2950 Niles Road, St. Joseph, MI 49085-9659, USA
269.429.0300 fax 269.429.3852 hq@asabe.org www.asabe.org

An ASABE Meeting Presentation

Paper Number: 152190009

Peanut Digging Losses Across Soil Moisture Contents

Andrew C. Warner[1], Kendall R. Kirk[2], James S. Thomas[2], J. Warren White[3], Joel S. Peele[3], Hunter F. Massey[1], and Benjamin Fogle[1]

[1] Agricultural Mechanization & Business; Clemson University; Clemson, SC; awarne2@g.clemson.edu
[2] Edisto Research & Education Center; Clemson University; Blackville, SC; kirk2@clemson.edu
[3] Amadas Industries, Inc.; Suffolk, VA

Written for presentation at the

2015 ASABE Annual International Meeting

Sponsored by ASABE

New Orleans, Louisiana

July 26 – 29, 2015

Abstract. *Soil moisture plays a dynamic role in digger related yield losses. Two years of peanut yield loss data were analyzed for two different fields with sandy coastal plains soils in Blackville, SC. In both fields the sand content throughout was greater than 80%. Both fields were divided into three soil texture zones using soil electro-conductivity (EC) mapping. Similar soil texture properties were demonstrated for each EC zone, across fields. For the 2013 and 2014 studies, respectively: the average sand contents were 95% and 96% for the low EC zones, 93% and 92% for the medium EC zones, and 92% and 88% for the high EC zones; and the average silt contents were 3% and 2% for the low EC zones, 5% and 6% for the medium EC zones, and 6% and 8% for the high EC zones. For each soil texture zone, digging losses were measured for a prescribed top link setting to represent minimum digging losses. Digging losses were also measured for application of the prescribed setting for the high EC zone in all EC zones to represent typical grower settings. Digging for the 2013 study was conducted in dry field conditions with average soil volumetric moisture content of 1.9% and ranging from 0.0% to 3.5%. At prescribed top link positions in 2013, digging losses (dry basis) were 379 kg ha^{-1} (338 lb ac^{-1}) in the low EC zone, 580 kg ha^{-1} (518 lb ac^{-1}) in the medium EC zone, and 673 kg ha^{-1} (601 lb ac^{-1}) in the high EC zone. Digging for the 2014 study was conducted under wetter field conditions with average soil volumetric moisture content of 4.9% and ranging from 0.3% to 7.7%. At prescribed top link positions in 2014, digging yield losses (dry basis) were 88 kg ha^{-1} (79 lb ac^{-1}) in the low EC zone, 442 kg ha^{-1} (395 lb ac^{-1}) in the medium EC zone, and 326 kg ha^{-1} (291 lb ac^{-1}) in the high EC zone. Although direct comparisons are not absolute because two separate fields were used, the results suggest that soils with higher volumetric moisture content at the time of digging result in reduced digging yield losses and reduced need for top link adjustment. This could indicate more profit to be made in peanut production by applying water prior to digging.*

Keywords. *Peanut, precision agriculture, digger, harvest losses, management zones, site-specific*

Introduction

Harvesting peanuts, unlike other commercially grown row crops requires a two part process: the inversion or digging of the peanut which removes the plant from the ground and inverts the peanuts upward to accelerate field-drying of the peanut pods; and the combining of the peanuts. The digging or inversion of the peanuts requires the use of a peanut digger, which when setup properly will remove the plants from the ground with minimal yield losses. However, the inversion process is where most pod losses are incurred (Bader et al., 2012). Pod losses may 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. Soil conditions, especially friability, impact pod losses profoundly (Grichar and Boswell, 1987). Digging losses of 450 kg ha^{-1} (400 lb ac^{-1}) are not uncommon using the current digger design even when soil conditions are favorable (Kirk et al., 2013). A twin row vs. single row digging loss study in a Virginia variety 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, or about 9 to 22% of the total production for optimum digger top link setting (Kirk et al., 2013).

