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DISTRIBUTION OF MAIZE SEED IN A SEEDING LINE PROTOTYPE USING MICROCONTROLLED DATA ACQUISITION SYSTEMS

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ELTON F. DOS REIS[1*], ANTÔNIO C. BORGES NETO[2], RÓDNEY F. COUTO[2]

[1*]Corresponding author. State University of Goias - UEG/ Anápolis - GO/ Brazil. E-mail: fialhoreis@ueg.br

ABSTRACT: The aim of this study was evaluate the longitudinal distribution of maize seeds using a seeding line prototype, whit a microcontroller data acquisition system, at different speeds and types of horizontal feeder discs. Initially it was constructed a prototype simulator of seeding line, in the laboratory, and mounted two systems of microcontroller data acquisitions with infrared sensors for maize seeds counting. A test was conducted in a completely randomized design in split plots with factorial scheme of treatments 5 x 2 x 2, being the parcel two types of microcontroller data acquisition systems (infrared sensors in parallel and an diffuse infrared sensor), the factors were two feeder discs of maize seeds (inclined and normal) and five sowing speeds (3.0, 4.0, 5.0, 6.0, and 8.0 km h^{-1}), with three replications, totaling 60 plots. The results showed that the data acquisition systems presented efficiency higher than 93% in the perception of the seeds. The lower speeds provided a seed distribution closer to the desired. The spacing average error between seed with the microcontroller data acquisition system with diffuse sensor was 0.0206 meters and the system with infrared sensors in parallel was 0.0158 meters.

KEYWORDS: sensor, microcontroller, horizontal disc.

INTRODUCTION

Increasingly, in agriculture, the automation makes possible the monitoring of systems and environments, through sensors with a wide variety of purposes, allowing having computational basis for that the collected data could be analyzed and, thus, give support to the decisions-making.

The application of automation can contribute to agriculture to improve quality, reduce losses, increase productivity, reduce costs and decrease the return time to the investment, planning and decision making as well as reducing the impact to the environment, facilitating the work and increasing the quality of life of the producer, aiming at a greater competitiveness (Teruel, 2010).

In the sowing operation, one of the contributions that the automation can propose is the possibility of monitoring the regularity of the sowing process in a way that can improve the final yield of the crop. As pointed out by Ros et al. (2011) the sowing is one of the stages that require greater perfection in its execution, as it may compromise the profitability of agricultural activity. The failures of the sowing process are difficult to detect at the time of the task execution, in a way that it will only be noticed after the germination, which makes the correction unfeasible and compromises the final productivity.

According to Storck et al. (2015), a proper population allied to the uniform distribution of longitudinal maize plants in the line, are necessary aspects to reach high productivity.

In the precision sowing the feeder mechanism of the seeder has as function the regular dosage of the seeds within the seeding line, with pre-defined spacings (Jasper et al., 2011; Mao et al., 2015; Weirich Neto et al., 2012).

Silva & Gamero (2010) state that speed is one of the main factors that interferes with the quality and operational performance during sowing. Because of these obstacles, the authors commented that the seeder-fertilizers have undergone modifications in order to improve the

[2] State University of Goias - UEG/ Anápolis - GO, Brazil.
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efficiency of longitudinal distribution, as well as to positively influence the productivity of the crops.

With an increase in the average power of the models of agricultural tractors, the operational speed used in sowing could be higher, if it was not for the limitation of the feeder mechanisms. Concerned about the robustness, national manufacturers practically ignored the need to improve the feeder mechanisms, especially those to operate at high speeds without damaging the seeds (Mialhe, 2012).

Aiming at a proper plant stand, it is necessary that the seeds are dosed correctly, which leads to the use of precision feeder mechanisms, which deposit these at a pre-established seeding density according to the recommendation of each crop. Among the different types of feeder mechanisms, the most important are of horizontal alveolar discs and the pneumatics (Dias et al., 2014).

The maize is highly sensitive to plant population variations, line spacing, to emergency uniformity and to uniform distribution of plants in the line, as it has limited plasticity (Sangoi et al., 2011, 2012).

