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USE OF ELECTRIC MOTORS IN SEEDERS AND GAIN IN PRODUCTIVITY IN SOYBEAN CROP

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Abstract: The use of electric motors in seeders aims to increase the efficiency of the dosing mechanisms by eliminating the mechanical transmission, reducing the interference of the set in the productive potential of the crop. With the application of this technology, it is possible to add functions capable of determining the correct application, in quantities and location, of inputs in accordance with the precepts of Precision Agriculture. The use of electric motors provided a reduction in the Coefficient of Variation, failures, in addition to an increase in the number of acceptable plants for the variables, with an average increase in productivity of 335 kg ha^{-1}. In addition, with the electric motors, the curve compensation function was evaluated, this feature ensures that all lines of the seeder apply the seeds at the same distance, stabilizing productivity in the same sowing pass. The survey showed a productivity increase of around 13.3% greater than not using the function. The results of the analyzes indicated, on average, an increase in productivity of 276.5 kg ha^{-1} for electric motors, converted into R$ 829.50 per hectare.
Keywords: Coefficient of Variation, Electric Motor, Productivity.

INTRODUCTION

The need to increase the productivity of grain crops is becoming more evident every day, as are the opportunities for reducing production costs. In this sense, the quality of sowing is a factor that is increasingly debated and fundamental. Increasing the efficiency of seeders in the field is one of the essential factors for increasing productivity and guaranteeing an economic return at the end of the cycle.

Seeders aim to distribute a predetermined amount of seeds, but this operating principle presents errors in dosage and distribution of applied inputs, according to Biulchi (2016). Many of these errors occur in the adjustment and by the components of these machines. In a study carried out with 35 seeders, the average seed dosage ranged from 0.06% to 48.94%, with an average of 11.39%. These factors contribute to a reduction in productivity, according to CASÃO et al (2019). The productivity increments varied between 6% and 76% considering only the planting quality, better seed deposition in the soil means higher productivity (PICHINIM, 2012).

In the evaluation of pneumatic and mechanical seeders in soybean planting in the northern region of Paraná, the average Coefficient of Variation (CV%) was 45% and 71%, respectively (SCHMALZ, 2014). This variable directly interferes with the productive potential. According to Desbesell et al (2018), productive losses in soybean crops with a coefficient of variation greater than 60% can exceed 16%, that is, more than 12 bags of soybeans per hectare, depending on the cultivar.

The technology of electric motors appears in the market of seeders aiming to minimize these problems, replacing the mechanical transmission system, in addition to offering a variety of resources for Precision Agriculture, from the simplest to the most complex, such as: application at varied rates; automatic shutdown of lines; seed compensation in curves and; generation of information that the installed ecosystem can send to cloud platforms to be worked on in Digital Agriculture environments.

For Dorsey (2017), in a 24-row seeder during the corn season, they found that the inner rows were overloaded by up to 124% of the target population, while the outer rows had only 81% of the target population. She also observed that the centerlines had a higher yield than the endlines.

The present work was developed with the objective of comparing the performance of a precision seeder equipped with mechanical transmission in relation to the resources made available by electric motors and the benefits for operations in Precision Agriculture environments.

MATERIAL AND METHODS

The experiments were implemented in the municipality of Getúlio Vargas/RS in an area of 2 hectares in the 19/20 harvest. The sown cultivar was BMX Ativa in a population of 323,809 plants per hectare, that is, 13.6 seeds per linear meter spaced 0.42 m between rows of plants.

Sowing was carried out using a Massey Fergusson 292 4x2 tractor equipped with TDA and a Semeato 2007 seeder, model SHM 1517, with 8 sowing rows (FIGURE 1) spaced 42 cm between rows, equipped with mechanical seed dosers from the company itself. Semeato and FertiSystem brand fertilizer dosers with 2" auger. The electrical system used was that of the company ROJ TECHNOLOGY, consisting of 8 DMD-2 motors (12V) with a torque of 4.5Nm to drive the seed dosers. These motors are made up of an aluminum block where the electric motor with brushless technology is integrated, an axial reduction and an electronic board responsible for managing the functions of the motor and the sowing line, such as seed statistics, for example. The fertilizer dosers were always activated by the mechanical transmission through the replacement and with the same fertilizer dosage, that is,250 kg ha^{-1}. The controller (ECU) used in the research was with ISOBUS technology, model CM 20, Topcon brand, as well as the display and the GNSS receiver, models X25 and AGI-4, respectively. The signal correction commercially available to the market as TOPnet was used. This option enables the precise location of the equipment in the field, with an approximate error of ≅3cm, a necessary requirement for the automatic disconnection of lines, for example.

