and 47%, respectively. Soil compaction within the harvest depth was reduced by 3.3 and 4.7 times by the raised bed and rip and bed, respectively compared to flat strip-till. The rip and bed increased peanut yield by 465 kg ha^{-1} over flat bed. At Tifton, no significant differences in yield or digging losses occurred between tillage methods. Soil compaction in the harvest depth was reduced by 1.9 and 2.5 times by raised bed and rip and bed, respectively on this coarse soil type. Reduced compaction and digging losses along with increased yield suggest bedding is more important on finer textured soils.

Key Words: *Arachis hypogaea* L., conventional tillage, bed type, flat bed, rip and bed, raised bed, reduced tillage, harvest efficiency, digging efficiency, digging losses, soil compaction, yield potential.

Peanut (*Arachis hypogaea* L.) is a popular row crop in the Southeast, especially in Georgia. In 2007 and 2008, Georgia accounted for approximately 43 and 44% , respectively, of the entire U.S. peanut production (NASS, 2008). The majority of this acreage was produced under conventional tillage practices involving deep tillage and turning of the soil along with multiple trips over the field for seedbed formation prior to planting. Deep turning is accomplished by moldboard plowing the soil. Following this operation, several disking or cultivations are often needed for fertilizer and chemical incorporation or to firm the soil and reduce the number of clods formed by the moldboard plow prior to planting. These practices are highly intensive in terms of energy, labor, equipment maintenance and replacement. The trips generally must occur in rapid succession during a short period in the spring of each year and can be delayed by unfavorable weather conditions. With the recent volatility in production costs, coupled with shortages of skilled farm labor, there has been increased interest from growers in finding ways to reduce inputs without sacrificing yield. One way of achieving this goal is through reduced tillage. Along with reducing labor, fuel, and equipment cost, reduced tillage adds the benefits of conserving soil and water along with improving soil quality (Durham, 2003). Reducing tillage trips would also allow farmers to enter and prepare a field in a timelier manner.

There are numerous variations to conservation tillage, but the reduced tillage system that is most popular in peanut is strip tillage (Johnson *et al.*, 2001). However, even with all the adversities currently facing growers, there is still skepticism about the efficacy of this tillage system for peanut production. This skepticism is even more pronounced when growers consider fields with finer texture and higher clay content. According to Sholar *et al.* (1995), despite the potential benefits of reducing erosion and production inputs, conservation tillage does not consistently produce yields equal to conventional tillage.

One of the biggest challenges facing farmers using strip-till is getting a good peanut stand at planting (Campbell *et al.*, 2002). Growers using full tillage peanut production systems generally include the preparation of a friable, residue-free, flat or slightly raised seedbed (Sholar *et al.*, 1995; Grichar, 1998). This insures adequate seed-to-soil contact for proper moisture absorption (Porter and Wright, 1991), low levels of competition from diseases and weeds (Buchanan and Hauser, 1980), and aids the harvest process by producing a raised

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seedbed which provides the digger's blades a place to penetrate the soil surface at a point beneath the crop. Recent innovations in precision tillage and planting equipment have reduced plant stand issues associated with accurate seed placement in strip-tillage peanut. Newer herbicides and fungicides are also more effective at controlling weeds and diseases than those that were available when conventional tillage was the best recommendation available for peanut. Therefore, adoption of strip-till has lagged compared with other crops, due mainly to producer reluctance and concern for digging problems (Faircloth *et al.*, 2005) with the lack of an elevated bed (Grichar and Boswell, 1987; Wright and Porter, 1991; Jordan *et al.*, 2001; Grichar, 2006).

Much of the concern growers express is related to greater soil resistance and residue buildup in strip-till compared to conventional tillage that can cause increased difficulty at the time of digging. Previous research in conventional tillage demonstrated that a ripper-bedder bed type lowered soil compaction by 5.5 times that for other bed types and flat tillage (Wright and Porter, 1980). This is important, because soil compaction is a good indicator of the ease of the digging process at harvest. In this 3-yr study, peanut yields were 1.9% to 3.6% higher for disk-bedder and ripper-bedder plots than those from plots prepared flat. Due to higher costs with bedding, it was concluded that additional costs of production equipment to lower soil resistance to root penetration must be considered on an individual basis among farming operations.