The regulatory standard project NBR 04:015.06-004 considers acceptable or normal spacings between seeds of 0.5 to 1.5 times the expected average spacing, with requirements of regularity of longitudinal distribution. Thus, for example, for spacing between seeds idealized to be 0.02 m, are considered failures spacing between plant greater than 0.03 m and, multiples or doubles those below 0.01 m (ABNT, 1994).

The so-called mechanization costs represent the second component of the cost of production in rural activity, losing only to inputs. Therefore, in the properties that use mechanization in the production, the monitoring of the work done by agricultural machines and implements should deserve more attention (Sichonany et al., 2011). An adequate purchase of agricultural machinery is not enough if its use is not monitored in operational and financial aspects (Piacentini et al., 2012).

The objective of this study was to construct a seeding line simulator prototype, in a laboratory, to evaluate different types of horizontal feeder disks of maize, at different speeds, using a microcontroller data acquisition system.

MATERIAL AND METHODS

The construction of the seeding line prototype, as well as the data acquisition systems, and the execution of the tests were carried out at the Laboratory of Prototypes of Agricultural Machines of the Agricultural Engineering course at the University of the State of Goiás, Anápolis-GO.

Initially a prototype was built, with a conveyor belt, which allowed the simulation of a seeding line at different speeds. In order to the microcontroller data acquisition systems realized the monitoring of the passage of the seeds, by the seed tube of the seeding line, were used microcontrollers of the Arduino project and infrared sensors. The perception by reflection of the diffuse sensor or the interruption of the light beam between the emitter and the infrared receiver generated a signal to the microcontroller when the seed passes. These data were transferred to a computer that registered the number of seeds and the time of fall for later analysis.

The data acquisition system with diffuse sensor was assembled using a sensor of the Metaltex brand with a capture field of up to 0.40 meters. The microcontroller data acquisition system with infrared sensors, in parallel, was assembled using four sets of infrared emitters and receivers, in radial arrangement, inside the seed passageway.

To perform the test, the seed distribution system was regulated for maize cultivation so that it distributed 7 clean seeds and classified per meter with spacing of 0.14 meters between seeds.

In the seeding line simulator prototype, were used normal horizontal and inclined discs for maize seeds.

In order to evaluate the efficiency of the feeder discs and microcontroller data acquisition systems at the different displacement speeds of the set, regarding to the regularity of maize seed distribution, a completely randomized design was used, in slip plots with a factorial scheme of 5 x 2 x 2 treatments, being the plots two types of microcontroller data acquisition systems (Infrared sensors in parallel and a diffuse infrared sensor), the factors the two feeder discs of maize seeds (inclined and normal) and five seeding speeds (3.0, 4.0, 5.0, 6.0, and 8.0 $km.h^{-1}$), in three replications, totaling 60 plots.

The data were submitted to analysis of variance by the F test, at 5% probability and, when there was a significant difference between the treatments, their average were compared by the Tukey Test, also at 5% of probability, using the Software SISVAR (Ferreira, 2011).

RESULTS AND DISCUSSION

The analysis of variance of the variables: multiple spacings, acceptable spacings, failure spacing, seeds total and sensor spacing error is presented in Table 1. It can be seen that the multiple spacings, acceptable spacings, failure and total spacing of seeds suffered significantly influence by the type of seed feeder disc. However, the speed of the set influenced only the multiple spacings. The multiple spacings, failure spacings, and the error of the sensor spacing suffered significantly influence of the interaction between different sensors and disks. Failure spacings were influenced by the interaction between sensor and speed.

