PROFITABILITY OF RTK AUTOGUIDANCE AND ITS INFLUENCE ON PEANUT PRODUCTION

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ABSTRACT

Efficient harvest of peanuts (*Arachis hypogea* L.) requires that the digging implement be accurately positioned directly over the target rows. Small driving errors can produce large harvest or more importantly yield losses. Producers have traditionally relied solely on tractor operator skills, without the help of GPS-based autoguidance systems, to harvest peanuts. However, as peanut production has shifted to new growing regions in the US, particularly in Alabama, producers face difficulties in having inexperienced tractor operators for peanut digging operations. Further, new varieties with higher yields, on the order of 4 metric tons/ha or more, make accurate digging much more difficult even for experienced operators. The goal of this study was to quantify the impact that deviations from the planted row during peanut digging might have on peanut yield and to determine the economic return of using GPS-based autoguidance systems on peanut production. The study consisted of a factorial combination of tillage (conventional and strip tillage), row patterns (single and twin) and deviations from the target row (0, 9, and 18 cm). The treatment of "0 cm deviation" corresponded using a RTK GPS-based autoguidance system (RTK level or cm level accuracy) during digging. Results indicated differences in peanut yield between tillage and row patterns with yield losses increasing as the deviation from the target row increased. Peanut yield under conventional tillage conditions was 672 Kg/ha higher than strip tillage with more than 530 Kg/ha on twin rows with respect to single rows. If deviations of 9 cm and 18 cm occur, a producer can expect yield losses of 15% and 32%, respectively in relation the use of RTK autoguidance. Under strip tillage conditions, yield losses due to deviations from the target row were similar to conventional tillage conditions. A cost analysis for the conventional tillage conditions showed that producer's profitability decreased as deviation from the target row increased. Although the same trend was not observed for the strip tillage treatment, a producer might expect a reduction in profit if deviations from the target row during digging occur.

Keywords: Autoguidance system, GPS, Peanut, Precision Agriculture, Tillage.

INTRODUCTION

Peanut (*Arachis hypogaea* L.) production in the Southeast USA (Alabama, Florida, Georgia, Mississippi, and South Carolina) has increased during the last decade with increments up to 29 percent in the 2007-2008 harvested area. In Alabama, the production area has expanded from the traditional planting region in the southeast (1999 - 67% of the total production) to the central and southwestern parts of the state (2008 - 18% of the total production). The expansion towards non-traditional peanut production areas, in addition to the increased number of new producers, has partly influenced producers' decisions to adopt new technologies such as GPS-based autoguidance systems to improve field operations, management practices and ultimately profitability.

Before the introduction of GPS-based autoguidance systems, peanut producers relied on skilled tractor operators to plant and then accurately harvest peanuts. However, new producers growing peanuts, inexperienced tractor operators can find it difficult to keep the peanut digger positioned over the rows. Recent adoption of twin-row planter has increased the adoption of GPS-based autoguidance systems because the tractor operator find difficult to center the equipment on the target rows due to the canopy covers almost the entire ground making the rows less visible at harvest (Beasley, 1970). In addition, new peanut varieties with more disease tolerance are harder to dig even for experienced machine operators due to rank peanut vines that stay green at maturity. The green vines make it difficult for an operator to stay immediately over the row and invert peanuts properly. GPS based autoguidance on tractors might help the producers when adopting these new management practices because it allows the operator to place the tractor to within 2.5 cm of the desired center line. When used for deep tillage, planting, spraying, and digging, autoguidance systems have the potential of eliminating producer concerns about properly centering the equipment in a completely closed canopy especially when crops are planted using contour farming.

Most of the studies involving GPS-based navigation systems have focused on accuracy evaluation and factors impacting performance such as changes of the terrain, travel speed and distance from the base station (Adamchuk et al., 2007; Stombaugh et al., 2007; Stombaugh and Shearer, 2001). However, few studies have quantified yield benefits and economic return of using tractor guidance system. Raper et al. (2008) evaluated the use of tractors equipped with GPS-based guidance systems under Alabama cotton production conditions and demonstrated that cotton planted within 5 cm of the in-row subsoil strip yielded 44% more than cotton planted without subsoiling. The study also showed that the accuracy of in-row subsoiling and planting, however, was only maintained when an autoguidance system was used. An economic analysis of the same study indicated that autoguidance systems with the accuracy of less than 2.5 cm may be the most profitable for large farms, while systems with less than 10-cm accuracy may provide a better alternative for smaller farms (Bergtold et al., 2009). Griffin (2009) also studied the impact of farm size related to the economic returns gained by using autoguidance and found that GPS guidance systems becomes more profitable as farm size increases.

