Journal of Agricultural Science and Engineering
Vol. 6, No. 3, 2020, pp. 38-42
http://www.aiscience.org/journal/jase
ISSN: 2381-6821 (Print); ISSN: 2381-6848 (Online)

Effect of Different Speeds on the Performance of Tractor with Ridger by Using Automatic Steering System Under Field Conditions

Ayman Hassan Suliman[1], Hithum Abd Albagy Alobied Babiker[2], Abdulsalam Mohammed Ali Yhia Omer[3, *]

[1]Department of Agricultural Engineering, Faculty of Natural Resources and Environmental Studies, University of Alsalam, Al Fula, Sudan
[2]Senior Mechanical Engineering, Central Workshop, Kenana Sugar Company, Kenana, Sudan
[3]Department of Agricultural Engineering, Faculty of Agriculture and Natural Resources, University of Kassala, Halfa-elgadida, Sudan

Abstract

A field guidance system is required to keep field equipment operating only on the predetermined paths. Ridging can be fully implemented with an automatic guidance system for agricultural vehicles. An experiment was carried out in the farm of Kenana Sugarcane Company in November 2019. The objective was to study the effect of speed on the performance of Tractor with Ridger by using automatic steering under field conditions. A Case Tractor was equipped with Auto-guidance system (Trimble receiver). The treatments consisted of three forward speeds (6.5, 8.5 and 10 km/h). The experiment was laid out in a complete randomized block design (CRBD) with three replications. The cross-track error (cm) was determined to investigate the precision and accuracy of the auto-guidance system. Performance variables namely effective field capacity (ha/h), field efficiency (%) and fuel consumption (l/h) were also calculated. The results of the analysis showed that the cross-track error, effective field capacity and fuel consumption were significantly affected by tractor forward speeds. Increasing of operating speed from 6.5 km/h to 8.5 km/h then to 10 km/h led to increase in the cross-track error from 4.67 to 5.33 to 6.2 cm, respectively, effective field capacity from 3.9 to 5.1 to 6 ha/h, respectively, and fuel consumption from 3.13 to 4.27 to 5.17 l/h, respectively. In contrast, the field efficiency was not significantly affected by the tractor forward speeds. Furthermore, it decreased by increase of tractor forward speed from 6.5 km/h to 10 km/h. It can be concluded that the tractor forward speed was the major factor affecting the steering accuracy.

Keywords

Auto-guidance, Cross-track Error, Precision Agriculture, Effective Field Capacity

Received: September 19, 2020 / Accepted: October 28, 2020 / Published online: November 23, 2020

1. Introduction

With the world's population increasing, there is more and more emphasis on food production. Farm machinery and food production go hand in hand so the machinery we use needs to be more precise and more productive to meet the world's demands. Precision agriculture (PA) is a smart farming system that helps farmers collects information and data for better decision making. PA requires the use of inventive data on environmental and soil conditions. Then farmers use collected information to add precision to the quantity, quality, timing and location in the application and use of agricultural inputs. PA covers four key information communication technologies (ICTs): location determination via Global Positioning System (GPS); Geographic Information System (GIS); computer-guided controllers for

* Corresponding author
E-mail address: salamyahia86@gmail.com (A. M. A. Y. Omer), aymanhassan09@yahoo.com (A. H. Suliman), haytham.abdelbagi@kenana.com (H. A. A. A. Babiker)

variable rate application (VRA) of crop inputs; and sensing technologies for automated data collection and mapping [9]. Automatic tractor guidance defined as accurate automatic control of the tractor or implement along a predefined trajectory. The need for automatic control of agricultural machinery systems to increase the efficiency of field operation has been recognized for a long time. The major part of an automatic guidance system is the sensor to obtain positioning information. Sensors with a controller can successfully guide agricultural vehicles along predetermined paths. Precision steering systems for tractors and agricultural machines play a very important role in precision agriculture [10]. There are two basic approaches to automatic steering. In the first approach, the vehicle's surroundings are analyzed with the use of cameras, digital analysis and image processing methods [5]. The second approach relies on GPS navigation [15]. Automatic steering has numerous advantages, including repeatable path tracking, making full use of machine's operating width, reducing overlaps and easier operation during low visibility conditions. The operator of an automatically steered vehicle can fully control the quality of the farming operation [8]. Ridging in the sugarcane crop considers one of the most important operations, in which carried out by using ridger. Ridges are meant to dispose of excess surface water, and keep the roots above a water table or impervious layer [11]. Other advantages of growing cane on a ridge include favourable water and temperature environment for the roots [6], increased root development and erosion control [13]. The accuracy of steering control with the algorithm depends upon the accuracy of position measurement, error sampling rate and tractor forward speed. The tractor forward speed is the major factor affecting steering accuracy [17]. For getting the best out of the auto-guidance system in terms of guidance response and accuracy the following components should be considered such as auto-guidance application, implement set up and operation. When adapting auto-guidance to a particular farm operation, it is necessary to understand the positioning error. Also, the ability to maintain a desirable geometric relationship between passes is affected by vehicle dynamics, the ability of the field implement to track straight behind the vehicle, and the actual conditions of the field surface (rough, muddy, sloped, etc.) [1]. The purpose of an automatic guidance system is to control the tractor front wheels so that the implementation follows a predetermined path. The performance data of auto-guidance for different agricultural operations that is in ground-based is required. Therefore, the objective of this study is to study the effect of speed on the performance of the tractor with ridger by using automatic steering under field conditions.

