EVALUATION OF THE ADVANTAGES OF USING GPS-BASED AUTO-GUIDANCE ON ROLLING TERRAIN PEANUT FIELDS

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ABSTRACT

Increased biomass from higher yielding peanut (*Arachis hypogea* L.) varieties, the use of twin rows and the expansion from conventional growing regions to more rolling terrain has made accurate peanut digging difficult even for experienced operators. Thereby, potential driving errors during digging have increased and often result in yield losses. The goal of this study was to evaluate the benefits of Real Time Kinematics (RTK) GPS-based guidance systems for planting and digging peanut fields with contoured rows and rolling terrain. During 2010 and 2011, six peanut fields under conventional and conservation tillage having contour rows and rolling terrain were selected in the southern states of Alabama and Georgia, USA. The fields were planted and inverted in utilizing two treatments: with RTK GPS-based auto-guidance and without auto-guidance (Manual-MAN). Treatment differences were calculated by comparing yields from replicated strips and by comparing yields from plots representing various degrees of row curvature. The data collected from the plots was used to test the hypothesis that yield losses decrease when using RTK GPS-based guidance as a function of row curvature. Results from a Student *t*-test indicated significant yield differences between the MAN and RTK treatments on two out of the six fields of this study. However, the RTK guidance treatment out-yielded the MAN guidance treatment in all cases except one. There was not a clear trend for yield differences between the RTK and MAN guidance treatments as the degree of row curvature decreased. These results could be associated to the within-field variability in soil texture and terrain which impacted peanut growth at the sampling locations making it difficult to relate yield differences only to the method of tractor guidance. Data from this study shows that yield losses on rolling terrain peanut fields can be reduced by using of RTK GPS-based guidance systems for planting and digging operations.

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

INTRODUCTION

The use of guidance systems aided by global positioning systems (GPS) for ground based equipment in agriculture started in the United States (US) around the mid 90’s with 5% adoption on all custom fertilizer and pesticide application equipment by 1999 (Lowenberg-DeBoer, 1999). Today, guidance system adoption on US planted acres for corn and soybeans is in the range of 15 to 35 percent (Schimmelpfennig and Ebel, 2011). Adopters of GPS guidance systems have been interested in vehicle traffic control on farming operations of planting, spraying, fertilization, tillage, harvest, and they have experience net returns up to 42.42 \$ ha^{-1} (Griffin, 2009). The adoption of several precision agriculture technologies (PAT) including GPS guidance systems differs between regions in the US and between crops. Schimmelpfennig and Ebel (2011) reported that the use of PAT for cotton production is higher than the national average in the Delta States, but is lower in the Southern Plains, Southeast, and Appalachia. In 2009, a survey conducted to precision agriculture practitioners in Alabama and the Florida Panhandle area indicated up to a 60% adoption of lightbar GPS guidance. The same survey showed that 27% of Alabama and 40% of Florida respondents were using automated guidance in 2009 and 40% intend to use RTK guidance in the next two years (Winstead et al., 2010).

Peanuts (*Arachis hypogaea* L.) production seem to be a good candidate for increased PAT usage due to the economic importance in the Southeast US (Alabama, Florida, Georgia, Mississippi, and South Carolina), with 67% of US production coming from the states of Georgia and Alabama. 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. Recent adoption of twin-row planters have increased the adoption of GPS-based auto-guidance systems because the tractor operator finds it difficult to center the equipment on the target rows since the canopy covers essentially the entire bed, making the rows less visible at harvest (Beasley, 1970). The use of guidance systems by peanut producers may have greater benefits than other row crop producers. Peanuts develop in the soil and are harvested by digging them from the ground with a digger-shaker-inverter, letting them partially dry in the field before being harvested. Therefore, peanuts can be left in the ground if the tractor driver deviates from the peanut row resulting in higher risk for yield losses. Research conducted between 2005 and 2007 in straight row peanut fields indicated that for every two centimeters row deviation from the target, an average of 186 kg ha^{-1} yield loss can be expected. The study also showed that a farmer using an auto-guidance system with an accuracy within 2.5 cm could potentially expect net returns between 94 \$ ha^{-1} and 404 \$ ha^{-1} respect to row deviations of 9 cm, and between 323 \$ ha^{-1} and 695 \$ ha^{-1} by avoiding row deviations of 18 cm.

The objective of this study was to evaluate the performance and production benefits of GPS based auto-guidance when used in peanuts grown on rolling terrain fields (steep slopes and contours). The hypothesis that the benefits of GPS-based auto-guidance systems increase as a function of the row curvature will be also tested.

MATERIALS AND METHODS

Six farmers' fields located in Henry County, Alabama (AL) and Tuner County, Georgia (GA) were selected for the study in 2010 and 2011. The two Alabama fields in 2010 were planted with the Georgia Green cultivar and the Georgia O6G cultivar in 2011 and no irrigation was supplied during the growing seasons. In Georgia, the Georgia O6G peanut cultivar was planted in 2010 and 2011, Both Georgia fields were irrigated (Table 1).

Table 1. Description of the study fields during 2010 and 2011 growing seasons in Alabama and Georgia.

