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Importance of Proper Top Link Setting for Peanut Digging Loss Reduction

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Abstract. *The digging and inversion process creates the most yield loss during peanut harvest. Even if the grower produces great yield from proper care and management of this crop it can quickly be lost from the improper settings of the peanut digger. Although all losses cannot be prevented during the process a great deal of experienced yield losses are generally avoidable. Proper setting of the peanut digging angle for the soil texture is among the most important factors in optimizing yield losses during the inversion process. It is common practice for producers to set the peanut digger for the finest soil texture in the field. This is in part due to difficultly to adjust the top link every time the soil texture changes within a field, as well as the misconception that it is better to dig more aggressively. Tests conducted at the Clemson University Edisto Research and Education Center demonstrated that improper top link settings across soil textures within a field led to higher digging losses. Digging losses ranged from 3.3 to 10.9% of potential yield in the sand soil texture, 5.8 to 15.7% in the medium texture, and 12.3 to 24.1% in the clay soil texture. The data indicated that there was an optimum top link setting for each soil texture, with increased losses at both shallower and deeper depths. Average recoverable yield was statistically less in the sand texture zone (4,457 lb ac^{-1}) than in the medium (5,149 lb ac^{-1}) and clay (4,891 lb ac^{-1}) texture zones. Over-mature and diseased digging losses were greatest for the clay texture, but not statistically different from those for the sand and medium texture zones.*

Keywords. *Peanut digger, harvest losses, machinery management.*

Introduction

It has been documented that most peanut harvest losses occur during the digging, or inversion process (Bader, 2012). Pod losses generally result from weakened peg strength caused by disease and/or over-maturity (Chapin and Thomas, 2005; Grichar and Boswell, 1987; Thomas et al., 1983; Troeger et al., 1976), or mechanical actions of the digger, dislodging pods from plants. As a result, time of digging and proper digger settings are critical to reduce peanut yield loss. Invariably, some loss will be experienced due to the wide range of maturity existing across the pod profile in a given field. To harvest a field at the optimum time, some pods are over-mature and loss of these is generally unavoidable. Soil friability impacts pod losses profoundly (Grichar and Boswell, 1987). Even with favorable soil conditions and proper digger setup, 450 kg ha^{-1} (400 lb ac^{-1}) are common digging losses. A digging loss study in virginia varieties conducted by Clemson University demonstrated average digging losses ranging from 650 to 1,350 kg ha^{-1} (580 to 1,200 lb ac^{-1}) dry weight, equating to about 9 to 22% of the total production with proper digger settings (Kirk et al., 2013).

Soil texture, which can be highly variable throughout fields in the southeastern coastal plains can substantially impact proper top link adjustment for peanut digging angle. To reduce yield losses created from improper digging angle, the operator must stop and change the length of the top link for the digger. To save time in adjustments, some peanut growers set the digger blade depth to best match the finest or heaviest soil texture within field. However, this method of digger set up creates problems in coarser soil textures found within the field.

Proper depth adjustment results in blades cutting the taproot about an inch below the pods (fig.1a). Even if proper top link adjustment is established for a given area, travel within a field across various soil textures will result in variable digging depths. The digger blade experiences less resistance in coarser texture soils, allowing it to move to a greater depth at a given top link adjustment than the depth to which it would travel in a finer texture soil. Conversely, finer texture soils provide greater resistance to blade travel than coarser soils, which cause the blade to travel to a shallower depth for a given top link position.

If the top link is too short (fig. 1b), the tap root will cut too deep and excessive soil builds up on blades causing losses by pushing the plants forward before the taproot is severed. In extremely too deep cases, the taproot is not sheared and instead ripped from the ground. Further losses occur as pods ride over soil mounded on the blades. If the top link is too long (fig. 1c), the peanuts will be dug too shallow, shearing some pods and leaving others in the soil. So, if the top link is properly set up (fig. 1a) for a medium texture soil, relative to the textures present in a given field, movement into a coarser soil will result in the condition shown in figure 1b and movement into a finer texture soil will result in the condition show in figure 1c, both of which conditions will contribute to greater harvest losses.