Mechanical yield losses can be influenced by several factors including crop diseases, pests, soil water content and plant population (Zerbato et al., 2013). Another peanut digger study conducted Clemson University demonstrated that dry finer soil texture tended to introduce increased mechanical yield losses than coarser soil textures (Warner et al., 2014). With dryer soil textures, an optimum top link position can be assigned for each soil texture or EC zone in a field, which will reduce average mechanical yield losses across dry digging conditions (Kirk et al., 2014). A study at the Universidade Estadual Paulista demonstrated that at the same top link position the mechanical yield losses were statistically the same at 19.3% and 24.8% soil moisture content (Zerbato et al., 2013). This study showed that above a particular soil moisture content, mechanical yield losses across a field could be stabilized, in contrast to what was shown by the Clemson study under dry soil conditions (Kirk et al., 2014). In the Clemson study, variable top link position across soil textures was critical to reducing mechanical yield losses. Comparisons of results from the Clemson studies conducted in 2013 and 2014 (Warner et al., 2014 and 2015), suggested that soil moisture had an impact on average mechanical yield losses and a larger impact on top link position, especially the need for or lack thereof adjustment as a function of soil texture. This indicated that it could be profitable to the grower to prescribe digging time as a function of both soil moisture content and maturity, versus the conventional practice of basing digging decisions solely on maturity of the crop.

Because the majority of profits or losses in peanut production can be connected 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 study were to compare recoverable yield and digging losses at various top link settings across soil texture zones and across the 2013 and 2014 Clemson digging loss studies (Warner et al., 2014 and 2015), especially in the context of soil moisture contents at the time of digging. The purpose of these comparisons is to highlight evidence suggesting that digging in moist soil conditions could reduce mechanical digging losses and lessen the need to adjust top link position across variable soil textures.

Methods and Materials

Field Study

The plots for the 2013 study were approximately 12 m (40 ft) long with row spacing at 97 cm (38 in.) and planted with a Champs variety, a virginia peanut variety. The plots for the 2014 study were approximately 29.3 m (96 ft) long with row spacing at 97 cm (38 in.) and were also planted with the Champs variety. In both years of the studies 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™ (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 University Extension 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.

In both the 2013 and 2014 studies, soil electrical conductivity mapping using a Veris 3100 (Veris Technologies Inc., Salina, Kans.) was used to identify three different soil texture zones within the field. The three zones were defined using a contour map of the shallow EC (0-30 cm, 0-12 in.) constructed in Farm Works Software

(Trimble Navigation Limited, Sunnyvale, Cal.). Corresponding to general digging depth, soil samples were collected from the top 10 cm (4 in.), of each plot. Hydrometer tests were conducted on the samples using the procedures outlined by Huluka and Miller (2010) to quantify the relative mass fractions of sand, silt, and clay. Soil volumetric moisture content was measured at the time of digging using a Decagon 10HS Large Volume soil moisture sensor (Decagon Devices Inc., Pullman, Wash.).

In both years, the digger was set up for the proper digging blade angle within each of the three soil texture zones, providing a Low EC setting, a Medium EC setting, and a High EC setting. Assessment of proper blade angle and depth was performed as described in Kirk et al. (2013). In both study years digger top link position data were collected using a model 9-5152 8x20x4 cm (3x8x1.5 in.) double acting hydraulic top link (Surplus Center, Lincoln, Neb.) coupled with a model 3582 linear potentiometer (Phidgets Inc., Calgary, Alberta, Canada) attached to the cylinder. The linear potentiometer was connected to a model 1018 interface kit (Phidgets Inc., Calgary, Alberta, Canada), which was coupled with data acquisition software developed in Visual Basic 2010 Express (Microsoft Corp., Redmond, Wash.); data was collected at 10 Hz. Once the proper blade angle was determined for each of the three soil texture zones, each of these three settings was applied to each soil texture zone. Six replicates were provided for each treatment and compared as described in the results.

Digging Loss Data Collection

Digging loss data collection in both the 2013 and 2014 studies occurred six days after digging. During the 2013 study digging losses were distinguished from combine losses by gently lifting the windrow of the two-row plot 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 sample area was then randomly defined along the length of each plot. Above ground digging losses were collected and weighed from this area, independently quantifying mechanical pod losses from over-mature and diseased pod losses. Over-mature and diseased pods were distinguished from mechanical digging losses due to their high probability of being lost during harvest regardless of digger setup from to weakened peg strength. Each test area was then excavated to a depth of 10.2 cm (4 in.) and the excavated soil was mechanically sieved to collect the below ground losses. Below ground losses were weighed, once again distinguishing between mechanical pod losses, over-mature, and diseased pods. Mechanically caused above and below ground losses from each plot were oven-dried using ASABE S401.2 conventional oven method (ASABE, 2010). All losses reported in the results section are mechanical digging losses and combine yields are reported on a dry weight basis.