2. Materials and Methods

2.1. The Study Area

A field experiment was carried out in November 2019 in Kenana (located at the intersection of latitude 13° 10' N and longitude 33° 40' E with an altitude of 410 m above sea level, on the east bank of the White Nile 300 km south of Khartoum) in field 121 07. The climate of the area is tropical with high temperature during summer and low temperature during winter. Average annual rainfall is 400 mm occurs in the period from late June to early October. The soil is heavy clay characterized by excessive swelling when wet and cracking when dry [2].

2.2. Experimental Procedures

A field experiment was conducted to study the effect of speed on the performance of the tractor with ridger equipped with an automatic guidance system under field conditions. The average slope was less than one per cent. A Case IH tractor (210 hp) and the four-body ridger (1.5 m spacing and operating width of 6 m) were used. Auto-guidance system in this study was based on Trimble receiver satellite navigation system (AFS Pro 700 AFS AccuGuide Auto guidance System AFS Row Guide Software). The GPS receiver antenna was mounted at the centre of the cabin roof. The accuracy based on real-time kinematic (RTK). The pass-to-pass accuracy or cross-track error (the distance between passes made over the same track in the opposite direction) was ≤ 5 cm. The operating route in the field programmed by the operator by using A and B points method. The guidance system was tested for the straight-line path; the tractor was operated at three travel speeds of 6.5, 8.5 and 10 km/h. The ridger depth was adjusted to be 10 cm at all speeds. Regarding the performance of auto-guidance system the cross-track error (pass-to-pass error) which based on a sensor system was identified by recording the number incidents as displayed on the touchscreen console (monitor) (Figure 1), and then it was calculated. As well as the technical performance namely effective field capacity (ha/h), field efficiency (%) and fuel consumption (l/h) were determined. The effective field capacity and fuel consumption were also obtained from the screen monitor. While the field efficiency was calculated using the following equation was stated by Hanna [7].

$$\mathrm{FE} = \frac{EFC}{TFC} \times 100 \tag{1}$$

Where:

FE = field efficiency, %.

EFC = effective field capacity, ha /h.

TFC = theoretical field capacity, ha /h.

The Theoretical field capacity (ha/h) as stated in the above equation is calculated using the following equation introduced by ASABE [4].

$$\text{TFC} = \frac{W \times S}{C} \tag{2}$$

Where:

TFC = Theoretical field capacity, (ha/h).

S = Speed, (km/h).

W = Width of implement, (m).

C = Constant, (10).

The experiment design was a randomized complete block design with three replications. The tractor operating speeds (6.5, 8.5 and 10 km/h) were set as treatments. The plot size was 6.2 m wide and 200 m long.

2.3. Statistical Analysis

The collected data were analyzed using Statistix 8 software program for analysis of variance and means separation.

