Plantability and corn productivity: influence of furrow opener mechanisms and oat straw management[1]

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ABSTRACT

Straw management associated with furrow opener mechanisms under a no-tillage system can enable better yields in the corn crop. Thus, this study aimed to evaluate corn productivity under a no-tillage system as a function of furrowing mechanisms and oat straw management. This research was conducted in the 2019/2020 growing season in Pato Branco, Paraná, Brazil, in a factorial scheme consisting of furrow opener mechanisms (shank and double disk) and oat straw management (rolled, desiccated, and crushed), with four replications. Oat dry matter, furrow depth, furrow width, tilled soil area, emergence rate index, initial and final plant stand, initial and final plant height, initial and final stem diameter, ear insertion height, number of rows per ear, number of grains per row, ear length, ear diameter, thousand-grain weight, and productivity were evaluated. The results were subjected to analysis of variance by the F-test at a significance 5% probability and the means were compared by Tukey's test. Corn development, yield, and productivity were more influenced by the furrow opener mechanisms, standing out the use of a shank compared to the double disk.

Keywords: straw management; sowing quality; *Zea mays* L; plantability.

INTRODUCTION

Corn (*Zea mays* L.) is among the most produced grasses in the world, considered the third most important cereal (Prestes *et al.*, 2019). The corn crop production chain has great relevance in Brazilian agribusiness, cultivated in all regions and with significant expressions in the country's economy (Contini *et al.*, 2019). The national production of corn in the 2019/2020 season reached 102.5 million tons and mean productivity of 5,533 kg ha^{-1} (Conab, 2020).

Cultivation and management techniques are options that can lead to the maximum expression of the productive potential of crops. In this perspective, the no-tillage system (NTS) is a tool that can improve the corn production cycle. NTS is a management strategy in which straw and plant residues are left on the soil surface, with minimal disturbance during the implementation of the subsequent crop and crop rotation (Favarato *et al.*, 2016). It would allow partial erosion control, higher soil moisture maintenance, increased microbial activity and organic matter, and improved soil structure, among others (Younis *et al.*, 2020).

An NTS premise is the use of straw obtained from cover crops, which prevent soil erosion, minimize the appearance of weeds and fungal diseases, maintain the soil at mild temperatures, and favor nutritional improvement. Furthermore, the interrelationship between cover crops and the soil becomes beneficial to the environment and production systems (Theodoro *et al.*, 2018).

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Among the cover crops, black oat (Avena strigosa Schreb) stands out mainly due to its capacity to supply biomass, which can reach 6,000 kg ha^{-1} (Wutke *et al.*, 2014). However, there is a need to carry out previous management of this straw to minimize its negative influence on the sowing components. When this handling is performed incorrectly, the same can lead to clogging, causing irregularities in the opening of furrows and deposition of seeds and fertilizers, irregular emergence of seedlings, the appearance of heterogeneous fertility bands, areas prone to erosion, and higher incidence of weeds in areas without the presence of straw (Franchini *et al.*, 2015).

The straw management process must be carried out aiming to avoid operating problems in sowing, reflecting on the main crop. Straw management is common through chemical handling, through the application of herbicides or desiccants, and mechanical handling, usually carried out with knife roller and crushers (Favarato *et al.*, 2018). Mechanical management of straw facilitates the sowing process. However, it increases the risk of soil compaction due and accelerating straw decomposition, while chemical management has the advantage of high operational efficiency.

Associated with straw management are the furrow opener mechanisms, that is, furrow opening implements for deposition of seeds and fertilizers, which also interfere with the crop establishment.The most prominent furrow opener mechanisms are the double disks and shanks, which can present performances that vary with the texture, structure, and amount of plant residues in the soil (Da Silva Filho *et al.*, 2018). These components also establish a relationship between the soil and the sowing machine, in which both can influence and optimize conditions for seed germination and crop installation (Giacomeli *et al.*, 2016).

Thus, considering that the straw management and furrow opener mechanisms affect crop productivity, this study aimed to evaluate the interference of two furrow opener mechanisms and three methods of oat straw management on corn sowing quality and productivity.

MATERIAL AND METHODS

Study area characterization

The experiment was conducted in the 2019/2020 agricultural season at the Experimental Area of the Agronomy Course, belonging to the Federal University of Technology – Paraná (UTFPR), Pato Branco, Paraná, Brazil. The experimental area is located at the geographic coordinates 26°16′ S and 52°41′ W (Figure 1).