Sowing was carried out under two different conditions, at one point equipped with a mechanical transmission and then with electric motors directly driving the dosing elements. For seeding with mechanical drive, the cables of the battery electronic system were removed and for seeding with electric motor drive, the chains of the gears integrated in each seeding line were removed.

32 plots of 25 meters long and 3.5 meters wide were delimited, 16 plots for each treatment, that is, the seeder equipped with the mechanical transmission and 16 plots with the seeder equipped with electric motors. Four variables were evaluated within each treatment, 4, 5, 6 and 7 km h-1, with four replications for each variable.

For each repetition, measurements and plant counts were made in two planting rows at a distance of 5 meters in each row, totaling 10 meters of measurements in each repetition, for evaluation and calculation of the percentage of the Coefficient of Variation, the number of failures, doubles and acceptable. To determine productivity, all plots were harvested, in addition to plant sampling for data generation and subsequent comparisons.

For the evaluation of treatments with and without curve compensation, possible only for the machine operating with electric motors, determinations of the plant population were made with three replications for the Internal Line (L.I), Central Line (L.C) and External Line (L.E) in planting With Compensation of Curves (C.C.C) and Without Compensation of Curves (S.C.C) to determine the plant population in each of the rows in the two treatments with the objective of crossing this information and determining productivity.

The radius of the curve where the data were collected was 30 meters, the plant count occurred in 10 linear meters and the productivity evaluation occurred with the collection, threshing and weighing of the plants in 5 linear meters for each repetition.

FIGURE 1. Seeder equipped with mechanical transmission and line-to-line electric motors.

PRODUCTIVITY (kg ha^{-1})					
Streaming	CV% (statistics)	Average kg ha^{-1}	4km h^{-1}	5km h^{-1}	6 km h^{-1}	7 km h^{-1}
Electric	5,0%	2,688 a	2,626 aA	2,940 aA	2619 aA	2,567 aA
mechanics		2,353 b	2,373 bA	2,553 bA	2418 bA	2,069 bA
COEFFICIENT OF VARIATION (%)						
Streaming	CV% (statistics)	Average CV%*	4 km h^{-1}	5 km h^{-1}	6 km h^{-1}	7 km h^{-1}
Electric	9,2%	45,3% b	44,0% aA	40,8% bA	47,0% aA	49,3% bA
mechanics		52, 4% a	49,8% aA	49,0% aA	53,3% aA	57,8% aA
FAULTS(%)						
Streaming	CV% (statistics)	Average Fails	4 km h^{-1}	5 km h^{-1}	6 km h^{-1}	7 km h^{-1}
Electric	30,8%	10,3% b	8,8% bAB	2,8% bB	13,3% aA	16,3% bA
mechanics		18,0% a	16,5% aA	15,8% aA	16,6% aA	23,3% aA
DOUBLE(%)						
Streaming	CV%(estatística)	Médias Duplas	4km h^{-1}	5km h^{-1}	6km $^{-1}$	7 km h^{-1}
Electric	30,8%	16,9% a	16,3% bA	16,3% bA	16,5% aA	17,5% bA
mechanics		18,7% b	16,5% aA	17,3% aA	21,5% aA	20,5% aA
ACCEPTABLE(%)						
Streaming	CV% (statistics)	Acceptable Average	4km h^{-1}	5 km h^{-1}	6km h^{-1}	7 km h^{-1}
Electric	10,6%	72,9% a	74,8% aA	80,0% aA	70,3% aA	66,5% aA
mechanics		63,3% b	67,3%bA	68,0% bA	62,8% aA	56,5% aA

*CV% - Coefficient of Variation. Means followed by the same lowercase letters in the columns or uppercase in the rows do not differ by Tukey's test at 5%

TABLE 01. Result of the statistical analysis to evaluate the effect of the speed and the respective Coefficient of Variation (CV%) between the plants in each treatment on the productivity of the soybean crop.

