Guide for Peanut Harvest Machinery Setup and Operation

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The purpose of this chapter is to provide growers with some items to consider relative to harvest losses and capacities when operating diggers and combines. Digger setup and operation, along with proper timing often has a greater impact on yield recovery than any other aspect of peanut production; put simply, more revenue can be made or lost during digging than during any other field operation from seedbed preparation to combining. Even with the greatest care in proper setup and maintenance, digging losses in 2013 through 2017 Clemson studies on virginia type peanuts were demonstrated to range from 52-700 lb/ac (average 275 lb/ac) under good soil moisture conditions (3-7% volumetric moisture content) and 140-600 lb/ac (average 344 lb/ac) under dry soil moisture conditions (1.6-2.4% volumetric moisture content). In all of these studies, the numbers reported were as dry weight and only those losses considered to be mechanically induced; over-mature and diseased pod losses were not included in the numbers reported.

Digger: Row Center Deviation

Substantial losses will be incurred if the digger's path is not maintained precisely over the row center. One study indicated 105 lb/ac yield loss for every 0.5 in. deviation from row center (Ortiz et al., 2013). Studies conducted by N.C. State and University of Georgia independently demonstrated approximately 10% boost in yield recovery from the implementation of RTK auto-steering to maintain the peanut digging path directly over the planting path (Gary Roberson and George Vellidis, personal communication). While capital costs of such guidance systems are high, the payoff period can be short due to the large gains. Assuming 2 ton/ac peanuts at $400/ton, a 10% increase in yield recovery would amount to an additional 0.2 tons/ac, or $80/ac. The average peanut producer in S.C. harvests about 250 ac per year, so his expected return on investment from an RTK system could be as much as $20,000 in just the first year, which is in the ballpark of the cost of an RTK guidance system. In other words, the system would be paid for in the first year.

Digging Angle (and therefore depth)

Digging angle is controlled by top link extension length. Retracting or shortening the top link results in a more aggressive angle, causing the blades to run deeper; extending or lengthening the top link results in a less aggressive angle, causing the blades to run shallower. To complicate this, soil friability will also have an effect on blade depth. Soil friability defines the ease in which digger blades and pods can be moved through the soil; generally heavier soils or less sandy textures have lower friability and lighter soils or more sandy textures have higher friability. Soil moisture and organic matter content can also impact friability—generally friability increases with increasing soil moisture and/or organic matter content. While increasing soil moisture content generally results in improved friability and therefore reduced digging losses, in soils with sufficient clay content there is a point where further increasing moisture content can make the soil sticky, which will cause it to adhere to the digger blades and to the pods, increasing digging losses.

It has been speculated that the primary function of the digger blade is to sever the tap root. Observations from Clemson research suggest that another important function of the blade is to destroy the soil structure in the pod zone, making the pods easier to remove from the soil. If the blade is too deep, then it has less effect on destruction of the pod zone. If the digging angle is set properly for the least friable soil in a field, then it will likely be too aggressive and therefore too deep in the most friable soil. Clemson studies have demonstrated that the effect of soil friability on blade depth as a function of digging angle is most pronounced in dry soil conditions, where the soil is less friable. Clemson studies also suggest that the effect of soil friability on blade depth is most pronounced with lighter weight diggers; i.e., heavier digger models (per unit width) have less tendency to move vertically. Proper depth adjustment results in blades cutting the taproot about an inch below the pods. The digger blade experiences less resistance in more friable 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 less friable soil. Conversely, less friable soils provide greater resistance to blade travel than more friable soils, which causes the blade to travel to a shallower depth for a given top link position.

If the top link is too short, the peanuts will be dug too deep and excessive soil builds up on blades causing losses presumably by pushing the plants forward before the taproot is severed. Additionally, destruction of the soil structure in the pod zone is reduced at greater blade depths. In extremely too deep cases, the taproot is not sheared, the soil structure is intact, and plants are ripped from the ground. Further losses may occur as pods ride over soil mounded on the blades. If the top link is too long, 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 for a medium texture soil, relative to the range present in a given field, movement into a lighter or more friable soil will result in excessive blade depth and movement into a heavier or less friable soil will result in inadequate depth, both of which conditions will contribute to greater harvest losses. This assumes that the field has sufficient differences in soil variability to warrant different settings.