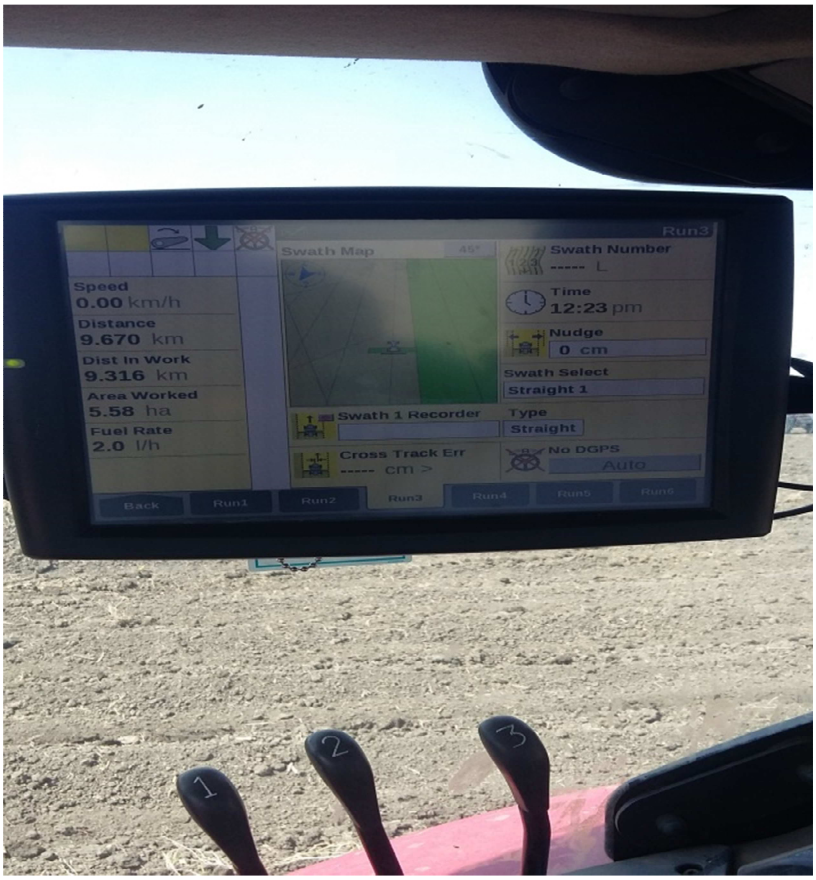

Figure 1. Touch screen console.

3. Results and Discussion

3.1. Auto-guidance Performance (Cross-Track Error)

The effect of forwarding speed on the cross-track error (pass-to-pass error) showed in Figure 2. The cross-track error significantly affected by tractor travel speed. The speed 10 km/h recorded the highest value of cross-track error 6.2 cm, while the lowest value of 4.67 cm recorded at speed 6.5 km/h. both values of cross-track error at speed 6.5 km/h and speed 8.5 km/h are within the range of prescribed accuracy level. The cross track error increased with speed increase, this because tractor travel speed one of the factors that effect on accuracy of auto-guidance, also this increase could be attributed to inappropriate land preparation. Similar observation was reported by Adamchuk et al [1].

3.2. The Technical Performance Variables

3.2.1. Effective Field Capacity

Table 1 shows that there was significant difference ($P \leq 0.05$) ineffective field capacity among different tractor travel speeds. The highest value of effective field capacity obtained at speed 10 km/h was 6 ha/h, while the lowest value of 3.9 ha/h obtained at speed 6.5 km/h. It is obvious that effective field capacity increased with the speed increase, and this could be attributed to the positive relationship between them.

This agreed with the observation of Muhsin [12] and Al-jubory [3].

3.2.2. Field Efficiency

The effect of tractor travel speeds on the field efficiency didn't give any significant difference Table 1. There was a trend to increase in the field efficiency at the speed 6.5 km/h is 95% followed by the speed 8.5 km/h is 94%. The result indicated that the time utilization factor was high. This can be attributed to the advantage of using the auto-guidance system in terms of reducing the time required to overlap and for turning on the ends of the field as compared to the manual steering system.

3.2.3. Fuel Consumption

Fuel consumption of tractor was significantly affected (P ≤ 0.05) by the tractor forward speed Table 1. The highest value of fuel consumption obtained at speed 10 km/h was 5.17 l/h followed by 4.27 l/h at speed 8.5 km/h, while the lower value of fuel consumption was 3.13 l/h recorded at speed 6.5 km/h. The fuel consumption of tractor increased with the speed increase, this may be due to the increase in tractor forward speed led to increase in engine speed, and then, as a result, the amount of fuel consumption increased. Similar findings were observed by Ramesh et al. [14] and Taha [16].

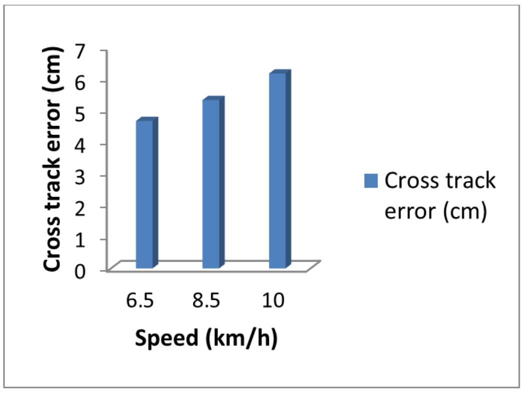

Figure 2. Effect of the tractor forward speed on the cross-track error.