The experimental design used in this research was completely randomized blocks and the free software SISVAR® was used for the processing of descriptive statistics.

RESULTS AND DISCUSSION

The planting of the experiment area to evaluate the sowing efficiency was on December 27, 2019, while the sowing of the area for the evaluation of the C.C.C and S.C.C functions was carried out on January 7, 2020. The harvest of the plots for evaluation of the mechanical transmission systems (MEC) and electrical drive (ELE) was carried out on April 29th and the harvest of the crop where the evaluation of the C.C.C and S.C.C treatments was carried out was carried out on May 7, 2020 where the rainfall total during the crop cycle was 450 mm and 316 mm respectively.

The results of the statistical analysis are presented in Table 01, where the productivity data, CV%, Failures, Doubles and Acceptable are listed.

It was evident that there is a significant difference in productivity between the seeder with Electric Transmission and the seeder with Mechanical Transmission, 2.688 kg ha-1 and 2.353 kg ha-1, respectively. The transmission through electric motors presented an average productivity of 335 kg ha-1 higher than the mechanical drive in the total of the experiment, that is, in the four variables under study, as it is possible to visualize graphically in figure 2.

For all variables, that is, the 4 speeds, there was a significant difference with higher productivity for the machine with transmission by electric motors, being 253 kg ha^{-1}, 387 kg ha^{-1}, 201 kg ha^{-1} and 498 kg ha^{-1} for 4 km h^{-1}, 5 km h^{-1}, 6 km h^{-1} and 7 km h^{-1}, respectively.

The CV% analysis followed the same results of the productivity evaluation, except for the speeds of 4 km h-1 and 6 km h-1 that did not differ between treatments, that is, transmission through electric motors and mechanical transmission. By comparing the two graphs, it is possible to identify a very close relationship between CV% and productivity, that is, the lower the CV%, the greater the productivity and vice versa. Within the treatment itself, the CV% had no significant difference between the variables. In Figure 3, it is possible to verify that the CV% increases for both drive modes as the speed increases.

The analysis for determining sowing efficiency information was based on the methodology published by ABNT (1996) which considers the following standards: acceptable are all spacing between seeds that are 0.5 to 1.5 times the average spacing. Values obtained below the limit of 0.5 times are considered as double or multiple spacing, while spacing above 1.5 times the average spacing are considered seeding failures.

The graph in figure 4 shows the superiority of the number of failures for actuation through mechanical transmission, as demonstrated in the statistical analysis where the number of failures for actuation by electric motors was, on average, 75% lower. Only in the variable 6 km h^{-1} there was no statistical difference between the two evaluated treatments. Within the treatment itself, the activation by electric motors differed in the speed of 5 km h^{-1}.

The evaluation of the number of pairs within each treatment did not differ statistically, and even showed no difference between the two treatments either. Even so, in Figure 5 it can be seen that, although there is no statistically significant difference, as the speed is increased, the tendency is for distancing with a greater number of pairs for the mechanical drive system.

Figure 6 shows the graph relating to the number of acceptable plants between the two treatments in the four analyzed variables and again the electric motor drive system showed