Because the majority of profits or losses in peanut production can be attributed to digging decisions (Monfort, 2013), thorough knowledge of digging performance and diligent regulation across a range of conditions and situations is critical to peanut production. The objectives of this project were to: quantify recoverable yield across three soil texture zones, quantify digging losses across different top link settings in three soil texture zones, and quantify over-mature and diseased digging losses across three soil texture zones.

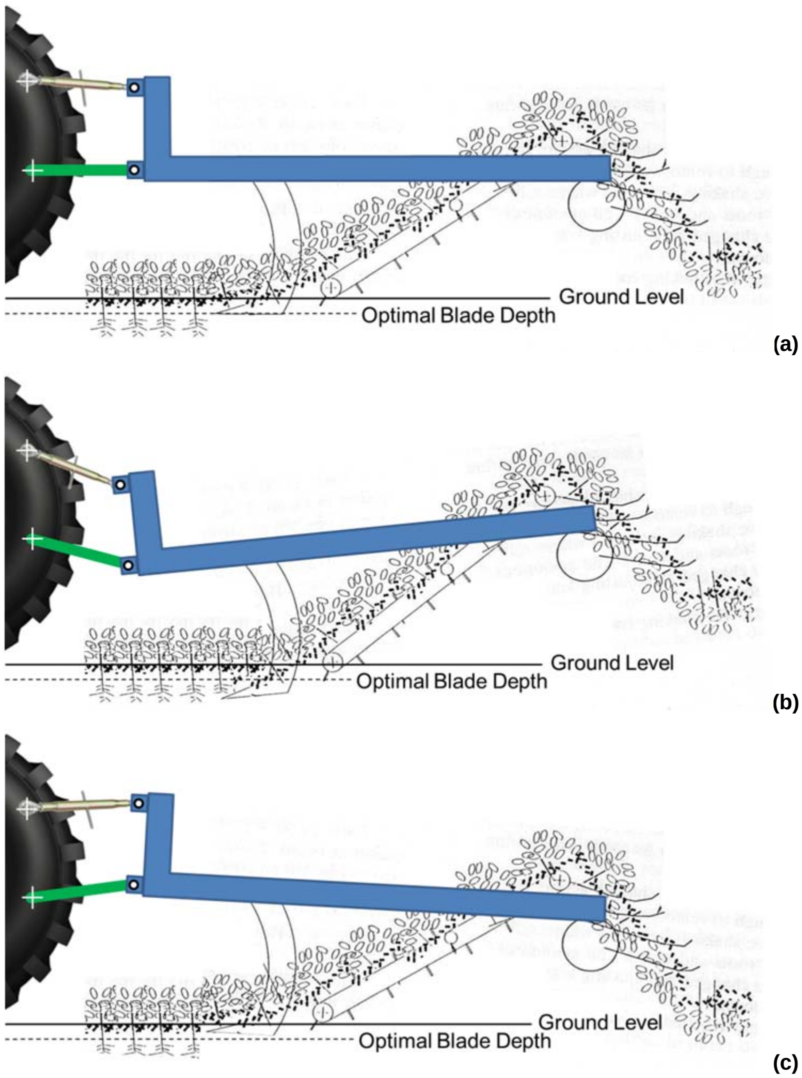

Figure 1. Illustration depicting various top link settings for a given soil type: (a) represents proper top link adjustment with the blade operating about one inch below pods; (b) represents digging too deep as a result of the top link being too short creating an excessive digging angle; and (c) represents digging too shallow as a result of the top link being too long creating an insufficient digging angle (adapted from Bader, 2012).

Materials and Methods

Digging tests were conducted at Clemson University's Edisto Research and Education Center in Blackville, SC. The field used was approximately 6 ha (15 ac) with a substantial amount of soil texture variability, from 0 to 75% sand content, 5 to 85% silt content, and 0 to 50% clay content. The plots in the study were 12 m (40 ft) long with row spacing at 97 cm (38 in) and planted with Champs, a virginia peanut variety. Plots were dug with a KMC two-row, three-point hitch mounted digger/shaker/inverter (Kelley Manufacturing Co., Tifton, Ga.) and a John Deere 7330 equipped with Trimble RTK AutoPilot^{TM} (Trimble Navigation Limited, Sunnyvale, Cal.) following the same path from planting to minimize digging losses from row center deviation. Tillage was conventional and cultural practices and pest control followed Clemson Extension (Clemson University) recommendations. The digger blade was mounted so that the bevel was down. Care was taken to ensure that blades were not dull, conveyor speed was properly matched to ground speed, vines were not wrapping around shanks, and that blade angle and depth were set properly.

