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Single Row vs. Twin Row Digging Losses for Two Virginia Type Peanut Varieties

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Abstract. *Twin row peanut production was initially introduced to take advantage of production benefits noted in narrow, single row studies, while still accommodating typical machinery involved in peanut production. Studies on twin row peanut production have been conducted since at least the early 1980s and many report increased yields and reduced weed pressure when compared to single row studies. Because the conventional peanut harvest is a two stage process where the plants are first dug and then combined several days later, there are two opportunities for yield losses. This study compares the yield losses at digging for twin row and single row peanuts of two virginia type varieties, Bailey and Champs. Digging losses were quantified as "above ground" and "below ground" losses. Peanuts were planted and dug using RTK navigation to reduce operator induced errors. Mean above ground, below ground, and total digging losses were higher for twin row than for single row configurations across both varieties, but only statistically different for percent above ground losses and percent total digging losses in the Champs variety. Single row mean pod production was higher than that for twin row, but single row mean harvested yield was lower than that for twin row, although not statistically different. The results of this study were not statistically conclusive, but indicate that despite greater pod production and lower digging losses for single row than that for twin row peanuts. This suggests that combining losses for the single row peanuts in this study may be dominant in accounting for total harvest losses. Further study is needed to verify.*

Keywords. *twin row, peanut, yield losses, digging losses, row configuration.*

Introduction

Studies in peanut row spacing dating back as far as the late 1800s, many years prior to mechanization of the peanut harvest, have generally commented that narrow spacing results in higher yields and reduced weed pressure. Row spacing was recommended primarily on optimal yield, with superseding consideration of practicality in cultivation and harvest. Although row spacing as small as 46 cm (18 in) has proven to be advantageous in production, minimum practical spacing on the basis of cultivation and harvest has generally been recommended at a minimum of 67 cm (26 in).

As early as the late 1980s, studies were conducted to plant peanuts in narrowly-spaced double rows within conventional bed spacing. Such an arrangement has come to be known as “twin row” configuration and takes advantage of yield increase and weed suppression generally documented for narrower row spacing, but while still accommodating mechanized cultivation and harvesting operations. Twin row plantings represent a hybrid configuration between narrow row spacing and conventional row spacing, with narrow rows planted on conventionally spaced beds.

A review of the literature documenting studies focused on evaluation of row spacing and row configuration was conducted as a summary of the work conducted in this area over the last three centuries. Figures 1 and 2 show average yields and relative weed abundance reported across the studies found in the literature review (Hauser and Buchanan 1981; Besler 2004; Brecke and Stephenson 2006; Cardina et al., 1987; Colvin et al., 1985a; Colvin et al., 1985b; Culbreath et al., 2008; Lanier et al., 2004a; Lanier et al., 2004b, Place et al., 2010; Sconyers et al., 2007; Wehtje et al., 1984; Yoder, 2003), (Scott Monfort, unpublished data, 2012. Blackville, SC: Clemson University, Edisto Research & Education Center). The collection of data gathered from these sources included 446 distinct trials or reps reporting on yield, weed population, or both. In interpreting these figures, it is important to recognize that these sources represent a range of investigations (e.g. yield, weed management, and diseases), a range of geographies in the United States, a range of plant populations, and a range of cultural practices. Error bars in both figures represent 95% confidence intervals of the means, which do not indicate statistical significance. Narrow, as distinguished in the figures from standard row spacing was defined as that where the single rows or sets of twins were centered 76 cm (30 in) or closer.