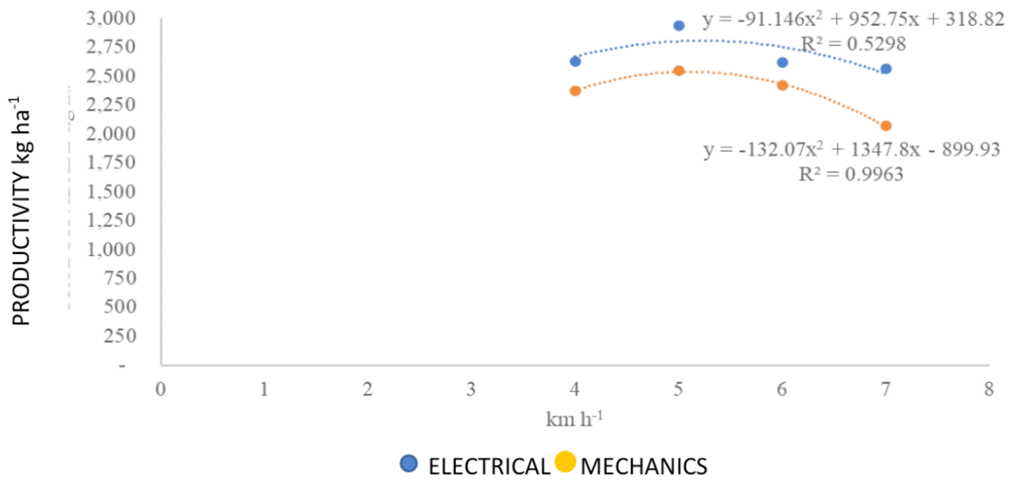

FIGURE 2. Yield response for different speeds in both treatments.

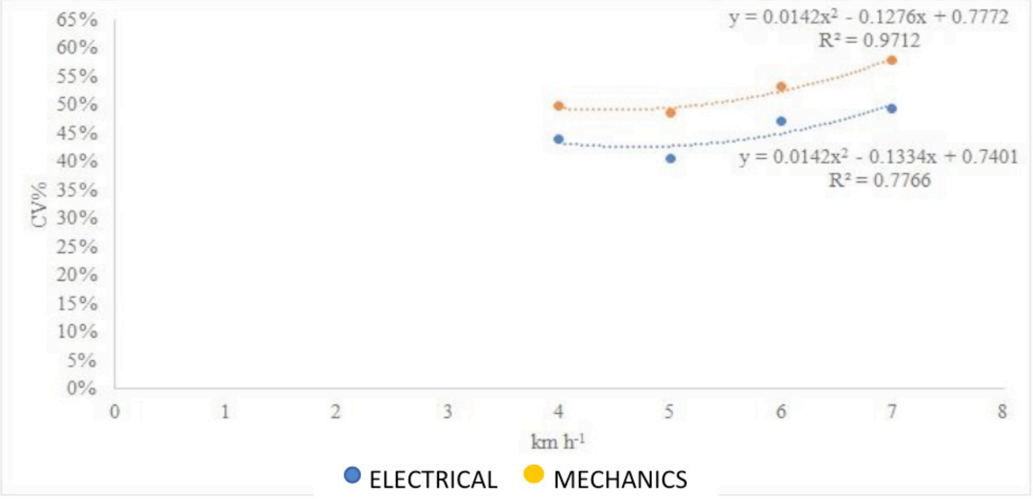

FIGURE 3. CV% behavior for different speeds in both treatments.

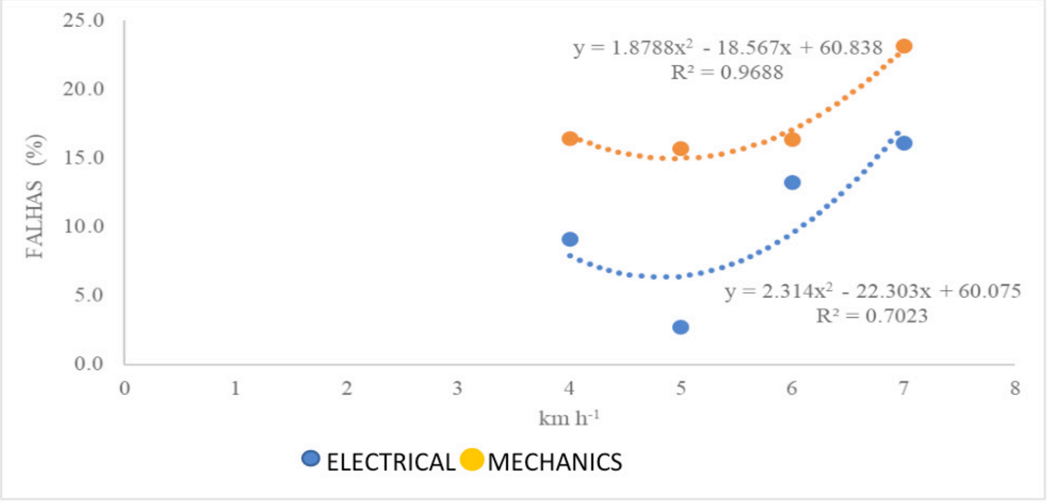

FIGURE 4. Evidence of the percentage of failures for the different speeds in the two treatments.