While Clemson University and Amadas Industries (Amadas Industries, Inc., Suffolk, Va.) are working on development of an automated blade depth control system, the technology is not currently commercially available. In the meantime, a 2013 digging loss study in virginia type peanut conducted by Clemson University at Edisto REC provides some direction as to proper top link setup for soils with variable textures. In this study, the proper digging angle was established in each of three soil texture zones on the basis of EC, defined as “lightest”, “medium”, and “heaviest”. If the entire field had been dug using the proper digging angle for the lightest texture, digging losses would have been 720 lb/ac. Applying the proper digging angle for the medium texture to the entire field would have resulted in 474 lb/ac digging losses. And, application of the proper digging angle for the heaviest soil texture to the entire field would have resulted in digging losses of 437 lb/ac. So, this study suggested that if a fixed top link position is to be applied across the entire field, that the least digging losses will be incurred if that setting is determined in the heaviest or least friable soil in the field. In short, the study suggested that if proper depth cannot be maintained, then it is better to dig too deep than to dig too shallow.

The 2013 Clemson study also indicated that on-the-go adjustment of digging angle to match conditions should result in reduced digging losses. There are operators who adjust digging depth on-the-go; to do so, they generally set the top link for the heaviest (least friable) soil texture in a field with the three point hitch in its lowest position, resulting in the most aggressive digging angle required. When lighter, or sandier soils are encountered where the blades would otherwise travel too deep, adjustment is performed by either lifting the three point hitch slightly or by manually extending a hydraulic top link. Such methods require a high level of operator experience and attentiveness but can be very successful in reducing digging losses. This on-the-go adjustment is the same principle employed in the Clemson/Amadas digging depth control technology, except that adjustment is automated through feedback from a depth gauge sensor mounted to the digger.

Digger: Conveyor Speed

Amadas and KMC operator’s manuals suggest that the conveyor speed should be matched to your forward travel speed. It is generally assumed that conveyors traveling too fast tend to prematurely rip the vines from the soil, which increases pod losses. It is also assumed that conveyors traveling too slowly tend to cause the vines to bunch up at the bottom of the conveyor, causing excessive agitation of the vines and therefore increased pod losses. A 2016 Clemson study demonstrated similar results for Amadas and KMC diggers in virginia type peanut, suggesting that digging losses for 80-110% conveyor speed (as percent of travel speed) were similar, whereas digging losses increased by 100-200 lb/ac when conveyor speed was equal to 120% of travel speed. Results from a similar Clemson study in in 2017 suggested optimum conveyor speeds of 85% for both digger brands in virginia type peanuts, with significant reductions in yield (>250 lb/ac) at all higher conveyor speeds tested (100%, 115%, and 130%). Similar tests in 2017 in runner type peanut suggested that optimum conveyor speeds for the KMC digger were 100-115%, with at least 350 lb/ac reduction in yield observed from digging at 70%, 85%, or 130%; results for the Amadas digger in runner peanut in 2017 were inconclusive at the time of this report. The results do not refute the manufacturers’ recommendations of matching conveyor speed to ground speed, but suggest that lagging the conveyor slightly in excessive vine growth conditions (e.g., virginia type) peanut may be beneficial. More testing across a range of soil textures, soil moistures, and peanut varieties must be conducted for confidence in recommendations.

A simple way to set the conveyor speed to match ground speed is to adjust it until the inverted windrow falls slightly (about 2 ft) down-field from where the plants were growing. This can be assessed by placing a flag outside of the digger path at the beginning of a row and observing the location of the end of the windrow relative to the flag. This only works well if the digger is engaged at full operating speed prior to entering into the peanuts. If the end of the windrow is several feet farther into the field than the flag, then the conveyor speed is lagging. If the end of the windrow is equal in position to or behind the flag, then the conveyor is faster than the ground speed. Current models of Amadas and KMC diggers provide an interface with a digital readout of the conveyor speed in mph, so that hydraulic flow rate can be easily adjusted to match conveyor speed to travel speed.