In the 2014 study digging losses were distinguished from combining losses by gently lifting a 1.8 m (6 ft) section of windrow above the sample area of 1.2 m (4 ft) long by 2-rows with a custom built windrow lifter (fig. 1). This allowed individuals to crawl under the windrow to collect above ground digging losses for the defined sample area prior to combining. As in the 2013 study, mechanical losses were distinguished from over-mature and diseased pod losses. The location of the sample area was assigned at 18.3 m (60 ft) from the start of each plot, measured along the forward direction of travel to allow time for the digger to acquire a stable digging depth. Once above ground losses were collected a research plot combine (Kirk et al., 2012) was used to harvest peanuts, record yield weight, and collect combine samples from each plot. Prior to excavation, the combine discharge and combining losses were gently removed from the test areas using a leaf blower. Once each sample area was clear of debris, the sample area was excavated to a depth of approximately 10 cm (4 in.). The excavated soil was mechanically sieved to collect the below ground losses. For both above and below ground digging losses, categorization as over-mature, diseased, or mechanical pod losses was conducted after field data collection by one individual to ensure consistency of categorization across plots. Above and below ground mechanical losses along with a 500 g (1.1 lb) combine yield sample were weighed and oven-dried using ASABE S401.2 conventional oven method (ASABE, 2010). All losses reported in the results section are mechanical digging losses on a dry weight basis.

Figure 1. The custom made windrow lifter allowing individuals to remove above ground losses prior to combining.

Results and Discussion

Relative mass fractions of sand, silt, and clay are demonstrated in tables 1 and 2. Means comparisons using Student's t-tests (α=0.05) indicated that sand contents were statistically different across all EC zones within each test year and silt contents were statistically different across all EC zones in the 2014 test year (table 1). When comparing sand, silt, and clay contents across test years and within EC zones, several were statistically different at the α=0.05 level (table 2), but none were statistically different at the α=0.01 level.

Table 1. Relative fractions of sand, silt, and clay across EC zones for the two test years. Connecting letters reports are for comparisons within test years (α=0.05).

Test	EC	Sand Content			Silt Content			Clay Content		
Year	Zone	%		SD	%		SD	%		SD
2013	Low	95.1	A	1.7	3.1	B	1.7	1.8	B	1.1
	Medium	93.4	B	1.5	4.9	A	1.3	1.6	B	0.9
	High	91.6	C	1.7	5.8	A	1.6	2.6	A	1.3
2014	Low	96.1	A	1.0	1.7	C	1.0	2.2	B	0.9
	Medium	92.2	B	1.7	5.5	B	1.6	2.3	B	1.5
	High	87.6	C	3.9	8.3	A	3.1	4.1	A	1.7

Table 2. Relative fractions of sand, silt, and clay across test years for the three EC zones. Connecting letters reports are for comparisons within EC zones (α=0.05).

Test	EC	Sand Content			Silt Content			Clay Content		
Year	Zone	%		SD	%		SD	%		SD
2013	Low	95.1	B	1.7	3.1	A	1.7	1.8	A	1.1
2014		96.1	A	1.0	1.7	B	1.0	2.2	A	0.9
2013	Medium	93.4	A	1.5	4.9	A	1.3	1.6	A	0.9
2014		92.2	B	1.7	5.5	A	1.6	2.3	A	1.5
2013	High	2.6	B	1.3	5.8	B	1.6	2.6	B	1.3
2014		4.1	A	1.7	8.3	A	3.1	4.1	A	1.7

The volumetric moisture content of the soil profile within the top 10 cm (4 in.), generally representing the maximum depth to which peanuts pods grow and are dug, demonstrated significant differences from one year to the next. In the 2013 study, the field conditions were very dry due to a lack of rain experienced during the harvest season. The average soil volumetric moisture content for the field was about 1.8% with a range across all readings between 0.0% and 3.5%; the low EC portion of the field was the driest. During the 2014 harvest season a substantial amount of rain caused field conditions to be wetter, resulting in easier removal of peanuts from the ground. The average soil moisture content of the entire field in the 2014 study was at 4.9% volumetric moisture content and a range from 0.3% to 7.7% volumetric moisture content. As demonstrated by the comparison of means using Student's t-tests (α=0.05) in table 3, there were statistical differences in volumetric moisture content at the time of digging across test years within all EC zones. Further analysis indicated that there were also statistical differences in soil moisture content across test years within all EC zones at the α=0.01 level.

Table 3. Volumetric moisture content across test years for the three EC zones. Connecting letters reports are for comparisons within EC zones (α=0.05).