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better results in relation to the mechanical drive. For this variable, the percentage was 13% in favor of the electric motor system, which did not differ statistically from the mechanical system only in the variable of 6 km h^{-1}.

Table 02 presents the statistical analysis data for the C.C.C and S.C.C treatments for the internal (L.I), central (L.C) and external (L.E) lines.

According to the evidence above, the plant population is stable in the C.C.C treatment, that is, 117.6 plants in 10 linear meters. On the other hand, in the S.C.C treatment, the population in 10 linear meters in the L.I was 121.7, in the L.C from 116.7 to 105.3 in the L.E. Regarding the L.C, it meant a population variation 4.3% higher in the L.I and 9.8% lower in the L.E, totaling a variation of 14.1% between one end and the other of the seeder in the same operating condition.

The seeder operating with the C.C.C technological resource differs significantly from the productivity of the same seeder operating without this feature enabled. In average productivity, within the same pass of the seeder in a curved line, for the S.C.C operation there was a decrease of 202 kg ha^{-1} in the productivity between L.I and L.E.

This behavior was repeated for all the variables compared between treatments, that is, in L.I there was a reduction of 302 kg ha-1, in L.C a reduction of 238 kg ha^{-1} and in L.E a reduction of 113 kg ha^{-1}. Within the same treatment, no significant differences were recorded, except for the L.E variable of the S.C.C treatment, which differed from the other variables within this same treatment.

Note that the productivity is associated in an inverse proportion to the plant population, that is, in the experiment condition, the larger the population, the smaller the productivity evidenced.

In Figure 7, it is possible to visualize the significant variation of the population with the S.C.C feature disabled. On the other hand, when the C.C.C resource was enabled (FIGURE 8) there is productivity stability among the various planting lines of the seeder, having a direct impact on the harvest results.

When evaluating the variables analyzed, it can be seen that at certain points in the crop losses occur, on average, around 276.5 kg ha^{-1} or, if converted into "species", based on the current price (R$ 180.00) for soy, the numbers are around R$ 829.50 per hectare.

In the context of Precision Agriculture, efficient systems with resources for digitalization, such as the automation of the seeder through electric motors, present significant gains in productivity and elimination of variables that limit the productive ceiling of crops. In this research, only some functions available in these systems were evaluated, other resources must be evaluated as well.

CONCLUSION

The result of the research demonstrated a positive effect of the transmission system by electric motors in relation to the mechanical transmission system. The increase in technology improved the efficiency of the seeder, provided solutions that added Precision Agriculture resources, brought benefits such as the reduction of the CV% of the plant population, reduction in the number of failures, increase of plants within the acceptable distribution, population uniformity in curved conditions and, consequently, increased productivity.