More recently, studies in North Carolina indicated that use of preformed beds in conjunction with strip-till can improve yields compared to those of strip-till conducted on a flat soil surface and approach those of conventional tillage (Jordan *et al.*, 2001; Jordan *et al.*, 2004b; Jordan and Johnson, 2006). These studies stated lower yields in flat strip-till plots were most likely related to increased pod loss at digging. They went even further to indicate that bedding may have increased benefits on finer textured soils compared to coarser textured soils when followed by strip-till. However, the results could not be officially confirmed, because pod loss was not measured. They acknowledged the possibility that other agronomic and soil fertility factors could have been affected by the bedding operation, which could have possibly led to the higher yields.

In North Carolina, an advisory index for growers transitioning to reduced tillage (Jordan *et al.*, 2004a) was created that attributed the following risk values to tillage intensity: (a) no tillage into flat ground = 40, (b) strip tillage into flat ground = 20, and (c) strip tillage into stale seedbeds = 0. Other components of the risk index include peanut cultivar (market type), irrigation availability, soil series, cover crop, and history of tomato spotted wilt virus (Bunyaviridae: Tospovirus). The risk levels of each of the components are then summed to give the producer's total risk (low, moderate, or high) of yield being lower than that of conventional tillage. Higher values indicate a grower is more likely to experience yield loss in a transition from conventional tillage to reduced tillage while low values indicate there is little risk of yield loss involved.

These theories have never been tested in Georgia. Therefore, the objective of this study was to determine if yield in strip-till peanut could be enhanced by utilizing fall prepared beds on fine and coarse textured soil types, and whether or not yield enhancement could be attributed to digging losses.

Materials and Methods

Experimental Design

Experiments were conducted at two locations to evaluate the effect of fall-bedding in strip-till peanut on different soil types over a two-year period beginning in 2006 and ending in 2008. Beds were established in the fall of 2006 and 2007, and peanut crops were grown in the 2007 and 2008 growing seasons. The first location was at the University of Georgia Southwest Georgia Research and Education Center in Plains, GA on a Greenville sandy loam (Fine, kaolinitic, thermic Rhodic Kandiudults) (USDA-NRCS, 2009), with sand, silt, and clay of 69, 15, and 16%, respectively. The second location was at the University of Georgia Coastal Plain Experiment Station Lang Farm in Tifton, GA on a Tifton loamy sand (Fine-loamy, kaolinitic, thermic Plinthic Kandiudults) (USDA-NRCS, 2009), with sand, silt, and clay of 94, 4, and 2%, respectively. Each year, plots at both locations were fall-established following either two tillage passes with a disk to a depth of 12 cm or one tillage pass with a disk to a depth of 12 cm and one field cultivation to a depth of 12 cm.

At Tifton, a two-way factorial based on three bed types, with and without a winter cover crop was used in both years. Plots were arranged in a randomized complete block design (RCB). Six-row plots 15.2 m long were used in both years to reduce any border effects. There were eight replications in 2007 and four replications in 2008, due to reduced land availability. The study followed a conventional tillage system rotation of cotton *(Gossypium hirsutum* L.)-corn (*Zea mays* L.)-peanut in both years, and was located under a lateral irrigation system. This system was responsible for supplying water to an array of crops and research trials; therefore, irrigation was received on an availability basis.

At Plains, a three-way factorial design based on three bed types, with and without a winter cover crop, and a row pattern of twin or single row peanut was used in 2007. In 2008, a two-way factorial design was utilized with the peanut row pattern factor omitted. In both years, a RCB was used. Six-row plots 15.2 m long and six replications were present both years. The study followed the same cotton-corn-peanut rotation system as the Tifton location. This location was also located under a lateral irrigation system and irrigated based on availability.

Fall Bed Types

Three tillage systems were implemented in the fall (Nov.) of each year: (a) flat bed (no further fall tillage after disking), (b) rip and bed (single beds for each peanut row spaced 91 cm apart being approximately 28 cm high and 40 cm wide), and (c) raised bed (one wide bed to accommodate two peanut rows spaced 91 cm apart being approximately 18 cm high and 180 cm wide). The rip and bed plots were established in the fall using a two-row KMC Ripper-Bedder (Kelly Manufacturing Co., Tifton, GA). This process included in-row subsoiling to a depth of approximately 25 cm, followed by disks located behind the shank on each side of the subsoil furrow that pulled soil toward the furrow forming a bed directly over the center of each row. The raised bed plots were established using the same implement (KMC Ripper Bedder), but for this bed type the ripper-bedder was equipped with a drag attachment and 18-cm bed shapers in the wheel middles. This setup allowed the two individual beds to be leveled enough to form one wide two-row bed. All bed types were followed by spring strip-tillage.