Test Year	EC Zone	VMC %		SD
2013	Low	1.5	B	0.8
2014		3.2	A	1.1
2013	Medium	2.4	B	0.7
2014		5.7	A	0.9
2013	High	1.7	B	0.8
2014		5.9	A	1.0

It is the opinion of the authors that soil textures within the three zones of the two fields is sufficiently similar for general and suggestive comparisons to be made across the data from the two years of data. Despite these similarities in soil texture, proper top link extension length varied across EC zones much more in the 2013 (dry soil) test year than in the 2014 (wetter soil) test year (table 4), which is suspected to be due to soil moisture differences at the time of digging. As expected, and in both test years, the prescribed top link length decreased as a function of soil EC, with more aggressive digging angles (shorter top links) being required in the higher EC or finer textured soils. In the 2013 study the prescribed top link position ranged across 19.4% of total cylinder extension from the low EC zone to the high EC zone, or about 3.9 cm (1.6 in.) of total adjustment required in top link length. In contrast, in the 2014 study the prescribed top link position ranged across only 6.0% of total cylinder extension from the low EC zone to the high EC zone, or about 1.2 cm (0.5 in.) of total adjustment required in top link length.

Table 4. Proper top link cylinder extension, as prescribed, for 2013 and 2014 studies, as a percentage of full extension.

Test Year	EC Zone	% Ext.
2013	Low	75.5
	Medium	70.1
	High	56.1
2014	Low	88.0
	Medium	85.0
	High	82.0

Table 5 demonstrates comparisons of mechanical digging losses across test years when the prescribed top link setting was used in each EC zone. The last two rows of the table demonstrate average mechanical digging losses across the entire field if the prescribed top link setting was applied within each zone. Digging losses in the 2013 (dry) test year were in all cases numerically greater than those in the 2014 (wetter) test year; in most cases, the differences were statistically significant. As compared to the dry year, average overall digging losses in the wetter year were significantly different and demonstrated a 48% reduction in digging losses on a lb ac^{-1} basis and a 37% reduction on a percent of recoverable yield basis. While it must be recognized that there were differences in field locations, environmental conditions experienced, and in crop maturity at digging, the results are suggestive that presence of soil moisture at the time of digging can reduce digging losses.

Table 5. Mechanical digging losses for prescribed top link settings applied in each EC zone across test years. Connecting letters reports are for comparisons within EC zones (α=0.05).

Test Year	EC Zone	Digging Loss lb ac^{-1}, d.b.		SD	Digging Loss %rec.[1]		SD
2013	Low	338	A	222	7.0	A	3.6
2014		79	B	51	2.1	B	1.2
2013	Medium	518	A	258	9.4	A	4.0
2014		395	A	79	9.4	A	1.4
2013	High	601	A	244	12.3	A	2.5
2014		291	B	130	6.5	A	1.1
2013	All	486	A	254	9.5	A	4.9
2014		255	B	161	6.0	B	3.5

[1] %rec. = percent of recoverable yield, d.b.

Because growers do not generally have the capability to adjust top link position on-the-go, they typically set the digger up for the most aggressive digging angle expected in a field by setting the top link for the prescribed setting in the finest textured soil, which would correspond in these studies to that in the high EC zones. Table 6 demonstrates this commonly applied method of digger setup, where the prescribed setting for the high EC zone was applied across all three EC zones. Again, the digging losses were in all cases numerically greater for the 2013 (dry) test year and in most cases significantly greater than those in the 2014 (wetter) test year. Subtraction of the digging losses in table 5 from those in table 6 reveals a cost of non-adjustment. In the 2013 (dry) test year the cost of non-adjustment was 48 lb ac^{-1} or 0.6% and in the 2014 (wetter) test year the cost of non-adjustment was 8 lb ac^{-1} or 0.3%.

Table 6. Mechanical digging losses for high EC top link settings applied in each EC zone across test years. Connecting letters reports are for comparisons within EC zones (α=0.05).

Test Year	EC Zone	Digging Loss lb ac^{-1}, d.b.		SD	Digging Loss %rec.[1]		SD
2013	Low	417	A	293	8.8	A	4.8
2014		52	B	25	1.7	B	0.8
2013	Medium	395	A	95	9.0	A	1.8
2014		294	A	163	5.8	A	3.8
2013	High	601	A	244	12.3	A	2.5
2014		291	B	130	6.5	A	1.1
2013	All	438	A	249	8.9	A	5.1
2014		247	B	187	5.7	B	4.0

Conclusion

These two studies demonstrate that proper top link setting is most critical in dry field conditions and that greater digging losses will result from non-adjustment across soil textures in dry field conditions than in wetter field conditions. Higher ranges of prescribed top link settings were seen across EC zones in the dry soil conditions versus the wetter soil conditions, further suggesting that the need for adjustment is more critical in dry conditions. In the wetter field conditions the cost of top link non-adjustment was negligible and one sixth of that in the dry conditions. The results here suggest that if the grower does not plan on adjusting the top link for a field across different soil textures it may benefit them in dry soil conditions to irrigate before digging or wait until after a rain to achieve a higher soil volumetric moisture content in order to reduce mechanical yield losses.

