Evaluation of a Light Bar for Parallel Swathing Under Different Forward Speeds

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Comentário:

Abstract

The quality of ground application depends on a correct guidance. An equipment called light bar is replacing conventional guidance methods in parallel swathing. The purpose of this research was to evaluate the guidance accuracy of a Trimble© light bar model under different forward speeds. Results showed that the accuracy of the guiding system obtained with the light bar does not change significantly when the vehicle speed is increased from 1.39 m.s^{-1} (5.0 km^{-1}) to 5.55 m.s^{-1} (20 km^{-1}). Mean errors were similar at different distances between the rows. A 20 m distance was enough to align the vehicle.

Keywords: Precision Farming, Light Bar, DGPS.

Introduction

A lot of operations in precision agriculture depend on accurate positioning, directly influencing the quality of the agricultural operations. The use of DGPS (Global Differential Positioning System) as a positioning system is the most common available at present in precision agriculture. The use of DGPS, however, is not limited to determining and recording the position of the vehicle; it could be used as a guide for the vehicle in applications in parallel strips to eliminate flaws or overlaps among consecutive passages (TORRES et al., 2000). The conventional methods include demarcation techniques with flags in regular intervals, foam markers or disks markers.

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MOLIN & RUIZ (2000) showed that the light bar, which consists of luminous signs in front of the operator, is being proposed to substitute the conventional methods in the application of chemicals, fertilizers and seeds. TORRES et al. (2000) compared the use of light bar with foam marker in a self-propelled sprayer. The mean error of alignment obtained for the light bar was of 0.14 m, while the foam marker system registered a mean error of 0.67 m. VETTER (1995) evaluated an orientation system for light bar in terrestrial applications. The evaluation showed that in 50% of the observations the error was smaller than 0.38 m and in 90% of the observations, the error was smaller than 0.89 m. According to BUICK & WHITE (1998), the light bar can substitute the foam marker in agricultural operations.

The purpose of the present study was to evaluate the accuracy of the alignment obtained with the use of a Trimble light bar model under different forward speeds. The necessary distance for the accomplishment of headboard maneuvers was also determined.

Material and Methods

The test was accomplished in September of 2000 on an experimental field at the University of Sao Paulo, whose approximate coordinates are 22^{o} 42’ S and 47^{o} 37’ W.

A Trimble© DGPS receiver, model AG 132 was used for the vehicle positioning. The light bar utilized was the AgGPS Parallel Swathing Option (Figure 1a), from the same company. The vehicle used was a agricultural tractor, model MF 296, by AGCO© company.

For monitoring the speed it was used a Hohner© encoder installed on the front wheel of the tractor. The analogic signal coming from the sensor was sent to an A/D converter which transmitted the digital signal to a Notebook Pentium© 166 MHz that contained a software developed in C language, which converted the information coming from the rotation of the front wheel into instantaneous speed.

To mark the ground where the vehicle was passing, it was used a flat vertical coulter disk fixed to an articulated fork, which was attached to the three-point hitch of the tractor (Figure 1b), according to MOLIN & RUIZ (2000).

The vehicle was conducted by two different operators without experience about using the light bar, so it was necessary a previous training with them before doing the test. The statistical delineation used was the randomized complete-block in a 2x4x12 factorial experiment, with 2 replications for each treatment. The first factor was the operator with two levels: operators 1 and 2. The second factor studied was the speed of the vehicle, with four levels: 1.39 $m.s^{-1}$ (5 $km.h^{-1}$) (V1), 2.77 $m.s^{-1}$ (10 $km.h^{-1}$) (V2), 4.16 $m.s^{-1}$ (15 $km.h^{-1}$) (V3) and 5.55 $m.s^{-1}$ (20 $km.h^{-1}$) (V4). The third factor studied was the position of the trajectory measuring the errors at 12 positions: 10, 20, 30, 40, 50, 85, 135, 170, 180, 190, 200, 210 meters from the beginning of the row (point A). The variable measured was called error, in meters. The statistical analysis of the results was done with the SAS© software.