Wheat Cover

Immediately following the bedding procedures half of the plots were sown with wheat (*Triticum aestivum* L.) as a cover crop in 17.8 cm rows at a seeding rate of 101 kg ha^{-1} based on the experimental design. If necessary, winter weeds were controlled in all plots using an application of a herbicide premix of dicamba and 2, 4-D at 0.28 and 0.80 kg ai ha^{-1}, respectively (Culpepper *et al.*, 2007). Primary winter weeds were henbit (Lamium amplexicaule L.) and wild radish (*Raphanus raphanistrum* L.). Henbit tended to be the main problem in plots with no cover, while wild radish tended to be more pronounced in plots with cover. Controlling these weeds was of significant importance to prevent a false cover effect in plots without cover, and to prevent discrepancies in biomass samplings of plots with cover. Herbicides were applied in February each year if needed. Termination of the cover crop occurred in early-mid April each year with a single application of glyphosate at 1.12 kg ai ha^{-1} to all plots. Early termination was aimed at preventing viable wheat seed from being produced and to prevent excessive moisture extraction by the cover crop. The early termination was also more conducive to strip-tillage by allowing more time for cover crop decomposition.

Strip-tillage and Planting

Strip-tillage occurred in early May each year using a strip-till implement (Kelly Manufacturing Co., Tifton, GA). The implement utilized a coulter mounted in front of an in-row sub-soiler followed by fluted coulters and a rolling crumble basket to prepare a seedbed approximately 40 cm wide. In-row subsoiling occurred to a depth of 25–30 cm.

The peanut cultivar was planted at a rate of 18 to 20 seeds m^{-1} in each row of the single row pattern (rows spaced 91 cm apart) and at 9 to 10 seeds m^{-1} in each row of the twin row pattern (pairs of rows spaced 18 cm apart with outside rows 91 cm apart) after strip-tillage each year. Planting occurred with both single and twin-row vacuum planters (Monosem Inc., Edwardsville, KS) for precise and accurate seed placement. Occasionally, the inside row of the twin row pattern was placed on the edge of the tilled surface, but problems with this occurrence were alleviated with timely irrigation following planting. The cultivar 'Georgia-02C' was chosen due to its higher level of resistance to Cylindrocladium black rot (*Cylindrocladium parasiticum* Crous). This disease had a known history of prevalence at the Plains location, and producers in the area typically use a cultivar with higher levels of resistance to lessen the disease's impact. The in-furrow insecticide phorate was applied at planting at 1.12 kg ai ha^{-1} in both site years. Following planting, preemergence herbicides including glyphosate, pendimethalin, flumioxazin, and diclosulam were applied to all sites at 1.12, 0.92, 0.107, and 0.026 kg ai ha^{-1}, respectively. The applications were accompanied by an irrigation of approximately 12.7 mm of water for incorporation of herbicides within 24 hours. All plots were managed the same at each location based on year for weed, insect, and disease control according to agronomic recommendations in the University of Georgia Cooperative Extension 2007 Peanut Update (Prostko, 2007). Harvesting was based on the Hull-Scrape Maturity Profile method (Williams and Drexler, 1981).

2007

At Tifton, peanut was planted on 14 May. Rainfall totaled 398 mm for the season. Irrigation applied in 12 events totaled 215 mm. Water available totaled 613 mm. Peanut digging occurred on 15 Oct. Rainfall delayed combine harvesting until 25 Oct.

At Plains, peanut was planted on 15 May. Rainfall totaled 503 mm during the season. Irrigation applied in eight events totaled 174 mm. An irrigation of 18 mm was applied prior to strip-till, and one application of 13 mm was applied prior to digging to soften the soil. The remainder of the irrigation was applied during the growing season. The total water received over the growing season was 676 mm. Digging occurred on 16 Oct., but recurring rainfall delayed combine harvest until 31 Oct. Yield was not significantly affected by the delay in harvest, because little to no drying occurred before rain began.

2008

At Tifton, peanut was planted on 8 May. Rainfall during the growing season totaled 445 mm. Tropical systems deposited 286 mm in the month of August alone. Irrigation applied in 10 events totaled 168 mm. An irrigation of 23 mm was made prior to strip tilling to soften the soil. This made the total water received 613 mm. Peanut was dug on 15 Oct. and combine harvested on 20 Oct.

At Plains, peanut was planted on 14 May. Rainfall for the season totaled 541 mm. Tropical systems deposited 299 mm in the month of August alone. Irrigation applications were made seven times during the season totaling 150 mm. Total water for the season was 690 mm. Digging occurred on 22 Oct., and combine harvesting took place on 28 Oct.