In absence of a digital readout, an accurate method of setting conveyor speed relative to ground speed can be conducted through simple calculation and setup. Clemson Precision Ag has created a conveyor speed calculator website at the following link:

http://precisionag.sites.clemson.edu/Calculators/PeanutDigger/ConveyorSpeed/

Digger: Ground Speed

Amadas literature suggest "starting speeds" of 2.5 to 3 mph and KMC literature suggests ground speeds of 3 to 3.5 mph. KMC further suggests that digging too fast causes bunching and that digging too slowly pulls vines apart, pulling off pods. The larger pod virginia type peanuts have more surface area per pod and therefore higher drag forces, so they are more likely to be ripped from the peg resulting in losses. Because of this, it is reasonable to assume that lower speeds should be used for virginia type peanuts, as compared to those used for runner type and other, smaller pod peanuts.

A 2016 Clemson study in virginia type peanuts tested ground speeds of 2, 3, 4, and 5 mph on Amadas and KMC 2-row diggers. Conveyor speed for these tests was set to match ground speed, the Amadas digger was tested in a Champs variety and the KMC digger was tested in a Wynne variety, and tests were conducted in separate fields for each digger. Results from the Amadas test showed no significant difference in digging losses between ground speeds of 2 and 3 mph, which resulted in the lowest digging losses, with an increase in digging loss of 230 lb/ac per mph above 3 mph. The results suggested an economically optimum digging speed of 3 mph for the Amadas digger, given the conditions in the study. Results from the KMC test showed significant differences in digging losses between the 2, 3, and 4 mph digging speeds, with the least digging losses incurred at 2 mph and 270 lb/ac additional losses for each mph above 2 mph. The results suggested an economically optimum digging speed of 2 mph for the KMC digger, given the conditions in the study. Because the two diggers in this study were tested in different peanut varieties and separate fields, comparison of performance between the diggers from this test is not valid.

A similar test in 2017 showed similar results for both diggers. Comparisons between diggers cannot be made because the tests for each digger were conducted in different fields with different varieties. There was no significant difference in yield for the KMC digger in runner type peanut at speeds of 1.5 and 2.5 mph, but a significant yield reduction (>500 lb/ac) was observed from digging at 3.5 mph or 4.5 mph. Tests on the Amadas digger in runner type peanut were inconclusive at the time of this report. For the KMC digger in virginia type peanut, there was a significant reduction in yield from digging at any speed above 1.5 mph; yield losses were approximately 160 lb/ac per mph above 1.5 mph. The same results were observed in the Amadas digger in virginia type peanut with significant yield reduction observed at any ground speed greater than 1.5 mph, amounting to about 240 lb/ac in yield reduction per mph above 1.5 mph.

In ideal situations, digging ground speeds should be economically optimized. Further testing is required to substantiate, but it is expected that optimum digging speeds will vary as a function of conditions. Theoretically, economically optimum digging speed should: decrease with increasing pod size, increase with increasing sand content, increase with increasing organic matter, and decrease with decreasing soil moisture content. However, weather conditions at harvest and required timeliness of digging with respect to other farming operations must also be considered, which make generalizations about economically optimum digging speeds challenging to make. Table 1 can be used as a general guide for selecting digger speeds; it assumes a field efficiency (digging time divided by total time in field) of 85% and a row width of 38 inches.

Table 1. Peanut digging capacities and operating times across various ground speeds for 4- and 6-row diggers on 38 inch rows.