The operators began the course aligned and stopped. The initial alignment on each swath was done on a marked trajectory about 20 meters after and before de points A and B of the reference alignment. The area of the test was marked in fourteen positions along a basic alignment (line AB), took as reference. The points A and B of the basic alignment were used as reference for configuring the light bar. The other twelve positions of the basic alignment were used as reference for placing an electronic distance measuring instrument (EDM) Pentax©, model PX-06D, that measured the distances between the alignment AB and the lines marked on the ground by the tractor oriented by the light bar. The light bar was configured to make equidistant swaths 5 m wide, resulting in 16 passes. The intervals between the leds were configured to 0.33 m.

Results and Discussion

The Figure 2 illustrates the path of each swath of operator 1 guided by the light bar at different speeds ($m.s^{-1}$) in relation to the reference alignment. It was verified for this situation that the maximum error obtained was 1.0 m to the right (positive errors) and 1.4 m to the left (negative errors) of the reference alignment. A deviation to the left from the reference alignment was observed in the end of the field.

The Figure 3 illustrates the path of each swath of operator 2 in relation to the reference alignment. It was observed a maximum error of 1.7 m to the right (positive errors) and 1.6 m to the left (negative errors) of the reference alignment. A tendency of left deviation was also observed in relation to the reference (negative errors) in the end of the field.

A relative frequency of the error (%) is shown for each class of error (m) at the different speeds for operators 1 (Figure 4) and operator 2 (Figure 5). There is a tendency of a normal distribution of errors for both operators, except a pick frequency about 54% of errors smaller than 0.5 m for the operator 1, at speed of 1.39 $m.s^{-1}$ (5 $km.h^{-1}$). It is observed that the largest error frequency was about 0.5 m of the reference alignment (positive errors to the right and negative errors to the left from the reference alignment).

The original errors of alignment data obtained in the test with the light bar were transformed by the Equation 1, providing larger homogeneity of the variance.

$$e_1 = (e_0 + 0.5)0.1 \qquad (1)$$

Where: e_1 = value of the transformed error; e_0 = value of the original error.

As presented on Table 1, F test from analysis of the variance proved that there was not statistical significant difference for interactions among means of the treatments; also, there was not statistical difference between the treatments, with 5% and 1% of probability.

The mean error of the operator 1 treatment obtained with the light bar was 0.447 m, while in the operator 2 treatment the mean error was of 0.397 m. It is observed that the numeric value of the mean error obtained with the operator 2 was smaller, however there was not any statistical difference between the treatments, as it is illustrated in the Table 1. The mean error obtained in the 1.39 $m.s^{-1}$ (5 $km.h^{-1}$) treatment was 0.380 m, 2.77 $m.s^{-1}$ (10 $km.h^{-1}$) was 0.476 m, 4.16 $m.s^{-1}$ (15 $km.h^{-1}$) was 0.454 m and 5.55 $m.s^{-1}$ (20 $km.h^{-1}$) was 0.380 m. However, there was not statistical difference at the level of 5% of probability between these treatments, as it is illustrated in the Table 1; also the speed did not influence the accuracy in the alignment produced by the light bar. In the same way, there was not statistical difference at the level of 5% of significance for the mean errors measured in different positions along the swaths. It means that the mean errors measured at any point of the field is statistically the same, being enough the additional strip of 20 m previous to the initial point of the alignment, used for the pre-alignment of the vehicle with the light tested.

Conclusions

The accuracy of the alignment obtained with the light bar did not improve with the increase of vehicle speed. Both operators presented similar errors in alignment. The mean errors in the measured positions along the swaths were equal. The initial distance of 20 m for the pre-alignment of the vehicle is enough for applications with the light bar.