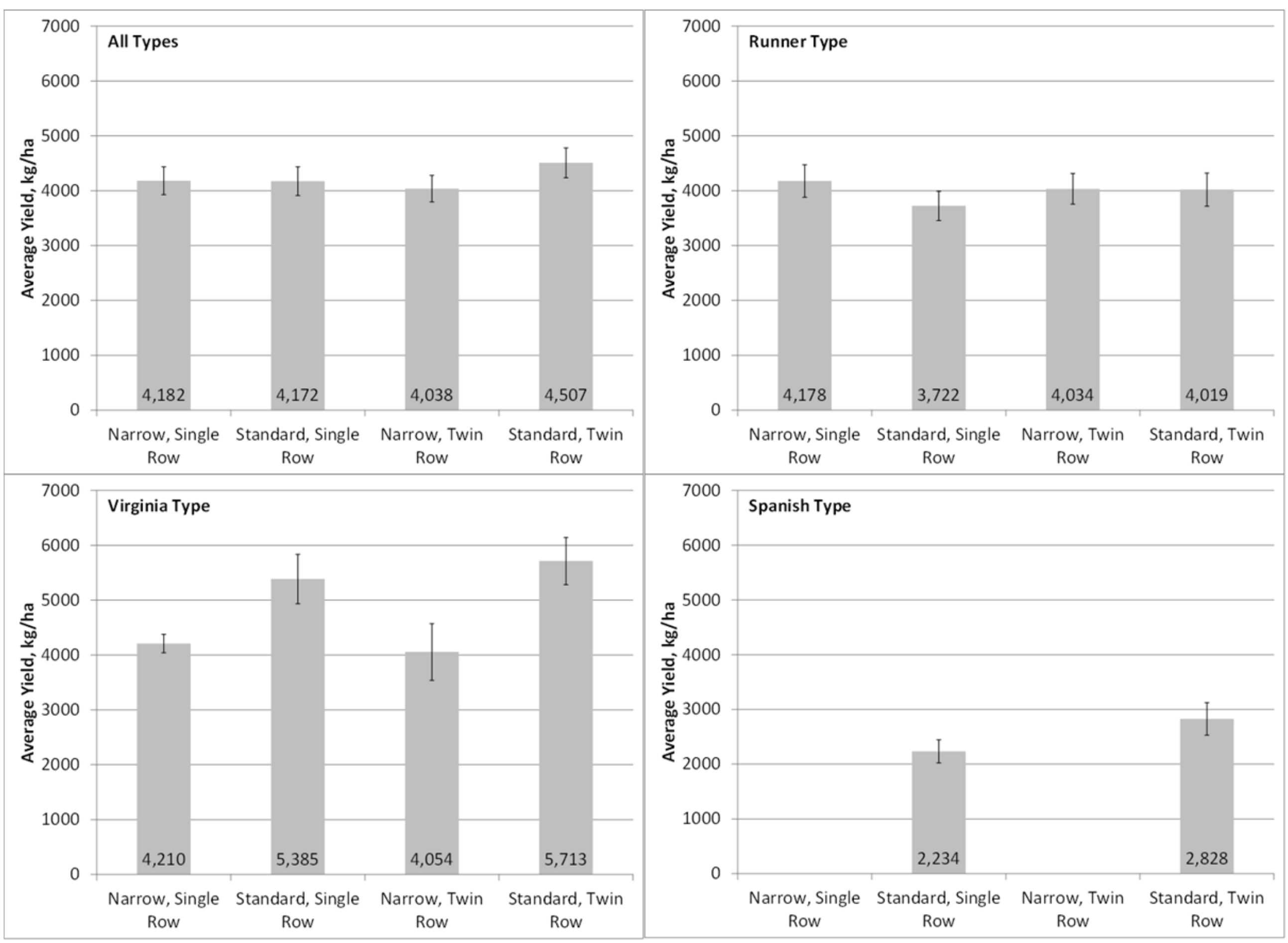

Figure 1. Average yields reported in literature studies of peanut row spacing and row configuration.

While mean values for average yield across all plots in figure 1 were higher for standard twin row configurations than for standard single row configurations, they confidence intervals overlapped across types (upper left figure) and within the virginia and runner types. Non-overlapping confidence intervals in the spanish type suggest that average yield is greater for standard twin row than for standard single row. Confidence intervals overlapped for narrow versus standard row spacing in both singles and twins across types and for the runner type, but it is suggested that average yield is less for narrow row spacing as compared to standard row spacing for the virginia type. No yield data was found in this review for spanish type narrow row spacings. Means were similar for narrow single row and narrow twin row configurations for all of the types, except spanish for which there was no data found.