Crop Year	Field ID	State	County	Area (ha)	Tillage	Planting date
2010	AL_JSF	AL	Henry	4.1	Conventional	04/29/10
	AL_MHP	AL	Henry	2.4	Strip-Tillage	05/14/10
	GA_B10	GA	Turner	4.8	Strip-Tillage	05/24/10
2011	AL_CPH	AL	Henry	2.6	Conventional	05/06/11
	AL_WGS	AL	Henry	-	Conventional	06/21/11
	GA_B11	GA	Turner	10	Strip-Tillage	05/11/11

The treatments implemented on each field consisted of peanut strips planted and inverted using two tractor guidance methods, manual (MAN) and RTK GPS autoguidance (RTK). Both treatments were imposed at random on strips of 12 rows each with a minimum of four replications per treatment-field (Fig. 1). Planting, digging, and harvesting were done with a 4-row equipment, thus each strip consisted of 3 passes of the equipment. All fields were planted in twin rows with a Monosem (Monosem Inc., Edwardsville, KS) twin row planter that had a coulter mounted in front of each individual row. The twin-row pattern consisted of outer rows 91 cm apart and 23 cm between twin rows. The same tractor was used to pull the planter and the inverter. Both tractors, a 7810 MFWD in Alabama and JD 7700 were equipped with a state-of-the-art Trimble AutoPilot® auto-steer system. Because this study was also intended to evaluate the yield differences between tractor guidance techniques respect to the degree of row curvature on rolling terrain field, before inverting the peanuts at the Alabama fields, certain sections of the two middle of each strip exhibiting various degrees of curvature (sharp vs. straight rows) were selected for manual harvest. The different degree of curvature observed from row sections were grouped in six to eight classes. For each treatment/replication, small plots (2 m wide x 9 m length) from each degree of curvature class were identified for manual harvest.

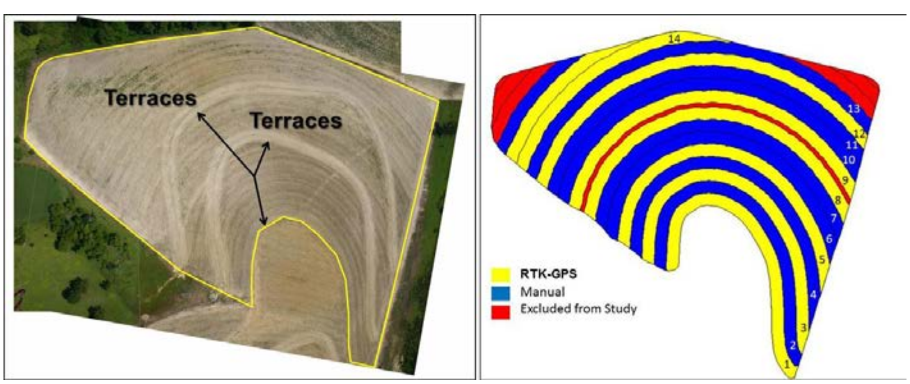

Fig 1. Example of one of the fields (GA_B10) and the treatments' layout.

For the Alabama fields, the middle two center rows of each strip plot were dug mechanically and inverted with a 4-row KMC digger/inverter (Kelly Manufacturing Co., Tifton, GA). The middle two rows of each strip were harvested and sacked with a 2-row Hustler peanut combine. The small curvature plots from the contiguous middle rows were harvested and sacked in the same manner. The plot bags of peanuts were dried to approximately 10% moisture to determine yield and total sound mature kernels (TSMK).

Yield data from the middle pass (middle 2 rows) of each strip was collected by weighing the mass of the peanuts with a weight wagon. In addition, curvature plots located in the adjacent two rows were individually harvested. For the Georgia fields, yield data were collected from the middle pass (middle 4 rows) of each strip by weighing the mass of the peanuts with a wagon pulled onto truck scales with 5 lb resolution. Statistical analyses of peanut yield and net return data were performed using Student t-test and the GLIMMIX model procedure (PROC GLIMMIX) in SAS version 9.2.

RESULTS

In Alabama, thepeanut production during 2010 was severely affected by drought., In Henry County (AL), total precipitation below the historic average values was 99 mm, 46 mm, and 18 mm for the months of July, August and September, respectively. Therefore, some of the results from this study could be confounded by the drought impact on peanut growth and yield.

The Student's *t*-test, analysis of variance (ANOVA), for the peanut yield data collected from each treatment allocated to strips spanning the length of the field's contour rows, showed significant yield differences between the manual (MAN) and RTK GPS-based auto-guidance (RTK) treatments on two out of the six fields of this study (Table 2). However, the RTK treatment out-yielded the MAN treatment in all cases except one. The 2010 drought conditions impacted the growth and development of peanuts at the AL_MHP field probably causing the contradictory treatment yield results when compared to the other five fields.

Table 2. Peanut yield as influenced by the guidance treatments for the study fields in 2010 and 2011.