Digging Losses

Following digging and inversion each year, harvesting efficiency was determined by sampling a random section of soil from each plot. Sampling after digging rather than after combine harvest prevented the incorporation of threshing losses into the digging losses analysis. An area 2 m^2 was cleared by moving the inverted windrow out of the area to be sampled. The soil in this area was then excavated with shovels to a depth of 25 cm, and sieved to collect any pods remaining in the soil. A tractor-driven power take-off (PTO) platform soil screening implement (National Peanut Research Laboratory, Dawson, GA) was used to sieve the soil and collect lost pods. Pods were washed and viewed under a dissecting microscope. Healthy pods were kept, but diseased, over mature, and immature pods were excluded. This was aimed at measuring only the marketable pods lost due to mechanical and soil resistance related causes. Loss of diseased and over mature pods is unavoidable under the most favorable digging conditions, and immature pods are usually lost in the curing and combining processes of harvest. The remaining pods were dried and weighed to determine the approximate amount of pod loss on a kg ha^{-1} basis.

Soil Compaction

Soil compaction measurements were taken at approximately 50 days after planting (DAP) following a rainfall event that brought soil moisture to near field capacity. Measurements were recorded at 10 locations within each plot with an SC 900 Soil Compaction Meter (Spectrum Technologies, Inc., Plainfield IL). Samples were taken 18 cm to the outside of each row (harvest zone) which was representative of where the digger's blades would come in contact with the soil surface at harvest. Sampling in this fashion also prevented the low resistance encountered when sampling directly in the row center where deep tillage occurred and the much higher resistance encountered when sampling directly in the row middle where no tillage and increased compaction occurred due to the wheel track. Resistance was recorded at 2.5 cm intervals from 0–20 cm in depth. The top 10 cm were considered the most critical in terms of the digging process at harvest, because most pods were located within this depth. Soil compaction was measured only in 2008.

Yield and Grade

Yield was determined from the pods combine harvested from the center two rows of each plot. Plots were harvested individually, so pods could be collected separately. The pods were first cleaned, then dried (when needed) and weighed. Random moisture samples were taken at the time of weighing. An average moisture percentage was assigned to each location. Weights were then adjusted to a 7% moisture standard. While weighing, random 500-g samples were also taken from each of the original yield samples for grading. Grading was performed by the Federal State Inspection Service in Tifton, Georgia. Total Sound Mature Kernels (TSMK) and Other Kernels (OK) were the grade factors used for comparison. The percentage TSMK is the total of sound mature kernels and sound splits as a percentage of farmer stock peanut. The percentage OK is the percentage of kernels in farmer stock that is slightly less mature, but still marketable and capable of being graded.

Statistical Analysis

The statistical analysis was performed using Proc Mixed (SAS Institute Inc., Cary NC). When F tests identified significant main effects and interactions, means were tested for differences using Fisher's protected LSD at $P = 0.10$. When applicable, probability levels of 0.05 and 0.01 were

Table 1. Actual peanut digging losses pooled over years, Plains and Tifton.

Characteristic	Plains	Tifton
Bed Type	kg ha^{-1}	
Flat Bed	1548.67 a[a]	265.48 a
Raised Bed	824.92 b	319.79 a
Rip and Bed	585.55 b	311.62 a
LSD (0.01)	411.87	—
LSD (0.10)	—	NS
Cover Crop		
Wheat	991.28 a	305.53 a
None	981.48 a	292.39 a
LSD (0.10)	NS[b]	NS

[a]Means within a column and effect followed by the same letter are not significantly different. Within an effect (Bed Type or Cover Crop), significance lettering is determined by the LSD presented for that effect.

[b]NS = not significant.

also considered. Data for the same location were combined over years.

Results and Discussion

The row pattern effect was not significant in 2007 at the Plains location and only single rows were planted in 2008. Therefore, twin row data was excluded from the analysis, so that data from the two years could be combined at Plains. Locations were not combined due to significant interactions and random effects. Only general assumptions and hypotheses are made pertaining to the differences between locations.

Digging Losses

Digging losses were significant only at the Plains location. At Plains, the main effect of bed type was significant at P = 0.01. No effects of cover crop or bed type by cover crop interactions occurred for any significance level. The flat bed plots exhibited significantly higher digging losses of 1549 kg ha^{-1} compared to raised bed and rip and bed plots with 825 and 586, respectively (Table 1). Raised beds and rip and beds reduced digging losses by 47 and 62%, respectively, compared to the flat beds. Digging losses decreased in the order of increasing degree of bedding intensity (flat bed, raised bed, rip and bed), but differences between the raised bed and rip and bed were not significant. The significant differences between the bedded plots and flat plots illustrate the importance of having elevated beds for harvesting efficiency in strip-till peanut on the soil type at this location.