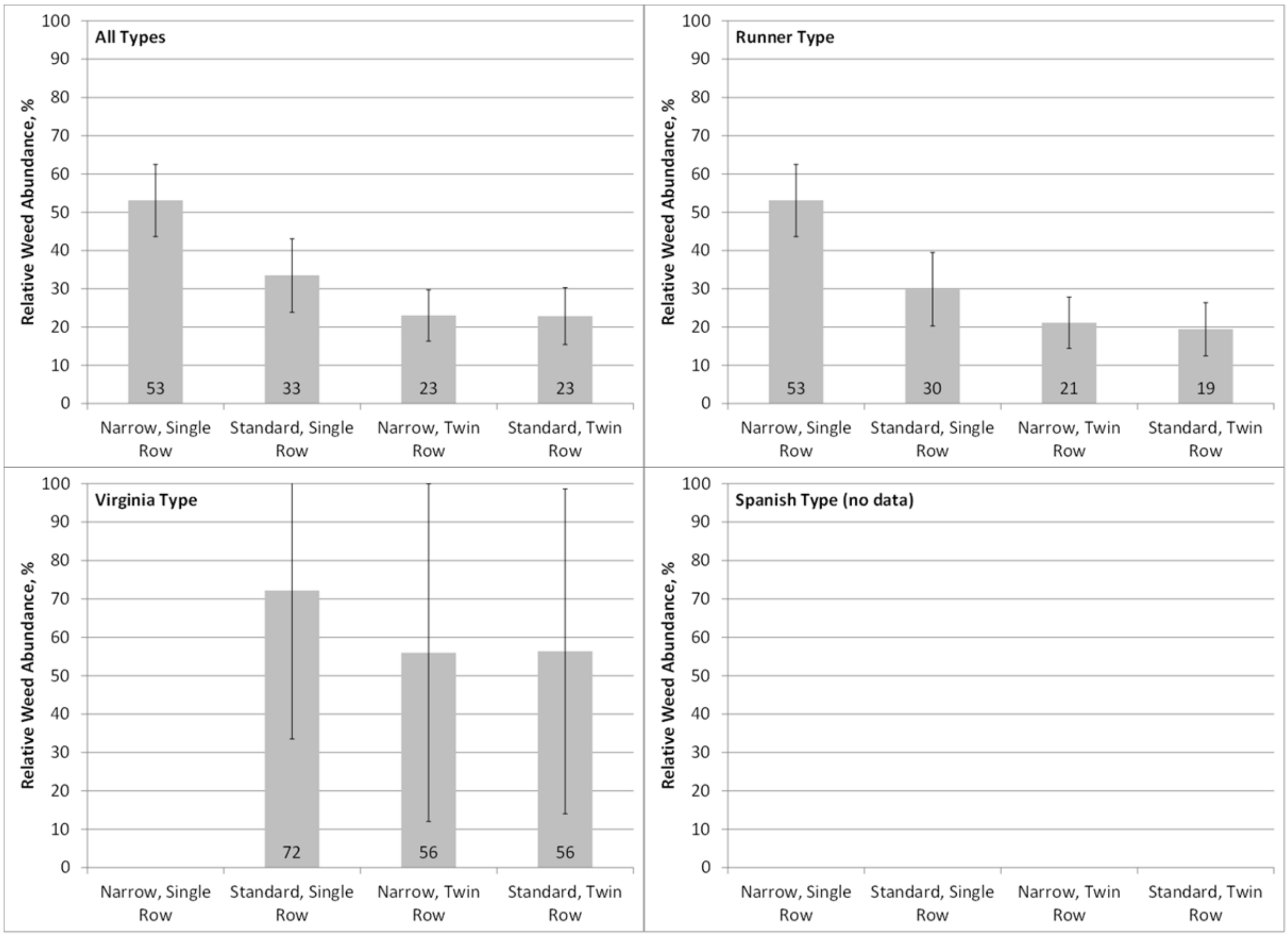

Figure 2. Relative weed abundance reported in literature studies of peanut row spacing and row configuration.