Soil EC mapping using a Veris 3100 (Veris Technologies Inc., Salina, Kans.) was used to spatially delineate three soil texture zones: sand, medium, and clay. The three zones were defined using an EC contour map (fig.2) constructed in Farm Works Software (Trimble Navigation Limited, Sunnyvale, Cal.). To verify the validity of the use of EC data for delineation of soil texture zones within the digging depth of influence, soil samples were collected from the top 10 cm (4 in) at the time of digging (Warner et al., 2014).

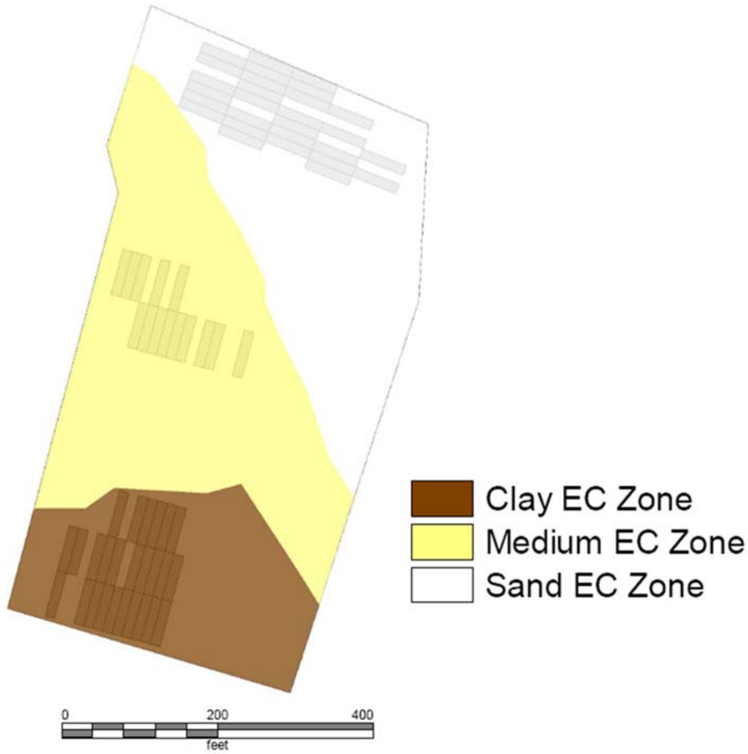

Figure 2. Soil texture zone delineation as a function of EC mapping and test plot locations within the zones.

The digger was set up for the proper digging blade angle within each of the three soil texture zones, providing a sand setting, a medium setting, and a clay setting. Assessment of proper blade angle and depth was performed as described in Kirk et al. (2013). Once the proper blade angle was determined for each of the three soil texture zones, all three of these blade angle settings were applied as digging treatments across each of the soil texture zones, giving nine treatments. An additional "too shallow" setting was applied in the sand zone and a "too deep" setting was applied in the clay zone, give a total of 11 treatments across the 3 soil texture zones (table 1). Six replicates were provided for each treatment and comparisons across treatments within each soil texture zone were performed using one-way ANOVA and Fisher's LSD tests (α=0.05). Analysis of variance was not performed across data from different soil texture zones.

Digging loss data collection occurred five to six days after digging. To distinguish digging losses from combining losses, the windrow from each two-row plot in the study was gently lifted with pitchforks to a trailer, which carried the windrows to a stationary combine. The windrows were manually fed into the combine header and the entire yield from each plot was bagged and weighed. A sample for moisture analysis of approximately 1 kg (2 lb) was collected and weighed. Samples were oven dried using ASABE S401.2 conventional oven method (ASABE, 2010).