4-Row Diggers			6-Row Diggers		
Speed (mph)	Capacity (ac/hr)	Time (hr/10 ac)	Speed (mph)	Capacity (ac/hr)	Time (hr/10 ac)
2	2.6	3.8	2	3.9	2.6
2.5	3.3	3.1	2.5	4.9	2.0
3	3.9	2.6	3	5.9	1.7
3.5	4.6	2.2	3.5	6.9	1.5
4	5.2	1.9	4	7.8	1.3
4.5	5.9	1.7	4.5	8.8	1.1
5	6.5	1.5	5	9.8	1.0

Estimation of Digging Losses

If you suspect problems with your digger setup or if you want to compare one mode of operation to another, you may want to take the time to estimate your digging losses. Digging losses are challenging to quantify because they must be distinguished from combining losses and because some of the lost pods are located below-ground. The best way to effectively measure pod losses is to count or weigh pod losses within a particular sample area. Sampling should be conducted after digging but prior to combining. A standard sample grid should be constructed, such as a small PVC pipe frame. A manageable frame size would be one or two rows wide by one foot long. Multiple samples should be collected from different areas to build confidence in the estimate, as digging losses can be highly variable. Sampling requires carefully moving a section of windrow to the side, placing the frame on the ground, and collecting all above- and below-ground losses found within the frame area. Digging losses will generally be greatest in the least sandy (heaviest) soils and lowest in the sandiest (lightest) soils, so it may be desirable to take samples from different areas of the field, although the most economically important areas to assess are generally the heavier soils.

NOTE: Digging losses reported in all of the above tests reflect what we refer to as mechanical digging losses; over-mature and diseased pods are not included in the counts. If you are comparing modes of operation of the digger, over-mature and diseased pods should be ignored, as they are generally not attributable to digger setup and operation.

A general estimate of losses is provided elsewhere in this guide, stating that each pod lost per row foot is equivalent to 40 lb/ac in runner type and 60 lb/ac in virginia type peanuts. A more accurate estimate of dry weight collected from the sampling area can be calculated by multiplying the estimated dry weight per pod by the number of pods. Table 2 gives some estimates of dry weight per pod for different pod lengths.

Table 2. Estimated peanut pod dry weight as a function of pod length (virginia types). From Clemson Agricultural Mechanization & Business, student Creative Inquiry data.

Pod Length, in	Pod Dry Weight, g	Pod Length, in	Pod Dry Weight, g
0.50	0.499	1.50	2.076
0.75	0.269	1.75	2.245
1.00	1.391	2.00	2.534
1.25	1.732	2.25	3.457

Another estimate of pod dry weight determined by the Clemson Agricultural Mechanization & Business undergraduates enrolled in a Creative Inquiry project was by measurement of total sample length. If all pods are lined up end to end, the total length of the "pod line" formed can be used to estimate weight of the sample as: DW = 1.423 * L (Eq.1), where DW is dry weight in grams and L is length of "pod line" in inches. More accurately, Equation 1 can be used to calculate digging losses based on each sample collected:

$$\text{loss} = \frac{DW}{L \cdot W} \cdot 15{,}193 \qquad \text{(Eq. 2)}$$

Where,
loss = digging losses, lb/ac
DW = dry weight of sample, as estimated above, g
L = length of sampling frame, measured along row, in
W = sampling frame width, in.

Example calculation. Consider an example where 12 pods averaging 1.5 in. length were collected from within a sampling frame, with a sampling frame width of 38 in. and a sampling frame length of 12 in. Using the data in Table 2, the dry weight of the sample is estimated to be 12 · 2.076 = 24.9 g. Alternatively, length of a "pod line" from the same sample would be 18 in. and Eq. 1 would estimate the sample dry weight to be 1.423 · 18 = 25.6 g. Either of these values could then be applied to Eq. 1 to estimate pound per acre digging losses, for example:

$$\text{Losses} = \frac{25.6}{12 \cdot 38} \cdot 15{,}193 = 853 \frac{\text{lb}}{\text{ac}}$$