References

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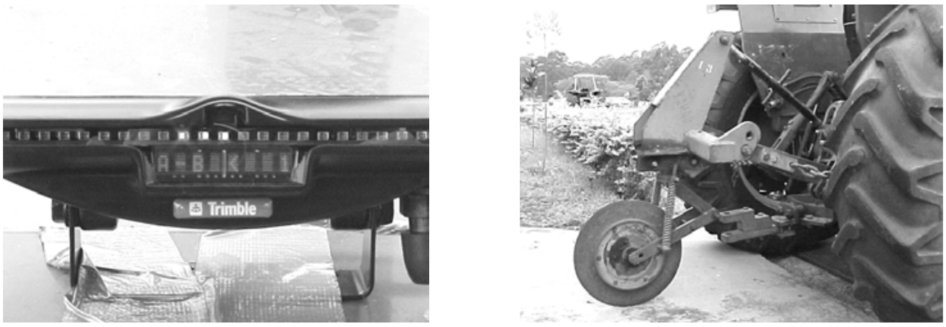
Tables

Causes of Variation	Degree of Freedom	Sum Squares	Mean Square	F Test	Probability > F
Statistical Model	95	0.1147	0.0012	0.83	0.8133
Residue	96	0.1392	0.0014		
Total	191	0.2538			

TABLE 1. Analysis of the variance from the transformed data of alignment errors obtained in the test with the light bar.

Figures



(a) (b)

FIGURE 1. Light bar (a) and the flat vertical coulter disk used to mark the ground (b).

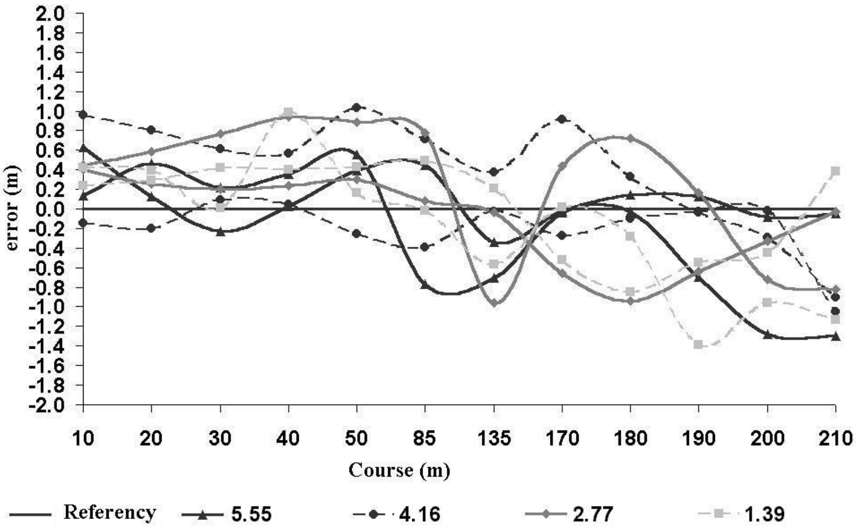


FIGURE 2. Path of each swath of operator 1 guided by the light bar at different forward speeds ($m.s^{-1}$) in relation to the reference alignment.

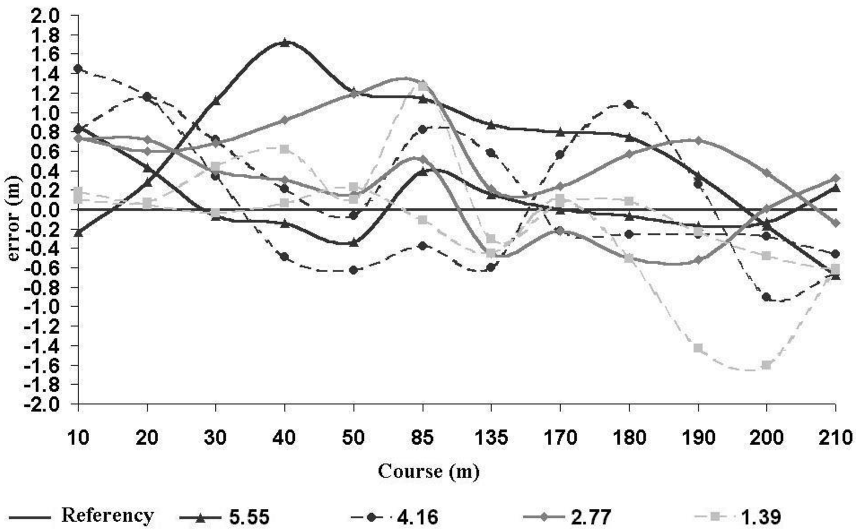


FIGURE 3. Path of each swath of operator 2 guided by the light bar at different forward speeds ($m.s^{-1}$) in relation to the reference alignment.