A 0.6 m (2 ft) long by 2 row test area was randomly defined along the length of each plot. Above ground digging losses were collected and weighed from this area, independently quantifying sound pod losses from over-mature and diseased pod losses. Over-mature and diseased pods were not considered to be "true" digging losses because of their high propensity to be lost during harvest due to weak peg strength regardless of digger setup. Each test area was then excavated to a depth of 4 inches and the excavated soil was mechanically sieved (fig. 3) to collect the below ground losses. Below ground losses were weighed, once again distinguishing between sound, over-mature, and diseased pods. "True", or sound above and below ground losses were oven dried using ASABE S401.2 conventional oven method (ASABE, 2010). All losses reported in the results section are "true" or sound losses on a dry weight basis.

Figure 3. Digging loss sampling, showing excavated test area and soil sieve in operation.

Results and Discussion

Recoverable yield for each plot was taken to be the weight collected from the stationary combine in addition to the digging losses considered to be true digging losses, or those that were not over-mature or diseased. As the data in table 1 demonstrate, there were no differences in recoverable yield within any soil texture across digging angle treatments; results of Fisher's LSD tests indicated in the table were conducted within, and not across soil texture zones. When comparing average recoverable yield across soil texture zones as presented in the last row of table 1, the medium and clay recoverable yields were statistically the same, and both were greater than the sand texture yield.

Table 1. Recoverable yield, as the sum of true digging losses and combined yield, for each soil texture zone across imposed digging angles.

Digger	Sand Zone			Medium Zone			Clay Zone		
Setting	lb ac^{-1}, d.b.		SD	lb ac^{-1}, d.b.		SD	lb ac^{-1}, d.b.		SD
Too Shallow	4,547	a	1,327	-		-	-		-
Sand	4,563	a	910	4,902	a	676	4,655	a	819
Medium	4,192	a	704	5,436	a	534	4,745	a	608
Clay	4,527	a	1,041	5,109	a	272	5,055	a	426
Too Deep	-		-	-		-	5,107	a	658
Average, All Plots	4,457		965	5,149		540	4,891		632

Digging loss results indicated that digger-related yield losses were substantially affected by soil texture and digging depth, supporting the need for adjustment of digging angle across soil textures (tables 2 and 3). The greatest digging losses were experienced in the clay texture zone, while the sand texture zone sustained the lowest yield losses. The data within the sand and clay texture zones demonstrate numerically that an optimum digging blade angle exists, above and below which digging losses increase, with statistical significance of this evidence in the sand zone. It can be speculated that an optimum digging blade angle also existed for the medium texture, although the greatest prescribed angle in this study did not achieve enough depth to generate values demonstrating this. The data do not statistically support the premise that digging too deep is worse than digging too shallow.

Table 2. True digging losses, as the sum of above ground and below ground losses, for each soil texture zone across imposed digging angles.

Digger	Sand Zone			Medium Zone			Clay Zone		
Setting	lb ac^{-1}, d.b.		SD	lb ac^{-1}, d.b.		SD	lb ac^{-1}, d.b.		SD
Too Shallow	496	a	197	-		-	-		-
Sand	338	a,b	222	761	a	475	1061	a	372
Medium	138	b	59	518	a,b	258	765	a	436
Clay	417	a	293	294	b	95	601	a	244
Too Deep	-		-	-		-	986	a	673

Table 3. True digging losses, as percent of recoverable yield, for each soil texture zone across imposed digging angles.

Digger	Sand Zone			Medium Zone			Clay Zone		
Setting	%		SD	%		SD	%		SD
Too Shallow	10.9	a	2.4	-		-	-		-
Sand	7.0	a,b	3.6	15.7	a	10.8	24.1	a	11.3
Medium	3.3	b	1.4	9.4	a,b	4.0	15.9	a	7.9
Clay	8.8	a	4.8	5.8	b	1.8	12.3	a	6.0
Too Deep	-		-	-		-	19.2	a	11.7

When considering only treatments where digging losses were minimal for each soil texture zone, the losses in the sand (155 kg ha^{-1}, 138 lb ac^{-1}, d.b.) and medium (330 kg ha^{-1}, 294 lb ac^{-1}, d.b.) texture zones were not statistically different and less than the losses in the clay zone (674 kg ha^{-1}, 601 lb ac^{-1}, d.b.). It should be noted that the top link adjustment thought to be best for the sand and medium texture zones did not produce the least digging losses in those zones, suggesting that our prescriptions for optimal settings were too shallow and/or that the test plots for digger setup were not representative of the plots used for yield loss testing.