An attempt at normalizing the weed data across the studies for comparison was conducted by calculating relative weed abundance for each trial or rep. This value was calculated as the abundance of weeds reported in an individual trial or rep divided by the maximum weed abundance reported across all reps or trials within its particular study. Where percent weed control was reported in a study, weed abundance was calculated as 100% minus the percent control value reported. These values were also normalized to a relative basis within each study as stated. Other measures of weed abundance encountered were directly normalized, such as number of plants per plot, weed weight, percent ground coverage, and weed yield.

The plot in figure 2 representing averages across all types is dominated by the runner type with 172 distinct measures; the virginia type only had 12 distinct measures and there were no measures in the cited literature for the spanish type. Because of the wide range of confidence intervals for the virginia type, comparisons are weak between row spacings and configurations. Non-overlapping confidence intervals for mean relative weed abundance suggest that it is higher in the runner type for narrow single row than for standard single row spacing. This is in contrast to many general statements made in the literature about the benefits of narrow row spacing in peanuts.

Regardless of whether single or twin row configurations and whether narrow or standard row spacing are used, determination of proper digging time plays an important role in influencing pod yield and is generally associated with pod maturity, but can also be influenced by environmental conditions at the time of digging (Jordan et al., 1998). Jordan and Beasley (2007) suggest that yield losses in excess of 280 kg ha^{-1} wk^{-1} (250 lb ac^{-1} wk^{-1}) may result from digging too early or too late relative to optimum maturity, although they do not distinguish what portions of these losses would be attributed to digging and combining.

Wright and Steele (1979) suggest typical digging losses ranging from 6 to 20% of the net yield from normal digging dates. Digging losses resulting from over-maturity are supported by Troeger et al. (1976), who demonstrated an inverse relationship between peg attachment force and maturity. Chapin and Thomas (2005) also studied peg strength as a function of maturity and indicated that peg strength increased until the point of full maturity and then declined in over-mature peanuts.

Degree of maturity is one of several factors that can influence digging losses. It is well known that pods can be shed by disease generally resulting in weakened pegs. Grichar and Boswell (1987) reported higher incidence of pod disease in the pods left below ground after digging than in the pods handpicked from the plants, suggesting that digging losses in that study resulted from disease.

It was speculated by Jordan et al. (2003) that digging losses may be greater for reduced tillage than for conventional tillage systems because digging is more difficult. At least one study has supported this claim in no-tillage plots (Grichar and Boswell, 1987) but attributed the problem to grass problems and poor soil moisture. Jackson et al. (2011) attribute yield loss in strip tillage primarily to lack of an elevated bed at harvest and demonstrated 47-62% reduced digging losses as compared to flat strip-till through fall bedding. Their results also indicated that fall bedding is less important on coarse textured soils than those with high clay content.

Jordan et al. (2003) suggest that digging losses may be greater for larger pods, which may result in greater tendency for detachment. This concept was addressed in a prior study (Troeger et al., 1976) showing an inverse relationship between peg attachment force to surface area ratio and harvesting losses, adding that runner varieties were measured to have the lowest peg attachment forces and spanish varieties had the largest. Because the peg is all that holds the pod to the plant at digging, weak pegs will inherently result in increased digging losses; however a peg that is too strong may result in increased pod damage during combining.

Mechanical issues such as digger design and setup can also play a critical role in influencing digging losses. The digger blade must cleanly sever the tap root, in contrast to dragging the plants, which would increase pod detachment. When the vines are lifted, detachment can also be increased if the soil is not adequately loosened. A study in Malaysia on different digging blades (Omer and Ahmad, 2001) produced results suggesting that there was an optimal speed for each plow tested with respect to digging losses. Digging too shallow will result in below ground losses from pods positioned below the depth at which the tap root is cut. Alternatively, digging too deep can result in increased detachment caused by reduced soil loosening, which will increase tendency for detachment due to greater soil resistance on the pods during lifting.