Digging losses were not significant at the Tifton location. Also, no clear trend existed with the degree of bedding intensity (Table 1). Overall, digging losses at Tifton were relatively lower across all bed types compared to Plains. Averaged over bed types, digging losses were roughly 70% less at Tifton than at Plains. The differences between locations cannot be considered significant from a statistical standpoint, because locations were not replicated within any given year. However, it is hypothesized that lower digging losses and lack of a bed type effect at Tifton are most likely related to differences in soil type between the two locations. Other uncontrollable variables may have contributed to the differences as well, but it is plausible to mention that the soil at Tifton was a much coarser textured soil with a higher sand content while the soil at Plains was finer textured with higher clay content. Peanut on the sandier soil was much easier to dig than peanut on the higher clay soil. Soil compaction data illustrate why the soil at Tifton was more conducive to digging. Therefore, the soil type certainly contributed to these results to some extent. These findings also agree with previous research that suggested elevated beds in strip-till peanut were more important on finer textured soils than on coarser soil types (Jordan *et al.*, 2004b).

Soil Compaction

At Plains, soil compaction was also affected by bed type in 2008. No effects of cover crop or bed type by cover crop interactions were present at any significance level. The main effect of bed type was significant on soil compaction in the harvest zone at P = 0.01 for depths of 2.5, 12.5, 15, 17.5, and 20 cm. Bed type was also significant for depths of 7.5 and 10 cm at P = 0.05, and it was significant for the depth of 0 and 5 cm at P = 0.10. As related to harvesting efficiency, the depth of 0–10 cm was considered most important. This was the depth to which harvesting generally occurred. When averaged over the 0–10 cm depth, bedding in the form of raised bed and rip and bed reduced soil compaction by 3.3 and 4.7 times, respectively, compared to flat bed plots (Table 2). These findings agree with a previous study that indicated rip and beds reduced soil compaction by 5.5 times compared to plots prepared flat (Wright and Porter, 1980). When averaged over the below harvest depth interval (12.5–20 cm), compaction was collectively reduced by approximately 1.7 and 3.8 times for raised bed and rip and bed plots, respectively, when compared to flat bed plots. Trends in compaction were similar to digging loss trends mentioned previously.

Soil compaction differences between bed types in both the harvest depth and below harvest depth intervals at Plains are illustrated in Fig. 1. On this soil type, there is a rapid separation between compaction for the flat bed and compaction for

Table 2. Harvest depth soil compaction, Plains 2008.

	Soil Compaction					
	Depth (cm)					
Characteristic	0.0	2.5	5.0	7.5	10.0	0.0–10.0
	kPa					
Bed Type						Avg.
Flat Bed	220.4 a[a]	557.3 a	1265 a	1843.4 a	2067.3 a	1190.7
Raised Bed	97.6 ab	195.8 b	364.3 b	488.3 b	644.6 b	358.1
Rip and Bed	53.7 b	104.5 b	231.5 b	387.8 b	489.5 b	253.4
LSD (0.01)	—	295.4	—	—	—	
LSD (0.05)	—	—	—	991.4	1127.6	
LSD (0.10)	157.8		793.3	—	—	
Cover Crop						
Wheat	147.7 a	344.6 a	757.5 a	1065.2 a	1200.1 a	703.0
None	100.1 a	227.1 a	483.0 a	747.8 a	934.2 a	498.4
LSD (0.10)	NS[b]	NS	NS	NS	NS	

[a]Means within a column and effect followed by the same letter are not significantly different. Within an effect (Bed Type or Cover Crop), significance lettering is determined by the LSD presented for that effect.
[b]NS = not significant.

the raised bed and rip and bed. By a depth of 5 cm, the flat bed compaction was 1265 kPa, while the raised bed and rip and bed compaction was 364 and 231, respectively. At 10 cm, soil compaction was 2067, 644, and 489 kPa for flat bed, raised bed, and rip and bed, respectively. The increased compaction in the flat bed contributed to the increased digging losses in the flat bed plots mentioned previously at this location.