Table 1. Effect of tractor forward speed on effective field capacity, field efficiency and fuel consumption.

Treatments Speed (km/h)	Effective field capacity (ha/h)	Field efficiency (%)	Fuel consumption (l/h)
6.5	3.9 c	95 a	3.13 b
8.5	5.1 b	94 a	4.27 ab
10	6 a	93.3 a	5.17 a
L.S.D 0.05	0.06	1.99	1.92

Means share a same superscript letter are not significantly different as separated by LSD test at 0.05 level of significance

4. Conclusions

It can be concluded from this study, the cross-track error significantly affected by tractor forward speed, it was increased by increasing the tractor forward speed. Regarding the technical performance, the actual field capacity was significantly increased by increasing the tractor forward speed. The field efficiency was decreased by increasing the tractor forward speed. The fuel consumption was significantly increased by increasing the tractor forward speed. Operating speed for different field operations should be determined to attain an optimal performance of the auto-guidance.

References

[1] Adamchuk, V. I., Stombaugh, T. S. and Price, R. R. (2008). GNSS-Based Auto-Guidance in Agriculture. Site-Specific Management Guidelines (SSMG) series. The International Plant Nutrition Institute (IPNI). SSMG-46.

[2] Adam, A. I. (1976). Semi-detailed soil survey report of Kenana Sugar Project. Soil Survey Administration, Sudan. In: Proceeding of the 5th International Soil Classification Workshop, Khartoum, Sudan, PP 77-96.

[3] Al-jubory, R. A. (2010). Effect of two plows, soil moisture and practical speed on some performance parameters and soil physical properties. Babel Journal. Vol, 16.

[4] ASABE. 2006. ASABE Standards: Agricultural Machinery Management Data. ASAE EP496.3 FEB2006. St. Joseph, Mich.: ASABE. http://asae.frymulti.com/standards.asp.

[5] Bayar, G., Bergerman, M., Koku, A. B., and Konukseven, E. I. (2015). Localization and control of an autonomous orchard vehicle. Computer and Electronics in Agriculture. 115, 118-128.

[6] Buchele, W. F, Collins, E. V and Lovely, W. G. (1985). Ridge farming for soil and water control. Agric Eng 36: 324-329.

[7] Hanna, M. (2002). Estimating the field capacity of farm machinery. Iowa State University. Extension service. Machinery management series. PM-696, File Engineering 3-1, and Economics 1-8. pp: 1-4. Ames, Iowa.

[8] Holpp, M., Kroulik, M., Kviz, Z., Anken, T., Sauter, M. and Hensel, O. (2013). Large-scale field evaluation of driving performance and ergonomic effects of satellite-based guidance systems. Biosystems engineering, 116 (2), 190-197.

[9] ICT Update. 2018. Technical Centre for Agricultural and Rural Cooperation ACP-EU (CTA), Wageningen. Issue 86.

[10] Jingato, H., Lei, G., Xiaoping, B., Taochang, L., and Xiaoguang, L. (2015). Review of research on automatic guidance of agricultural vehicles. Transactions of the Chinese society of agricultural engineering. 31 (10), 1-10.

[11] Meyer, J. H., Dewey, F. J. and Wood, R. A. (1988). Improving the quality of soils derived from Middle Ecca, Dwyka and Beaufort sediments. ProcS AfrSugTechno! Ass 62: 215-220.

[12] Muhsin, S. J. (2017). Performance study of moldboard plow with two types of disc harrows and their effect on some soil properties under different operating conditions. Basrah J. Agric. sci., 30 (2): 1-15.

[13] Radke, J. K. (1982). Managing early season soil temperatures in the northern Corn Belt using configured soil surfaces and mulches. Soil Sci. Soc. Am. J 46: 1067-1071.

[14] Ramesh, B., Palled, V., Veeranouda, M., Sushilendra, Nidoni, U. and Anantachar, M. (2014). Dynamic Performance of Agricultural Tractor Fuelled with Karanja Biodiesel Blends for Tillage Operation. International Journal of Engineering Sciences & Research Technology. 1565-1574.

[15] Roberson, G. T. and Jordan, D. L. (2014). RTK-GPS and automatic steering for peanut digging. Applied engineering in agriculture, 30 (3), 405-409.

[16] Taha, F. J. (2011). Performance of Chisel Plow under Tillage Depths and Tractor Speed. The Iraqi Journal of Agricultural Sciences 42 (5): 67-72.

[17] Young, S. C., Johnson, C. E. and Schafer, R. L. (1983). A vehicle guidance controller. Transactions of the ASAE 26 (5); 1340-1345.