Chapin and Thomas (2005) observed that pegs broke near the pod for diseased and over-mature pods, but at the attachment point for healthy pods that were not over-mature, leaving a portion of the exocarp attached to the peg. Such observations can assist operators in identifying potential problems with digging operations such as dull blades, improper blade angle, or hard ground (Monfort, 2013). Other losses can be encountered during the shaking and inversion processes. Losses can be a result of improperly matched conveyor speed to ground speed, which will result in erratic vine pickup from the conveyor, possibly dislodging peanuts from the plants.

Several studies have been conducted characterizing peanut digging losses across varieties and identifying the causes of digging losses, but none have specifically targeted twin row configurations. Likewise, many studies have been conducted investigating weed control, yield, and disease control in twin row configurations, yet none of these studies specifically assess the digging operation.

In short, factors affecting peanut digging performance are complex and little has been reported about digging differences for single and twin row peanuts. Because the majority of profits or losses in peanut production can be attributed to digging decisions (Monfort, 2013), thorough knowledge of digging performance across a range of conditions and situations is critical to peanut production. This research was targeted specifically at comparing digging losses for single row to twin row virginia peanuts when utilizing the same digger setup in order to provide evidence that might assist producers in making machinery management decisions when digging twin row peanuts.

Materials and Methods

There were four treatments for this experiment: Bailey single row, Champs single row, Bailey twin row, and Champs twin row. Bailey and Champs are high yielding, early maturing varieties of virginia type peanuts. There were six replications of each treatment, planted in two row, 12 m (40 ft) plots. Row spacing was 91 cm (36 in) for singles and sets of twins with spacing of the twins at 18 cm (7 in). Seeding rate was set about 9% higher for the twins than for the singles at 18 m^{-1} (5.5 ft^{-1}) for singles and 9.8 m^{-1} (3 ft^{-1}) for each row in a set of twins, although problems with the planter resulted in lower applied rates as discussed below and as demonstrated by plant stand counts. Plant stand was measured for each rep on 19 June 2012. The field was composed of a Norfolk loamy sand (40%) and a Barnwell loamy sand (60%) (NRCS, 2013). Peanuts were planted on shallow beds around late May and dug on 12 October 2012. Planting and tillage were performed using an RTK (Real Time Kinetic) guidance and auto steer system. Tillage was conventional and cultural practices and pest control followed Clemson Extension (Clemson University) recommendations. Irrigation was applied as needed using a center pivot.

Peanuts were dug using a two row, three-point hitch mounted KMC digger/shaker/inverter (Kelley Manufacturing Co., Tifton, Ga.). The 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. Assessment of proper blade angle and depth was performed by inspection of the tap root cut length relative to the pods along with ensuring that there was not excessive soil in the windrow. Assessment of proper lifting performance was conducted by inspecting the inverted vines for evidence that healthy pods were being ripped from the pegs, as would be evidenced by a portion of the exocarp remaining attached to the pegs. Digger settings were the same for all treatments. Peanuts were combined using the research plot yield monitor described by Kirk et al. (2012).

One sampling area was assigned in each plot, for a total of 24 sampling areas across the six reps of the four treatments. Sampling areas were two rows wide, or 183 cm (72 in), by 61 cm (24 in) long and spatially assigned within the inner 6.1 m (20 ft) of each plot. The vines from the sub plot were carefully removed from the sampling areas, the on-plant pods collected, and their field weight recorded. Pods on the soil surface within the sampling areas were collected and their field weight recorded as above ground losses. The soil was excavated to a depth of 10 cm (4 in) and sieved to collect all peanuts in the soil, which were weighed and recorded as below ground losses. In all cases above, immature pods were discarded and not included in the recorded weights. Pods were not classified for disease and therefore could not be discarded on this basis. All collected samples were oven dried using ASABE S401.2 conventional oven method (ASABE 2012). The total pod production was calculated as the dry weight sum of above ground losses, below ground losses, and on-plant pods. Percent loss was calculated as dry weight percentage of total production. Fisher's LSD tests (α=0.05) were performed to compare the results across the four treatments.