At Tifton, main effect of bed type was also significant for compaction. No effects of cover crop or bed type by cover interactions occurred at any significance level. The main effect of bed type was significant on soil compaction at P = 0.01 at the depth of 15 cm. At P = 0.05, main effect of bed type was significant at depths of 7.5, 10, 12.5, 17.5, and 20 cm, and compaction was significant for the depth of 2.5 cm at P = 0.10. No significant differences in compaction occurred at depths of 0 and 5 cm. When averaged over the 0–10 cm depth, raised bed and rip and bed plots reduced compaction by 1.9 and 2.5 times, respectively, compared to flat bed plots (Table 3). These reductions in soil compaction from bedding were approximately half those that occurred in Plains. When averaged over the 12.5–20 cm interval, bedding reduced soil compaction compared to flat beds by 1.7 and 4 times for raised bed and rip and bed, respectively. At this depth, the reduction in soil compaction for bedding was similar to the Plains location. However, at these depths it was unlikely that compaction influenced digging losses.

Soil compaction differences for bed types in both the harvest depth and below harvest depth

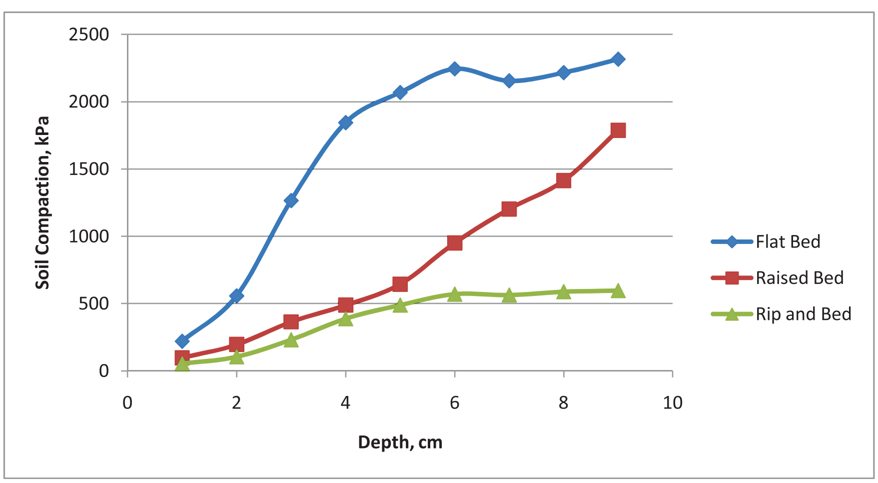

Fig. 1. Soil Compaction, Plains 2008. This figure illustrates the main effect of bed type on soil compaction.

Table 3. Harvest depth soil compaction, Tifton 2008.

	Soil Compaction					
	Depth (cm)					
Characteristic	0.0	2.5	5.0	7.5	10.0	0.0–10.0
	kPa					
Bed Type						Avg.
Flat Bed	76.7 a[a]	189.3 a	357.7 a	615.9 a	1043.7 a	456.7
Raised Bed	62.1 a	101.1 b	180.4 a	299.4 b	568.8 ab	242.4
Rip and Bed	41.7 a	77.9 b	181.0 a	260.0 b	346.6 b	181.4
LSD (0.05)	—	—	—	296.6	594.4	
LSD (0.10)	NS[b]	75.7	NS	—	—	
Cover Crop						
Wheat	56.5 a	122.8 a	269.9 a	426.1 a	677.2 a	310.5
None	63.8 a	122.8 a	209.5 a	357.4 a	640.8 a	278.9
LSD (0.10)	NS	NS	NS	NS	NS	

[a]Means within a column and effect followed by the same letter are not significantly different. Within an effect (Bed Type or Cover Crop), significance lettering is determined by the LSD presented for that effect.

[b]NS = not significant.

intervals at Tifton are illustrated in Fig. 2. Unlike the Plains location, the separation of compaction for the flat bed from the bedded plots is slow to develop in the harvest depth interval. When separation does occur, the differences between bed types were reduced for this soil type. Flat bed exhibited soil compaction of 357 kPa at a depth of 5 cm, and compaction for raised bed and rip and bed was 180 and 181, respectively. Soil compaction at 10 cm is 1043, 568, and 346 kPa for flat bed, raised bed, and rip and bed, respectively. Though there were significant differences between bed types at Tifton, the differences between flat bed plots and bedded plots were much smaller and soil compaction was lower in general compared to Plains. The degrees of differences for soil compaction between the two locations based on bed types partially explain why peanut was easier to dig at Tifton and why digging losses were significant at Plains.