These results demonstrate that absence of digging angle adjustment throughout a field with texture variability could substantially increase digging losses from those at the optimum angle for each texture zone. The data demonstrate that minimum digging losses for the test field were 386 kg ha^{-1} (344 lb ac^{-1}, d.b.) if the optimum digging angle was set for each of the three soil texture zones. As a worst case scenario, had the operator set the digging angle up for the sand texture zone and provided no top link adjustment throughout the field, losses would have more than doubled to 808 kg ha^{-1} (720 lb ac^{-1}, d.b.). If the digging angle was set at the medium setting for the entire field, losses would have been 531 kg ha^{-1} (474 lb ac^{-1}). In the more likely event that the operator set the digging angle up for the finest soil texture in this field without additional adjustment in the field, digging losses would have been 490 kg ha^{-1} (437 lb ac^{-1}, d.b.), or 104 kg ha^{-1} (93 lb ac^{-1}, d.b.) greater than optimum.

Over-mature and diseased losses were treated as one category during sampling, so the quantities for each of the two cannot be distinguished. When considering only the optimal digging angle treatments within each soil texture zone, or those digging angles that produced the least true digging losses, mean over-mature and diseased losses were 67 kg ha^{-1} (60 lb ac^{-1}, d.b.) in the sand texture zone, 64 kg ha^{-1} (57 lb ac^{-1}, d.b.) in the medium texture zone, and 146 kg ha^{-1} (130 lb ac^{-1}, d.b.) in the clay texture zone. These data were collected and presented in order to consider quantified recommendations for varying digging timing across soil texture zones, such as to dig zones on different days if practical. There were no statistical differences between any of these means, however the greater numerical value of diseased and over-mature losses for the clay texture zone is suggestive that a more detailed investigation should be conducted in this area.

Conclusions

The results of this study support the need to adjust top link position and therefore digging angle in fields with high soil texture variability. The data demonstrated that there was an optimum top link position as a function of soil texture zone, whereby greater or lesser digging angle increased digging losses. For the settings tested in this study, additional digging losses from digging too shallow were found to be similar to digging losses for digging too deep

As a percentage of recoverable yield, average digging losses for the tested digger settings ranged from 3.3 to 10.9% in the sand texture zone, 5.8 to 15.7% in the medium texture zone, and 12.3 to 24.1% in the clay texture zone. As indicated, if this field were dug entirely at the clay setting with no adjustment, digging losses in excess of minimal would have been 104 kg ha^{-1} (93 lb ac^{-1}, d.b.). At a conservatively assumed peanut value of \$441 mt^{-1} (\$400 ton^{-1}), this additional loss equates to \$47 ha^{-1} (\$19 ac^{-1}). It must be recognized that soil texture variability exhibits different extremes in different fields; the field used for this study exhibited a relatively high degree of variability.

The data indicated that over-mature and diseased losses in the clay texture zone numerically, but not statistically, exceeded those from the medium and sand texture zones. This may be an indication that variable digging times across textures within a field would be beneficial. However, in many cases this will not be practical due to the logistics of getting the digging and combining equipment moved between fields and because the management zone orientation may not align with the row orientation. While studies have been conducted to evaluate proper time for digging, none encountered in the literature have specifically addressed temporally variable zone management. Better understanding of proper digging time as a function of soil texture may improve decision making ability in determining when to dig, even if not practical to dig at different times within a field.

Future work should be directed at evaluating the digging loss impacts of top link adjustment in fields that exhibit different degrees of soil texture variability. A common practice growers sometimes employ to dig to a shallower depth for a given top link setting is to lift the three point hitch arms on-the-go in areas of the field with sandier soils. Research to quantify digging losses should be directed at this method of blade depth control, in contrast to the top link adjustment employed in this study, which changes the digging angle to impose a change in blade depth.

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