Results and Discussion

Although the planters were set at seeding rates that should have resulted in similar plant populations across single and twin row configurations, plant stand measurements conducted a little more than one month after planting indicated that there was a problem with the planter resulting in substantially reduced seeding rate for the single row configuration. Although different across row configurations, plant stands measured were similar across varieties, at 8.9 m^{-1} (SE = 0.61) for single and 13.7 m^{-1} (SE = 0.98) for twin row. It is unclear how these differences in plant population may have influenced the results, although it must be considered in interpretation of any comparisons made between single and twin row configurations.

Total pod production (table 1) for each sampling area was calculated on a dry weight basis as the sum of on-plant pods, above, and below ground losses, divided by the sampling area. There were no significant differences in total pod production across treatments. This should not be confused with stating that the realized, or recovered yields were equivalent across all treatments. As discussed earlier, digging performance is complex and can largely be a function of variety-specific properties such as peg strength. Average pod moisture content at the time of digging was 45.9% across all reps with no significant difference between treatments. The pod moisture content will be revisited later in discussion.

Table 1. Mean total pod production and pod moisture content at digging.

		Mean Total Pod Production			MC at Digging		
Variety	Row Configuration	kg ha^{-1} d.b.		SE	% w.b.		SE
Bailey	Single	5,556	a	436.2	48	a	1.4
Bailey	Twin	5,065	a	317.5	47	a	1.5
Champs	Single	5,366	a	615.6	46	a	1.5
Champs	Twin	4,999	a	558.9	43	a	1.0

Tables 2 shows mean digging losses separated into above ground, below ground, and total losses in terms of dry weight yield loss. Within varieties and across row configurations, there were no significant differences in digging losses as dry weight yield losses, and there were no significant differences within row configurations across varieties.

Table 2. Mean digging losses reported as yield loss.

		Mean Above Ground Digging Losses			Mean Below Ground Digging Losses			Mean Total Digging Losses		
Variety	Row Configuration	kg ha^{-1} d.b.		SE	kg ha^{-1} d.b.		SE	kg ha^{-1} d.b.		SE
Bailey	Single	353	a	54.5	223	a	38.2	576	a	80.4
Bailey	Twin	471	ab	73.5	271	a	32.1	742	a	68.9
Champs	Single	434	ab	70.0	456	ab	79.0	890	ab	138.6
Champs	Twin	626	b	70.6	573	b	117.0	1,199	b	176.0

Table 3 shows digging losses as a percentage of total pod production. Other digging loss studies have reported digging losses as percentage of recovered yield but this could not be done in this study because moisture contents were not measured at the time of combining and recovered yields are therefore only available on a wet basis, which cannot be compared to the dry basis losses reported here. Percent digging losses for Champs twin row were significantly higher in all three categories than Bailey twin row, and below ground and total percent losses for Champs single row are significantly higher than for Bailey single row. Within varieties and across row configurations, the only significant differences in percent digging losses were for Champs above ground and total losses, being higher for twin row than for single row.

Table 3. Digging losses reported as percent of total production.

		Mean Above Ground Digging Losses			Mean Below Ground Digging Losses			Mean Total Digging Losses		
Variety	Row Configuration	% Loss		SE	% Loss		SE	% Loss		SE
Bailey	Single	5.7	a	1.0	3.5	a	0.5	9.2	a	1.1
Bailey	Twin	8.1	a	1.2	4.9	ab	0.8	13.0	ab	1.1
Champs	Single	7.1	a	0.9	7.8	bc	1.6	14.9	b	2.3
Champs	Twin	11.2	b	0.8	10.5	c	1.8	21.7	c	2.5

Mean recovered yield (table 4), realized at combining is the yield value that is most important to the producer. There were significant recovered yield differences between Bailey and Champs varieties within both the single row and the twin row configuration, with Champs being the lower yielding variety. There were no significant differences in recovered yield within varieties and across row configurations.