TABLE 1. Summary of the analysis of variance for the variables: multiple spacing between seed, acceptable spacing between seeds, failure spacing between seeds, total number of seeds and error found between the spacing recorded by the data acquisition system (sensor) and measured at seeding maize**.**

VF	DL	MS				
		Multiples Spaces	Acceptable Spaces	Failure Spaces	Seeds Total	Sensor Spaces Error
Block	2	2.067	9.017	2.216	2.450	4.782
Sensor (S)	1	0.017	0.000	0.267	0.150	3.388
Residue A	2	4.467	6.650	1.116	1.850	0.564
Disk (D)	1	54.150*	38.400*	8.067*	114.816*	0.004
Speed (Sp)	4	12.058*	4.184	2.891	11.891	2.686
D x Sp	4	4.941	3.323	1.108	9.858	0.346
S x D	1	12.150*	1.667	13.066*	2.016	10.394*
S x Sp	4	3.725	7.833	9.891*	9.690	0.496
S xD xSp	4	5.275	8.250	0.108	6.725	1.877
Residue B	36	2.934	5.870	1.629	9.904	1.904
Total	59	-	-	-	-	-
CV A (%)	-	35.13	30.10	22.17	7.03	41.21
CV B (%)	-	28.47	28.28	26.78	16.28	75.69

* Significant at 5% probability by the F Test.
CV A: Coefficient of variation of plot (%).
CV B: Coefficient of variation of the sub-plot (%).

According to the analysis of variance the use of different seeds feeder disks influences on the sowing process. In this way, it can be observed that the inclined disk presents better performance in relation to the traditional disk (Table 2). In both disc types, the seeds fell mainly within the acceptable spacing. However, the average number of seeds that fell within the acceptable spacing was higher on the inclined disk.

TABLE 2. Averages of multiple, acceptable, failure and total spacings of the seeds in function of different types of seeds feeders, along the effective length of the conveyor belt.

Disks	Multiples Spaces	Acceptable Spaces	Failure Spaces	Seeds Total
Inclined Disk	6.96 a	9.36 a	5.13 a	20.73 a
Tradicional Disk	5.06 b	7.76 b	4.40 b	17.96 b

Means followed by different letters in the column differ from each other by the Tukey Test (P < 5%).

The inclined disc facilitated the insertion of the seeds and, consequently, better accommodation, providing a better performance in the sowing process when compared to traditional disc.

The speed variation significantly influenced in the multiple spacing between seeds (TABLE 3). The monitoring of this parameter becomes important, since its influence will only occur after germination, which makes the correction costly and difficult (Reis et al., 2006).

TABLE 3. Averages of multiple spacings between seeds at different speeds of the sowing system, in the effective length of the conveyor belt.

Speed (km h^{-1})	3	4	5	6	8
Multiples Spaces	6.08 ab	6.25 ab	7.00 a	6.41 a	4.33 b

Averages followed by different letters on the line differ from one another by the Tukey test (P < 5%).

It is observed that the largest number of seeds close to each other was obtained at the lowest speeds. Under field conditions, assuming full seed germination, these plants would compete with each other and their growth, development and production would be affected.

Castela Junior et al. (2014), verifying the influence of the speed of the seeder in the sowing process of soybean report that the increase of the sowing speed does not interfere in the multiple spacings.

The smallest quantity of multiple seeds was obtained at the highest speed. Such behavior was possibly due to the lower number of seeds released, regardless of the type of disk, at this speed. However, Weirich Neto et. al (2015) when evaluating 64 seeder-fertilizers in 30 properties, observed that the main causes of multiple spacings were: inadequate disk and/or ring for the hybrid sieve, lack or excess of graphite, inappropriate pressure in the pneumatic system, unsuitable soil moisture for the seeding, opening and closing of the furrow.

Regardless of the type of sensor evaluated, the smaller multiple spacings, failure and errors in the perception of the failure spacing detected by the sensors, occurred with the use of the seed feeder disc of the inclined type (Table 4).

TABLE 4. Multiple and failure spacings, measured by sensors, and spacing error detected by sensors in function of the disc type, along the effective length of the conveyor belt.

Discs	Number of multiple spacings	Number of failure spacings	Error of spacing detected by sensors
Inclined Disc	4.60 b	4.00 b	1.77 b
Tradicional Disc	7.40 a	5.66 a	2.48 a

Averages followed by different letters in the column differ from each other by the Tukey Test (P < 5%).