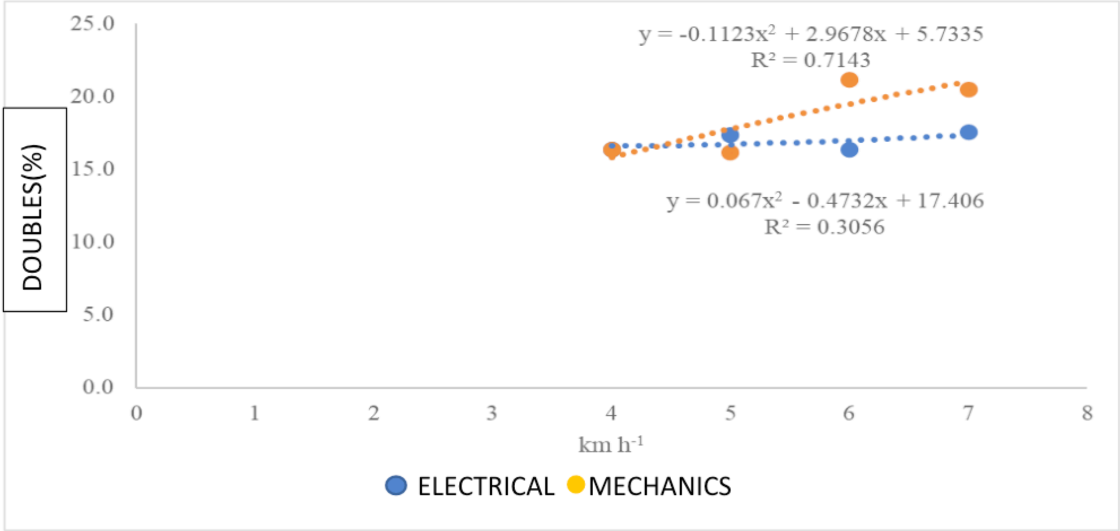

FIGURE 5. Evidence of the percentage of double plants for the different speeds in the two treatments.

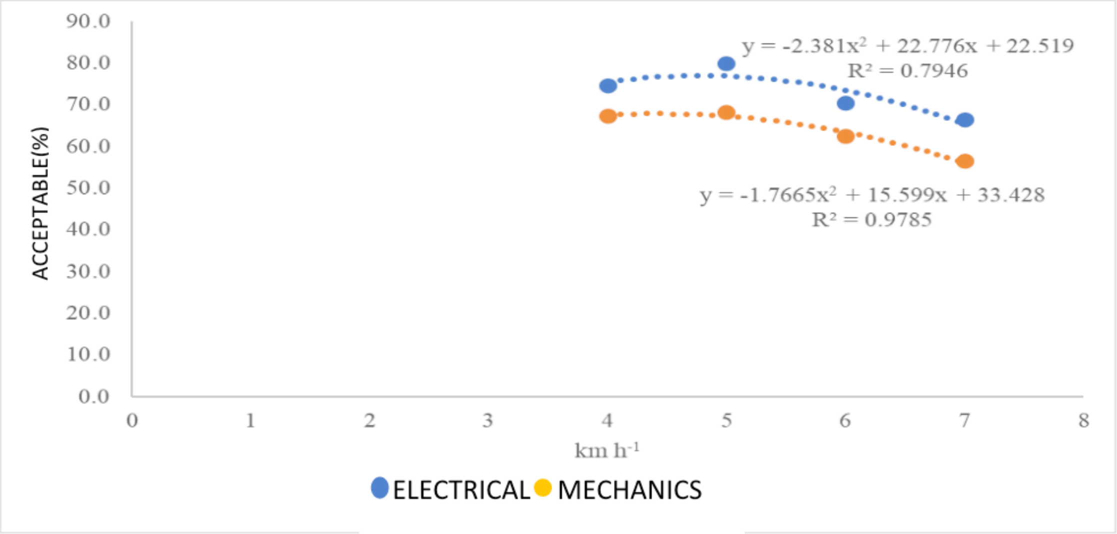

FIGURE 6. Evidence of the percentage of acceptable plants for the different speeds in the two treatments.

PLANT POPULATION (10m)					
Functionality*	CV% (statistics)	Average Plants-10m	L.I	L.C	L.E
C.C.C	2,0%		117,7 aA	117,3 aA	117,7 aA
S.C.C			121,7 aA	116,7 aB	105,3 Bc
PRODUTIVIDADE(kg ha^{-1})					
Functionality*	CV% (Statistics)	Average kg ha^{-1}	L.I**	L.C**	L.E**
C.C.C	2,4%	1642 a	1,635 aA	1,643 aA	1,648 aA
S.C.C		1424 b	1,333 bB	1405 bB	1,535 bA
*C.C.C- With Curve Compensation; S.C.C- No curve compensation. **L.I- Internal Lines; L.C-Central Line; L.E-External Lines. Means followed by the same lowercase letters in the columns or uppercase in the rows do not differ by Tukey's test at 5%.					

TABLE 02. Result of the statistical analysis to evaluate the effect of the curve compensation functionality activated in different lines of the seeder on the productivity of the soybean crop.