Field ID	Replications per treatment	Yield (kg ha−1) Guidance treatment		Yield Difference (kg ha−1)	Student's *t*-test
		RTK GPS	Manual		
AL_JSF	4	3915	3778	137	0.4750
AL_MHP	4	3385	3504	-119	0.1978
GA_B10	7	5837	5249	588	0.0198
AL_CPH	4	3944	3916	28	0.7860
AL_WGS	5	1775	1692	83	0.3733
GA_B11	10	6360	5955	405	0.0175

There was not a clear trend for yield differences between the RTK and MAN guidance treatments as the degree of row curvature decreased (Table 3). The curvature plot data collected from four of the study fields was not very conclusive to accept the hypothesis of higher yield gain using RTK GPS-based guidance system as the row curvature decreases (sharp and concave curves). However, for the AL_CPH field, curvature class 3; and AL_WGS, curvature class 2, significant differences between the RTK and MAN guidance treatments existed contrasting with no differences between the treatments on curvature class 8 (straight row sections) for the same fields. The yield gain on the RTK treatment for the AL_CPH field, curvature class 3; and AL_WGS, curvature class 2 was 755 kg/ha and 239 kg/ha, respectively (Table 3). The within-field variability of terrain and soil texture observed in the fields selected for this study may have masked the differences between the guidance treatments associated with curvature. Because a yield gain in the RTK treatments with respect to the MAN treatment was observed in most of the row curvature classes, all the row curvature classes' plots were grouped by guidance treatment and an Student *t*-test was conducted to evaluate differences between guidance treatments. Significant differences (P = 0.1) between RTK and MAN treatments was observed in the AL_JSF and AL_WGS fields.

Data from this study showed that, the yield gain on areas where the RTK GPS-based guidance system was used for planting and digging operations ranged from 28 kg/ha to 588 kg/ha (Table 2). Therefore, if we assumed an area of 73 ha planted in peanuts by a farmer in either Alabama or Georgia and a selling price of $US 950/ton; a financial gain of between $2,140 and $44,950 might be expected as a result of using RTK GPS-based guidance for planting and inverting peanuts.

CONCLUSIONS

Yield differences between RTK GPS-based and manual guidance were observed on rolling terrain fields with lower yield on most of the areas planted and inverted using manual guidance. Peanut average yield increase on areas (strips) planted and dug/inverted using the RTK GPS-baseed guidance system ranged from 28 kg/ha to 588 kg/ha when compared to manual guidance in six fields where the study was conducted. There was not a significant trend for higher yield on RTK GPS-based guidance plots as the row of curvature (sharp curves) decreased compared to manual guidance. Those results might be associated to high within-field soil texture and terrain variability affecting peanut growth which could confound the effect or differences between guidance systems.

Table 3. Peanut yield comparison of guidance treatments by degree of row curvature measured at the Alabama fields in 2010 and 2011.

Field ID	Row curvature class†	Yield (kg/ha) Guidance treatment		Difference estimate	Contrast *Pr* > |t|
		RTK GPS	Manual		
AL_JSF	2	4548.54	3666.45	882.09	0.2512
	3	4005.02	3048.87	956.15	0.1368
	4	3116.02	3407.51	-291.49	0.6787
	5	3867.08	3195.12	671.96	0.3052
	6	3833.86	3343.22	490.64	0.4622
	Ho: Guidance treatments have equal yield				*P* = 0.0875
AL_MHP	2	3420.7	2838.66	582.04	0.1713
	3	2946.65	3404.29	-457.64	0.3447
	4	2239.74	3563.85	-1324.11	0.0099
	6	2838.66	2878.49	-39.83	0.9130
	Ho: Guidance treatments have equal yield				*P* = 0.1736
AL_CPH	2	3614.62	3566.95	47.67	0.9340
	3	4498.79	3743.98	754.81	0.0546
	4	3530.7	4510.01	-979.31	0.2035
	5	4331.35	3197.37	1133.98	0.0597
	6	3989.66	4020.32	-30.66	0.9467
	7	4035.12	3737.07	298.05	0.5917
	8	4713.48	3820.73	892.75	0.1362
	Ho: Guidance treatments have equal yield				*P* = 0.1595
AL_WGS	2	1572.83	1333.55	239.28	0.0503
	3	1430.23	1335.37	94.86	0.4657
	4	1347.12	1357.6	-10.48	0.9721
	5	2190.77	1922.42	268.35	0.4414
	6	1759.39	1300.53	458.86	0.1120
	8	2279.37	1811.82	467.55	0.1291
	Ho: Guidance treatments have equal yield				*P* = 0.0233

† Two middle rows of each strip were selected to manual harvest of plots/sections 9 m long which have different degree of curvature. The curvature class numbers exemplify sharp row curvature sections (classes 2 and 3) to straight or none curvature (classes 6 – 8).

ACKNOWLEDGEMENTS

Keith Barnette, Mirion Johnson, Chris Parker, our grower-partners for this study. Trimble provided state-of-the-art AgGPS Autopilot systems for both the Alabama and Georgia studies as well as technical support during planting and inverting. Special thanks to Adam Anderson and Robbie Tab from Ag Technologies, Cordele, Georgia, for their steady and consistent support of the Georgia study.

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