Due to the fact that this disk allows a better accommodation of the seeds within itself, when compared to the traditional disk, the process of releasing the seed through the disc occurs more easily, avoiding bending them inside the conducting tube, facilitating their perception by the sensors.

The deployment analysis of the feeder discs inside the sensors was not presented, because it is not very understandable in practice the interference that the disks perform in the operation of the sensors.

The largest seed spacings occurred at the highest speeds (Table 5). This means that between one seed and another there was spacing greater than 50% of the expected spacing between the seeds ABNT (1994).

TABLE 5. Averages of failure spacings between seeds, detected by sensors, at different speeds of the sowing system, in the effective length of the conveyor belt.

Speed (km h^{-1})	3	4	5	6	8
Failure Spacing	4.00b	3.66b	4.50b	5.16 ab	6.83a

Averages followed by different letters on the line differ from one another by the Tukey test (P < 5%).

The above data show that the sowing process with a speed above 5 km.h^{-1} results in an increase in the gap spacing between the seeds. Consequently, this can lead to a reduction in productivity because the plants are further away reducing the final stand.

Reynaldo et al. (2016), when evaluating the influence of the displacement speed at sowing in relation to the longitudinal distribution quality of soybean seeds, concluded that the increase in speed increased the failure spacing. By contrast, Santos et al. (2011) assert that the increasing of the speed of the sowing operation is a factor that interferes with the establishment of the plant, because the speed increase has a negative influence on reducing the percentage of acceptable spacings and increases the number of failures during sowing.

As the displacement speed of the seeder increases, the rotation speed of the seed feeder disc is also increased, reducing the filling capacity of the disk, increasing the number of failure and double spacings and, as a consequence, it has a poor spatial distribution of plants.

In order to quantify the efficiency of the microcontroller data acquisition system, besides the counting performed by the system, the manual counting of the seeds was performed and the values compared (Table 6). The microcontroller data acquisition system with diffuse infrared sensor detected an average percentage of 96.23% of seeds that passed through the system.

TABLE 6. Efficiency of the microcontroller data acquisition system with diffuse infrared sensor, in relation to the count performed manually along the total length of the conveyor belt.

Discs	Count Performed Sensor	Manual Count	Efficiency (%)
Inclined Disc	488	498	97.99
Tradicional Disc	535	565	94.69
Total	1023	1063	96.23

The microcontroller data acquisition system with four infrared sensors, in parallel, was able to detect an average percentage of 95.14% of the seeds that passed through the conductive duct (TABLE 7). However, this system presents as inconvenience the delay for its calibration.

TABLE 7. Efficiency of the microcontroller data acquisition system, with infrared sensors in parallel, in relation to the count performed manually along the total length of the conveyor belt.

Discs	Count Performed Sensor	Manual Count	Efficiency (%)
Inclined Disc	464	480	96.66
Tradicional Disc	594	632	93.98
Total	1058	1112	95.14

Each data acquisition system was programmed to use the speeds, previously established, and to monitor the fall times between the seeds, making it possible to calculate the distances between maize seeds. Subsequently, the distances between the seeds were checked manually and the comparisons of these two results allowed determining the distance error between the estimated by the sensor and the real. The microcontroller data acquisition system with diffuse sensor provided an average error of 0.0206 meters and the system with infrared sensors, in parallel, an average error of

0.0158 meters. The higher accuracy of the data acquisition system with infrared sensors in parallel can be explained by the arrangement of four sensors working in parallel. The perception of the moment of seed passage showed more effective.

CONCLUSIONS

The disk for maize seeding of the inclined model presented an efficiency 3% higher compared to the normal disk for maize seeds.

The increase in the set speed provided increase in the failure spacings between the seeds.

The microcontroller data acquisition system with diffuse infrared sensor presented an average efficiency of 96.23% and the infrared sensor in parallel presented an average efficiency of 95.14% in the process of perception of maize seeds.

The spacing average error between the seeds with the microcontroller data acquisition system with diffuse sensor was 0.0206 meters and the system with infrared sensors in parallel was 0.0158 meters.

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