Yield and Grade

At Plains, main effect of bed type was significant for yield. There was no significant cover crop or bed type by cover crop interaction for yield for any significance level. No significant differences were found for TSMK or OK. This indicates that the crop matured consistently regardless of the tillage or cover crop. These findings are consistent with previous studies that have indicated peanut matures equally under most production systems regardless of the various reduced tillage methods utilized (Grichar and Boswell, 1987; Grichar, 2006). Yield was significantly higher (P = 0.05) for the rip and bed with 4961 kg ha^{-1} compared to the 4496 kg ha^{-1} for the flat bed (Table 4). The

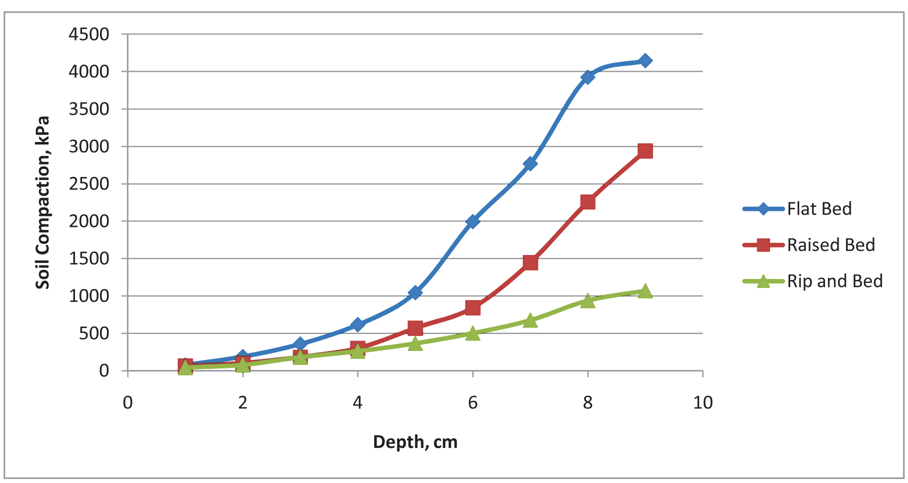

Fig. 2. Soil Compaction, Tifton 2008. This figure illustrates the main effect of bed type on soil compaction.

Table 4. Peanut yield and grade factors pooled over years, Plains and Tifton.

	Plains			Tifton		
	Yield	Grade		Yield	Grade	
Characteristic	kg ha^{-1}	% TSMK[a]	% OK[b]	kg ha^{-1}	% TSMK	% OK
Bed Type						
Flat Bed	4496 b[c]	74.4 a	4.0 a	5016 a	75.3 a	3.3 a
Raised Bed	4707 ab	74.3 a	4.1 a	4912 a	75.1 a	2.2 a
Rip and Bed	4961 a	74.2 a	4.3 a	4914 a	74.8 a	2.9 a
LSD (0.05)	262.5	—	—	—	—	—
LSD (0.10)	—	NS	NS	NS	NS	NS
Cover Crop						
Wheat	4671 a	74.3 a	4.1 a	5072	75.4 a	3.1 a
None	4772 a	74.3 a	4.2 a	4823	74.7 a	3.2 a
LSD (0.10)	NS[d]	NS	NS	NS	NS	NS

[a]% TSMK = Percent Total Sound Mature Kernels.
[b]% OK = Percent Other Kernels.
[c]Means within a column and effect followed by the same letter are not significantly different at each location. Within an effect (Bed Type or Cover Crop), significance lettering is determined by the LSD presented for that effect.
[d]NS = not significant.

raised bed yield was 4707 kg ha^{-1} and was not significantly different from the flat bed or rip and bed. Rip and bed plots increased yield over the flat bed plots by 465 kg ha^{-1} or 10.3%. For this finer textured soil, yield increased following the trend of increasing degree of bedding intensity much like decreased digging losses and soil compaction followed the trend of increasing bedding intensity.

At Tifton, no significant effects or interactions occurred for yield or grade factors. Means for bed type and cover crop effects are presented in Table 4. No difference in grade is indicative of the peanut crop maturing consistently across tillage and cover crop regimes. The lack of a bed type effect on yield at Tifton was related to the sandier soil being less compacted and more compatible with peanut digging. These same factors are partially responsible for the lower digging losses at this location.

Yield potential for bed type at Plains can be compared by summing the digging losses and yield means for each of the bed types to determine total marketable yield if no digging losses occurred. Yield potentials for flat bed, raised bed, and rip and bed were 6045, 5532, and 5547 kg ha^{-1}, respectively (Table 5). In terms of yield potential, flat bed had the highest yield, but as a percentage of the actual yield, harvesting efficiency was only about 74% for this bed type. The remaining 26% of marketable pods produced were left in the soil. For the raised bed, harvesting efficiency was approximately 85% with about 15% of the marketable pods being left in the field. Harvesting efficiency was highest for the rip and bed at approximately 89%

Table 5. Peanut yield potential pooled over years.