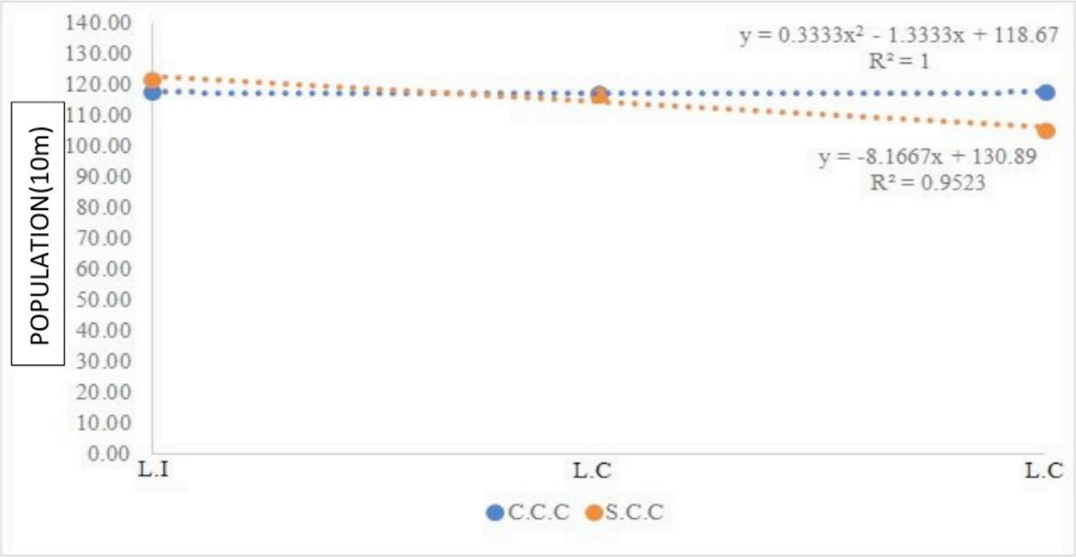

FIGURE 7. Population difference between the inner (L.I), center (L.C) and outer (L.E) lines with the curve compensation function activated (C.C.C) compared to the function deactivated, that is, without curve compensation (S.C.C).

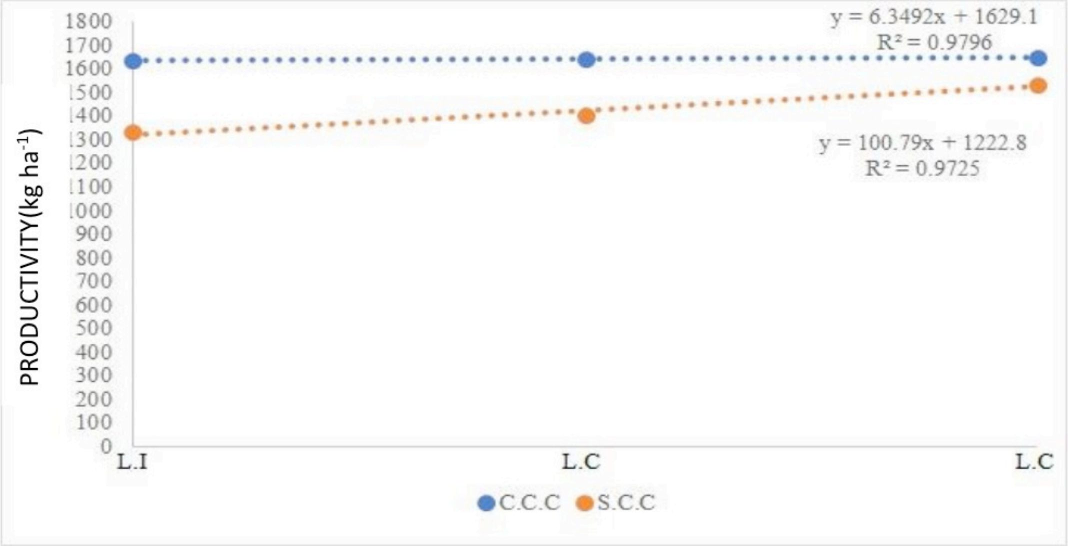

FIGURE 8. Difference in productivity between the inner (L.I), central (L.C) and outer (L.E) lines with the curve compensation function activated (C.C.C) compared to the function deactivated, that is, without curve compensation (S.C.C).

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