Future work related to this study will be directed at designing a randomized experiment within the same field in the same growing year with variably applied irrigation rates prior to digging. Such a study will better characterize how volumetric water content affects mechanical peanut digging losses across different soil textures. The results from the study here suggest that knowledge of an optimum volumetric soil moisture content for digging could dramatically reduce mechanical digging losses and provide a producer with soil moisture content recommendations for making digging decisions.

Acknowledgments

Thanks is due to the South Carolina Peanut Board, which supplied the bulk of the funding for this project, to the Clemson University Creative Inquiry Initiative, which provided additional resources and funding for participation by undergraduate students, to Amadas Industries, who provided technical support, and to the many individuals who assisted in data acquisition and analysis: Will Anderson, Ethan Barnette, Ashley Bonnette, Hunter Bruce, Jay Chapman, Thomas Chapman, James Cole, Daniel Compton, Kaminer Counts, John Covington, Alan Craig, William Creech, Nathan Downer, James Fleming, Benjamin Fogle, Justin Hiers, Jess Johnson, Jacob Koch, Justin Long, Matthew McCaskill, Trent Miller, Guy Ramsey, Baylor Ronemus, Coleman Ruff, Zachary Senn, Logan Simon, Cameron Wells, Charlie Westbrook, Kemp Wilson, and Coral Zadrozny.

References

ASABE Standards. 2010. S410.2: Moisture Measurement—Peanuts. St. Joseph, Mich.: ASABE,

Bader, M. 2012. Bulletin 1087: Peanut Digger and Combine Efficiency. Athens, Ga.: University of Georgia Cooperative Extension. Retrieved from http://www.caes.uga.edu/applications/publications/files/pdf/B%201087_2.PDF

Chapin, J. W., Thomas, J. S. 2005. Effect of fungicide treatments, pod maturity, and pod health on peanut peg strength. Peanut Science 32:119-125.

Grichar, W. J., and T. E. Boswell. 1987. Comparison of no-tillage, minimum, and full tillage cultural practices on peanuts. Peanut Science 14:101-103.

Huluka, G. and R. Miller. 2014. Particle size determination by hydrometer method. In F. J. Sikora (Ed.), Southern Cooperative Series Bulletin No. 419: Soil Test Methods From the Southeastern United States, (pp.180-184). Southern Extension and Research Activity Information Exchange Group - 6.

Kirk, K. R., H. F. Massey, W. S. Monfort, J. S. Thomas, B. Jordan, and W. B. Schmidt. 2013. Single row vs. twin row digging losses for two virginia type peanut varieties. ASABE Paper No. 1620957. St. Joseph, Mich.: ASABE.

Kirk, K. R., Warner, A. C., J. S. Thomas, W. S. Monfort, J. W. White, S. A. Brantley, J. S. Peele, H. F. Massey, and Y. J. Han. 2014. Importance of proper top link setting for peanut digging loss reduction. ASABE Paper No. 1914303. St. Joseph, Mich.: ASABE.

Monfort, Scott. 2013. Peanut money-maker production guide. Circular 588. Clemson, S.C.: Clemson University Cooperative

Extension.

Thomas, R. J., R. E. Pettit, R. A. Taber, and B. L. Jones. 1983. Peanut peg strength: Force required for pod detachment in relation to peg structure. Peanut Science 10:97-101.

Troeger, J. M., E. J. Williams, and J. L. Butler. 1976. Factors affecting peanut peg attachment force. Peanut Science 3(1):37-40.

Warner, A. C., K. R. Kirk, J. S. Thomas, W. S. Monfort, J. W. White, S. A. Brantley, J. Peele, H. F. Massey, and Y. J. Han. 2014. Variable depth peanut digger: Part II - Digging loss analysis. ASABE Paper No. 1914272. St. Joseph, Mich.: ASABE.

Warner, A. C., K. R. Kirk, J. S. Thomas, J. W. White, S. A. Brantley, J. Peele, H. F. Massey, Y. J. Han, and J. D. Mueller. 2015. Peanut digging loss analysis for three different depth control methods. ASABE Paper No. 152190003. St. Joseph, Mich.: ASABE.