Bed Type	Yield	Digging Losses	Yield Potential[a]
	kg ha^{-1}		
Plains			
Flat Bed	4496 b[b] (74)[c]	1548.67 a (26)	6045
Raised Bed	4707 ab (85)	824.92 b (15)	5532
Rip and Bed	4961 a (89)	585.55 b (11)	5547
Tifton			
Flat Bed	5016 a (95)	265.48 a (5)	5281
Raised Bed	4912 a (94)	319.79 a (6)	5232
Rip and Bed	4914 a (94)	311.62 a (6)	5226

[a]Yield potential in terms of total marketable pods as a sum of yield and digging losses for bed type. No statistical analysis was run for yield potential. This data was calculated for general discussion purposes concerning harvesting efficiency.
[b]Means in a column at each location followed by the same letter are not significantly different.
[c]( ) = Yield or digging losses as a percentage of yield potential.

with only 11% of marketable pods remaining in the soil. Rip and bed resulted in the lowest digging losses, the lowest soil compaction, the lowest yield potential, and the highest actual yield. Beds on this soil type hold their size and shape for a longer period of time during the growing season. It is hypothesized that lower yield potential is a result of the elevated nature of the plant preventing all pegs from reaching and penetrating the soil surface to form pods in the valleys between beds. This is logical, because peanut that exhibits the runner growth habit relies heavily on the maturation of a nut crop on the outer limb portion of the canopy for yield generation (Colvin and Brecke, 1988). Rip and bed procedures did not improve peanut yield potential, it simply improved the percentage of marketable yield that was recoverable on the finer textured soil at Plains.

Yield potential at Tifton was unaffected by bedding procedures. From highest to lowest, there was only a difference of 55 kg ha^{-1} (Table 5). All bed types were approximately 94–95% effective at recovering the total marketable pods with only 5–6% of the pods being left in the soil. These data agree with the small differences found in soil compaction, no differences in digging losses, and no differences in yield on this soil type. These data indicate that the lack of differences on this soil type is due to its coarse more friable texture. It is hypothesized that lack of difference in yield potential by bed type is a result of beds weathering away more quickly during the winter and growing season on this soil type, thus, allowing the plant more consistent access to the soil surface for pegging and pod formation on the outer limb portion of the canopy.

Summary and Conclusions

Fall bedding used in conjunction with strip-till peanut can be effective in Georgia on fine textured soils with a clay content of greater than 10 percent like those at Plains. For these fine-soil types, bedding reduced digging losses, lowered soil compaction, and increased yield. Rip and bed exhibited the greatest improvement. Bedding reduced yield potential (actual yield plus digging losses) at this location, and therefore it was assumed that the resulting increase in yield on the rip and bed was related to greater harvesting efficiency rather than improvements of agronomic factors. Raised bed was effective at reducing digging losses and soil compaction as well, but it did not significantly improve yield over plots prepared flat. Therefore, the added cost of this tillage makes justifying the use of the raised bed type hard when no enhancement in yield is expected. Rip and bed tended to be the most productive option on this fine soil type.

For coarser soil bedding reduced soil compaction to a smaller extent, but had no effect on digging losses, yield, or grade. As a result, no incentive exists to recommend bedding on these coarser textured soils. Grades were unaffected by bed type or cover crop, and there were no significant cover crop effects or bed type by cover crop interactions for any of the data presented at either location. These results suggest that peanut matures consistently regardless of bed type and that short term benefits of a cover crop may be negligible. This does not consider the long term benefits of a cover crop such increasing soil organic matter, decreasing erosion, and increasing water holding capacity.

Future considerations should be given to comparing reduced tillage in the form of rip and bed and strip-tillage to conventional tillage on finer textured soils under irrigated and dryland conditions. Inability to apply moisture for reducing soil compaction at time of digging will most likely prove to be an important component affecting harvesting efficiency. Another possible comparison would be to apply a taller, flat top style of raised bed that would allow for improved harvest efficiency like rip and bed, while providing the plant a larger area of access to soil for pegging and pod formation with potential for improving yield.

Acknowledgements

The authors acknowledge John Paulk III for his help in planning, managing, and setting up the trial. Thanks to Stan Jones and staff at the Southwest Georgia Research and Education Center in Plains and to Harvey Kendrick and staff at the Coastal Plain Experiment Station Lang Farm in Tifton, who played key roles in this study with their dedicated assistance and efforts. We also express thanks to Ben Mullinix for his assistance with the statistical analysis of the results, as well as the student workers who helped in collecting and processing data.

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