The objectives of this research were to: (1) determine peanut yield differences from harvest aided by RTK GPS-based autoguidance and two hypothetical deviations of the target row, and (2) determine the profitability of RTK GPS-based autoguidance systems on peanut production.

MATERIALS AND METHODS

Study field and experimental plan

Yield differences occurred during peanut digging as a result of deviation of the target row (9 cm and 18 cm off) respect to exactly over the row were evaluated over a three year period (2005 – 2007) at the Wiregrass Research Station in Headland, Alabama (31°21'N, 85°19'W). The soil type was a Dothan sandy loam (fine, loamy siliceous, thermic Plinthic Kandiudults) with less than 2% slope. The experimental design was a randomized complete block with twelve treatment combinations of tillage (conventional and strip), row patterns (twin and single row), and digging schemes (no deviations - 0 cm, and deviations of 9 cm and 18 cm off the target row) was implemented with four replications. The two hypothetical deviations of the target row corresponded to deviations that could be caused by manual driving or the use of non-RTK guidance. For this particular study, the two deviation treatments were implemented through the use of a RTK guidance system.

The conservation tillage plots were planted with an oat (*Avena sativa* L.) cover crop in the fall 2004 and during all subsequent years. The conservation tillage implements included a four-row KMC strip till unit with four coulters behind the in-row sub-soil shank followed by a rolling basket. The implements used for the conventional tillage system included a moldboard plow, disk, and two passes with a KMC field cultivator.

The experimental plots were 3.6-m wide and 18-m long planted with the Georgia Green variety in 2005, and the Ga O3L variety in 2006 and 2007. Single rows were planted in both tillage systems with a John Deere 1700 XP Max emerge vacuum planter on 0.9 m centers. The twin rows were planted in both tillage systems with a Monosem planter on 0.9 m centers with a 23 cm spacing between the twin rows. The tractor used for the experiment was a John Deere 7810 MFWD tractor equipped with a StarFire iTC and the GreenStar AutoTrac assisted steering using the StarFire RTK correction signal which can provide between 1.27 cm to 2.3 cm accuracy. The middle two rows from each plot were dug with a 2-row (1.8 m wide) digger-inverter implement for yield. These middle two rows of the plots, were picked and sacked with a 2-row Hustler peanut combine. The plot bags were dried down to 10% moisture and the dry weight was used to calculate yield.

Economic and Statistical Analyses

The economic analysis was based on the comparison of economic returns of digging peanuts using RTK GPS-based autoguidance systems and hypothetic scenarios of deviation off the planted row (9 cm and 18 cm) which could represent deviations due to manual driving or possibly use of non-RTK autoguidance system susceptible to drift or large errors. The economic framework of a commercial peanut farm in south Alabama assumed a production area of 200 hectares which used a RTK GPS-based autoguidance system. The analysis assumed a guidance system with 5 years economical life and an annual cost per acre of $19.43 dollars for the complete system. Variable cost of seed, fertilizer, micronutrients, insecticide and fungicides, drying and cleaning, hauling, crop insurance, labor, tractor and machinery, and interest on operating capital were included. Variable and fixed cost of specific machinery and labor requirements for each tillage treatment were also integrated. The yield goal was set at 4.32 metric tons of peanuts per hectare with a price of $400 dollars per metric tons. Statistical analyses of peanut yield and net return data were performed using the mixed model procedure (PROC MIXED) in SAS (Littell et al., 2006).

RESULTS

The analysis of results is presented by tillage treatments. When the yield losses average (2005-2007) under conventional tillage were estimated by subtracting single rows yield from twin rows yield, less than 368 Kg/ha, 345 Kg/ha, and 875 Kg/ha were observed for deviations of 0 cm, 9 cm, and 18 cm from the target row respectively (Table 1). These results also indicated that independently of the deviation from the row, yield from twin rows was higher than single rows. The percentage yield reduction increased from 16 to 32 with deviations of 9 cm and 18 cm respect to the harvest “over the target row” using a RTK guidance system (Table 2). For the strip tillage treatment, the average yield losses, single row versus twin row, were lower than conventional tillage for the same off the row deviations. Under this treatment, the trend of yield losses respect to deviation from the target row was different from the conventional tillage treatment; higher losses were observed on the “0-cm deviation” than the 18-cm deviation from the target row. However, the higher yield observed on the twin rows respect to single rows (672 Kg/ha, averaged over 2005-2006) might compensate by the possible losses occurred by row deviation during harvest.