Estimating Yield from Windrow Pod Count

There are occasions when a grower wishes to estimate peanut yields after digging but before combining. We have provided a calculator for your use in doing this, which is based on a pod count and estimated weight per pod. The calculator is available at the following link:

http://precisionag.sites.clemson.edu/Calculators/EstimatePeanutYield/

Peanut Combine Field Capacities

Estimation of peanut combine field capacity is especially useful when seeking to match your harvest capacity with your digging capacity. Data collected from several years of peanut combine harvest data was used to estimate typical field efficiencies for peanut combines. Header width multiplied by ground speed determines your theoretical field capacity, which is the amount of field area covered per unit time when harvesting. The field efficiency takes into account turning time, unloading time, and other "non-working" time in the field; it is calculated as "harvesting time" divided by "total time in the field". Field efficiency multiplied by theoretical field capacity calculates effective field capacity, which is the reasonable amount of area you should expect to be able to cover per unit time. When applying field capacity to determine harvestable acres per day, be sure to account for an appropriate number of suitable harvest hours in the day, since peanut combines in S.C. conditions can generally only work for a portion of each day. The tables below can be used to estimate effective field capacity. Combines with conveyor offloading systems have higher field capacities than those with dump-type offloading because offloading time is reduced if not eliminated entirely as “down-time”. Self-propelled combines also have higher field efficiencies than pull-type combines, mostly due to reduction in turning time. The following four tables provide estimated field capacities by combine type, header width, and ground speed. The field efficiencies applied here were generalized from field data but may not match the field efficiencies from your operation.

	Pull-Type, Dump, FE=0.60		
	Effective Field Capacity ac/hr		
Speed mph	**12 ft Width**	**18 ft Width**	**24 ft Width**
0.50	0.44	0.65	0.87
0.75	0.65	0.98	1.31
1.00	0.87	1.31	1.75
1.25	1.09	1.64	2.18
1.50	1.31	1.96	2.62
1.75	1.53	2.29	3.05
2.00	1.75	2.62	3.49
2.25	1.96	2.95	3.93
2.50	2.18	3.27	4.36
2.75	2.40	3.60	4.80
3.00	2.62	3.93	5.24

	Pull-Type, Conveyor, FE=0.75		
	Effective Field Capacity ac/hr		
Speed mph	**12 ft Width**	**18 ft Width**	**24 ft Width**
0.50	0.55	0.82	1.09
0.75	0.82	1.23	1.64
1.00	1.09	1.64	2.18
1.25	1.36	2.05	2.73
1.50	1.64	2.45	3.27
1.75	1.91	2.86	3.82
2.00	2.18	3.27	4.36
2.25	2.45	3.68	4.91
2.50	2.73	4.09	5.45
2.75	3.00	4.50	6.00
3.00	3.27	4.91	6.55

	Self-Propelled, Dump, FE=0.75		
	Effective Field Capacity ac/hr		
Speed mph	**12 ft Width**	**18 ft Width**	**24 ft Width**
0.50	0.55	0.82	1.09
0.75	0.82	1.23	1.64
1.00	1.09	1.64	2.18
1.25	1.36	2.05	2.73
1.50	1.64	2.45	3.27
1.75	1.91	2.86	3.82
2.00	2.18	3.27	4.36
2.25	2.45	3.68	4.91
2.50	2.73	4.09	5.45
2.75	3.00	4.50	6.00
3.00	3.27	4.91	6.55

	Self-Propelled, Conveyor, FE=0.90		
	Effective Field Capacity ac/hr		
Speed mph	**12 ft Width**	**18 ft Width**	**24 ft Width**
0.50	0.65	0.98	1.31
0.75	0.98	1.47	1.96
1.00	1.31	1.96	2.62
1.25	1.64	2.45	3.27
1.50	1.96	2.95	3.93
1.75	2.29	3.44	4.58
2.00	2.62	3.93	5.24
2.25	2.95	4.42	5.89
2.50	3.27	4.91	6.55
2.75	3.60	5.40	7.20
3.00	3.93	5.89	7.85

Acknowledgments

Clemson studies referenced in this guide were appreciatively supported by the South Carolina Peanut Board, the National Peanut Board, and the Clemson University Creative Inquiry Initiative. Thank you also to the Clemson University Agricultural Mechanization & Business program, which has provided student volunteers for several years to assist in the tremendously laborious task of collecting peanut digging losses. Finally, thank you is also due to Amadas Industries, which has provided equipment and engineering support for the Clemson Precision Agriculture Research and Extension program.