Table 4. Mean recovered yield from combining.

		Mean Recovered Yield		
Variety	Row Configuration	kg ha^{-1} w.b.		SE
Bailey	Single	6,462	ab	103.2
Bailey	Twin	6,677	a	68.2
Champs	Single	5,974	c	121.6
Champs	Twin	6,249	bc	155.3

Because moisture contents were not collected at the time of combining, it is difficult to make assertions based on the values in table 4 relative to the other quantities measured in this study. Although moisture content at the time of combining cannot be decisively assumed to be similar across all treatments, it was indicated in table 1 to have no significant difference across the treatments at the time of digging, roughly one week prior to combining. Because there were no significant differences in total pod production across the four treatments, significantly lower recovered yields for Champs in both row configurations is likely in part due to the significantly larger percent digging losses for Champs in both row configurations.

In every disease tolerance category provided by Monfort (2013), Champs is more susceptible than Bailey and average yields in variety trials over the past five years were reported Bailey as being 5.3% higher yielding than Champs, consistent with the results of this study. Based on the statistically similar total pod productions measured in this study between Champs and Bailey, there is a possibility that the reduced recovered yields in Champs is a result of reduced peg strength, although this was not measured in this study.

There were general trends, although not statistically significant, in the averages within both varieties for greater total pod production and less total digging losses, yet less recovered yield in single row configurations as compared to twin row configurations. Digging losses measured in this study cannot explain lower recovered yields despite greater total pod production. A potential explanation is overwhelmingly large combining losses in single row configurations as compared to twin row configurations.

Observations made during harvest in other studies suggested that the increased intertwinement of the plants in twin row production improved conveyor pickup at the digger, resulting in a smoother “ribbon” of plants being fed into the machine (Hollens Free, personal communication, 2012. Blackville, SC: Clemson University, Edisto Research & Education Center). As stated earlier, combining losses could only be assumed in this study because recovered yield cannot be calculated on a dry weight basis for comparison to total pod production. If substantially increased combine losses for single row production were responsible for the trends discussed above, another explanation may relate to maturity and its relationship with peg strength, but further work must be conducted to verify.

Conclusion

It must be reiterated that plant stands were substantially different across row configurations and it is unclear to the authors how this might have impacted productivity and other results. Although the primary objective of this study was to characterize differences, if any, between digging losses in single row and twin row configurations for two virginia peanut varieties, the results pointed to more conclusive findings between the varieties than between the row configurations, with percent digging losses for the Champs variety being consistently and significantly greater than those for the Bailey variety within row configurations. Champs was the only variety that demonstrated statistically different digging losses for twin versus single row configurations, being higher in the twin row configuration in terms of percent above ground and total digging losses. Further study could be done to address these findings and potentially lead to recommendations that would increase the recoverable yield for Champs. These studies should include measures of pod maturity, disease, and peg strength to help identify causal relationships for larger digging losses in Champs in general as well as for twin row Champs.

Albeit statistically insignificant, the general trend observed showing higher total pod production and lower total digging losses, yet lower recovered yield for single row as compared to twin row configurations may warrant further studies including, especially measures of combine pickup and combine threshing losses, which may be the underlying explanations for this trend seen across both varieties. Measures of pod maturity, disease, and peg strength would be useful here as well.

Average digging losses in the treatments in this study, where care was taken to minimize digging losses, ranged from 600 to 1300 kg ha^{-1} (550 to 1150 lb ac^{-1}), representing a potential revenue of $140 to $290 per acre at $0.25 per pound. Very little published work has been done in this area recently, and while digging losses in peanuts with mechanized equipment are inevitable, substantial gains could be realized by producers through studies directed at providing them with better digging recommendations across the wide range of varieties and conditions in which peanuts are grown today.

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