The results from this study indicated that under strip tillage, deviation from the target row has a similar, negative impact on yield as measured on the conventional tillage treatments. For both tillage treatments, the percentage yield losses was the same for single and twin rows when deviations from the target row were compared (Table 2).

Table 1. Peanut yield losses on single rows respect to twin rows both planted under conventional and conservation (strip) tillage; average data from 2005 through 2007.

Row Deviation (cm)†	Tillage	
	Conventional	Strip
	Yield differences (Kg/ha) (Single row - Twin Row)	
0	-368.4	-455.4
9	-345.0	-193.3
18	-875.1	-93.1

† Data is presented for different deviations of the peanut digger from the target row.

Table 2. Percentage yield reduction of peanuts dug on the row respect to the digger drifted 9 cm and 18 cm off the row; average data from 2005 through 2007.

	Row pattern			
	------- Single -------		------- Twin -------	
	Row deviation (cm)			
	18 vs. 0	9 vs. 0	18 vs. 0	9 vs. 0
Tillage	-------------- % Yield reduction --------------			
Conventional	38	16	27	15
Strip	32	13	31	16

In 2006, the highest yield over the three years was observed. Therefore, a comparison of yield differences between the treatments indicated the potential losses one can expect when deviation from the target row at harvest occurs. On average, yield from twin rows was higher than single rows (10% increase) as well as yield from conservation tillage compared with strip tillage (5% increase) (Fig. 1). Under conservation tillage, yield was reduced 8% and 29% when harvest of single rows deviated 9 cm and 18 cm from the target row (0-cm deviation), respectively. Less yield reduction was observed on twin rows, 10% and 19% for deviations of 9 cm and 18 cm respect to the target row (0-cm deviation), respectively. Under strip tillage, yield was reduced 14% and 25% when harvest of single rows deviated 9 cm and 18 cm from the target row (0-cm deviation), respectively. Less yield reduction was observed on twin rows, 15% and 33% for deviations of 9 cm and 18 cm respect to the target row (0-cm deviation), respectively.

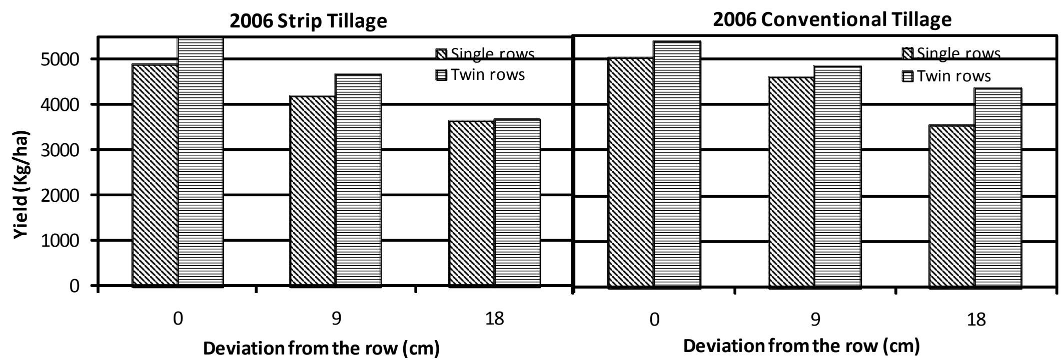

Fig. 1. Yield differences under the conditions of the peanut digger being on the target row (0 cm – RTK GPS based autoguidance system), 9-cm off the row, and 18-cm off the row.

Cost of yield losses

Cost analyses showed that less profit was earned for single row versus twin row peanuts under conventional tillage ($ 182/ha – 3-year average). Results indicated that under conventional tillage a producer could lose $171/ha and $433/ha when the digger deviates 9 cm and 18 cm on single rows compared to twin rows, respectively (Table 3). Under strip tillage, average peanut yield from the twin row and all the row deviations treatments were 520 Kg/ha less than the same treatments under conventional tillage. The low yield average under strip tillage and the small yield differences between single and twin rows compared with conventional tillage might explain the lower loss when the digger is operated off target row.

Table 3. Dollar losses on single rows respect to twin rows for different deviation from the target row at harvest.