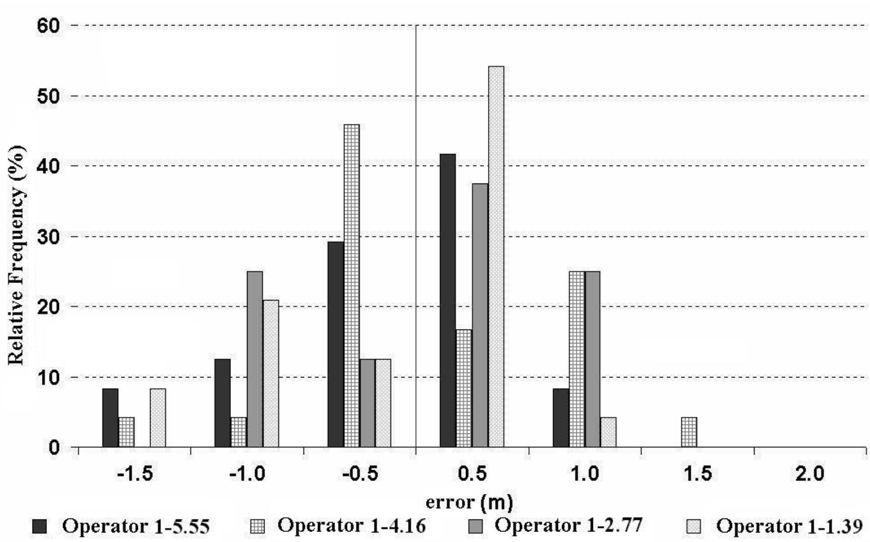


FIGURE 4. Relative frequency of errors (%) for each error class (m) at different forward speeds ($m.s^{-1}$) for operator 1 guided by the light bar.

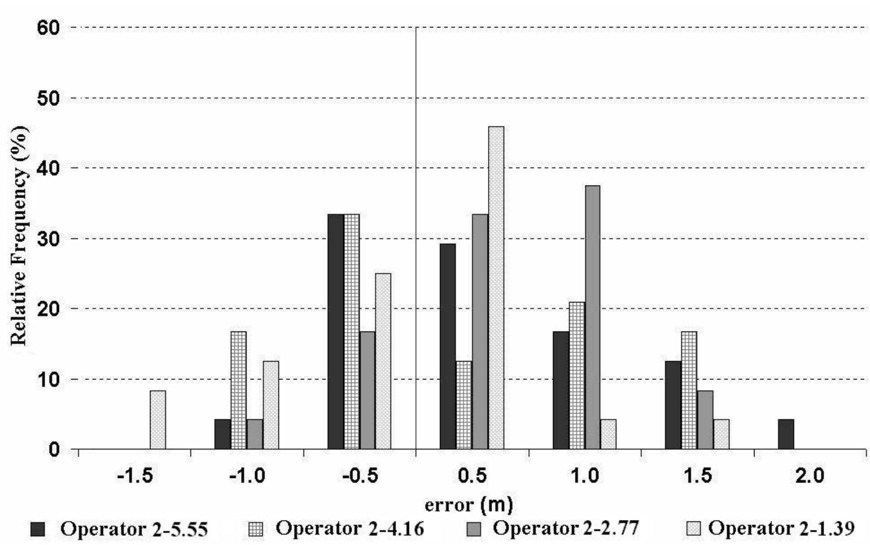


FIGURE 5. Relative frequency of errors (%) for each error class (m) at different forward speeds ($m.s^{-1}$) for operator 2 guided by the light bar.