Row Deviation (cm)	Tillage	
	Conventional	Strip

	US Dollar loss/ha (Single row - Twin Row)	
0	182	225
9	171	96
18	433	46

Table 4. Differences in Peanut Net Returns for different combinations of tillage and row pattern respect to various row deviations; average data from 2005-2007.

Row Deviation (cm)	Average Net Returns (US$)			
	Tillage			
	Conventional		Strip	
	Single	Twin	Single	Twin
0	195.19	282.75	125.98	189.24
9	94.29	181.85	25.08	88.34
18	-58.20	29.36	-127.41	-64.15

In our study, considering differences in yield between the treatments, significant differences in average net return for the combined effects of tillage and row patterns occurred as well as the interaction with row deviation were observed. Independently of the tillage conditions or row patterns, the net return decreased as the deviation from the target row increased (Table 4). When a deviation of 9 cm from the target row occurred, less return was obtained from single rows than twin rows for both tillage treatments. The producer lost money when deviations of 18 cm from the target row occurred for most of the studied scenarios. The highest losses were observed when deviations of 18 cm occurred on peanuts growing under strip tillage-single row plots. Most importantly, the highest profit was observed when the RTK GPS-based Autoguidance system was used (0 cm row deviation) (Table 4). The biggest differences in net return between the different row deviations occurred when peanuts were planted on single rows. Under conventional tillage, when RTK autoguidance system was used during peanut digging, an increase in expected net returns of US$101 (107%) and US$253.4 (335%) respect to deviations of 9 cm and 18 cm was computed. For strip tillage, when RTK autoguidance system was used during peanut harvest, an increase in expected net returns of US$101 (387%) and US$253.4 (198.8%) respect to deviations of 9 cm and 18 cm was found.

CONCLUSIONS

Yield differences between tillage and row patterns were observed with yield losses increasing as the deviation from the target row at digging increased. Peanut yield on conventional tillage was 672 Kg/ha higher than strip tillage with twin rows yielding more than 530 Kg/ha over single rows. When manual driving or non-RTKautoguidance system are used for peanut digging, deviations within a range of 9 - 18 cm might occur, therefore; a producer might expect yield losses of 15% and 32% with respect to harvest aided by an RTK autoguidance system. Similar yield losses due to deviations from the target row were observed for both conventional and strip tillage. Under conventional tillage conditions, cost analyses showed that a producer's profitability decreased as deviation from the target row increased. Although a similar trend was not observed for the strip tillage conditions, a producer might expect a reduction in profit if deviations from the target row at digging occur.

REFERENCES

Adamchuk, V.I., R.M. Hoy, G.E. Meyer, and M.F. Kocher. 2007. GPS-based autoguidance test program development. In Precision Agriculture 2007, J.V. Stafford, ed., pp.425-432, Wageningen Academic Publishers, Wageningen, Netherlands.

Beasley, E. O. 1970. Field losses of peanuts in North Carolina. J. Am. Peanut Res. Educ. Assoc. 2:78-86

Bergtold, J. S., R. L. Raper, E. B. Schwab. 2009. The economic benefit of improving the proximity of tillage and planting operations in cotton production with automatic steering. Applied Engineering in Agriculture. 25(2):133-143

Griffin, T. 2009. Whole-farm Benefits of GPS-enabled Navigation Technologies. In *Proc. 2009 ASABE Annual International Meeting*. ASABE Meeting Paper No. 095983. Reno, Nevada, June 21 – June 24, 2009.

Littell, R. C., G. A. Milliken, W. W. Stroup, R. D. Wolfinger, and O. Schabenberger. 2006. *SAS for Mixed Models,* 2nd ed. Cary, N.C.: SAS Institute Inc.

Raper, R. L., J. S. Bergtold, E. B. Schwab. 2008. Effect of row proximity to in-row subsoiled zones on cotton productivity. Applied Engineering in Agriculture. 24(5): 573-579.

Stombaugh, T.S., B.K. Koostra, C.R. Dillon, T.G. Mueller, and A.C. Pike. 2007.

Implications of topography on field coverage when using GPS-based guidance. In Precision Agriculture 2007, J.V. Stafford, ed., pp.425-432, Wageningen Academic Publishers, Wageningen, Netherlands.

Stombaugh, T.S. and S.A. Shearer. 2001. DGPS-Based Guidance of High-Speed Application Equipment. In *Proc. 2001 ASABE Annual International Meeting* .ASAE Meeting Paper No. 01-1190. Sacramento, California, USA.