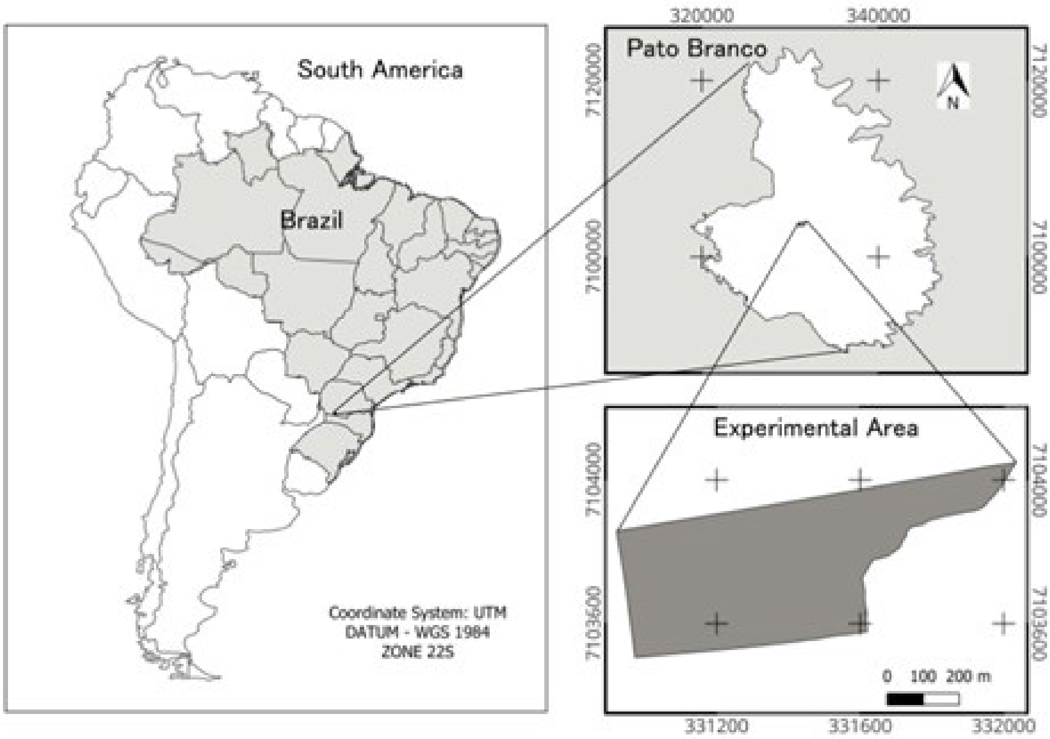

Figure 1: Geographical location of the study area.

According to the Köppen classification, the regional climate is Cfa, that is, a humid subtropical climate with an average temperature of 18 °C for the coldest month and 22 °C for the warmest month and an average rainfall of 2,025 mm per year. The region has hot summers, with higher rainfall concentrations, without a defined dry season, and infrequent frosts (Alvares *et al.*, 2013). Precipitation, average temperature, and evapotranspiration during the experimental period are shown in Figure 2.

The experiment was carried out on an Oxisol (Soil Survey Staff, 2014), with a very clayey texture (77.4% clay, 20.3% sand, and 2.3% silt), whose chemical characteristics at a depth of 0.0–0.20 m were: OM (Walkley-Black) = 37.53 g dm^{-3}; P (Mehlich I) = 3.36 mg dm^{-3}; K (Mehlich I) = 0.40 $cmol_c$ dm^{-3}; Cu = 0.00 mg dm^{-3}; Fe = 0.00 mg dm^{-3}; Zn = 0.00 mg dm^{-3}; Mn = 0.00 mg dm^{-3}; pH ($CaCl_2$) = 4.80; SMP index = 5.80; Al^{3+} = 0.09 $cmol_c$ dm^{-3}; H+Al = 5.76 $cmol_c$ dm^{-3}; Ca^{2+} = 4.30 $cmol_c$ dm^{-3}; Mg = 2.30 $cmol_c$ dm^{-3}; SB = 7 $cmol_c$ dm^{-3}; V = 54.86%, and aluminum saturation = 1.27%.

Treatments and experimental design

The treatments consisted of the combination of two furrow opener mechanisms (shank and mismatched double disk) and three straw management methods (rolled, desiccated, and crushed). Moreover, the experiment was carried out in a randomized block design, consisting of six treatments arranged in a 2 x 3 factorial scheme, with four replications. The area was divided into four randomized blocks, totaling 24 experimental units, each with an area of 72 m^2 (4 × 18 m) and spacing of 10 m between blocks.

Field evaluations were carried out within the useful area of each plot, which had a length of 5 m, in the three central sowing rows. Black oat (*Avena strigosa* Schreb) was used as a soil cover plant, at an amount of 80 kg ha^{-1}. Sowing was carried out in May 2019 and the different types of management were carried out when the crop reached flowering (September 2019).

A tractor-knife roller set Triton®, with a 1.2 m working width, was used for the rolled straw management. A tractor plus a Jan/Triton® 1800 straw crusher was used in the crushed straw management, with a cutting width of 1.8 m. Finally, the desiccated straw management was carried out using a knapsack sprayer with a boom to apply glyphosate at 0.5 L ha^{-1}. All management practices were carried out 30 days before corn sowing.

Shank-type furrowers with a 25 mm wide tip, 22º angle of attack, and 0.10 m depth of action and mismatched double disk furrower with 381 mm (15”) diameter were used. Each seeding line had a 381 mm (15”) diameter smooth cutting disk in both configurations.

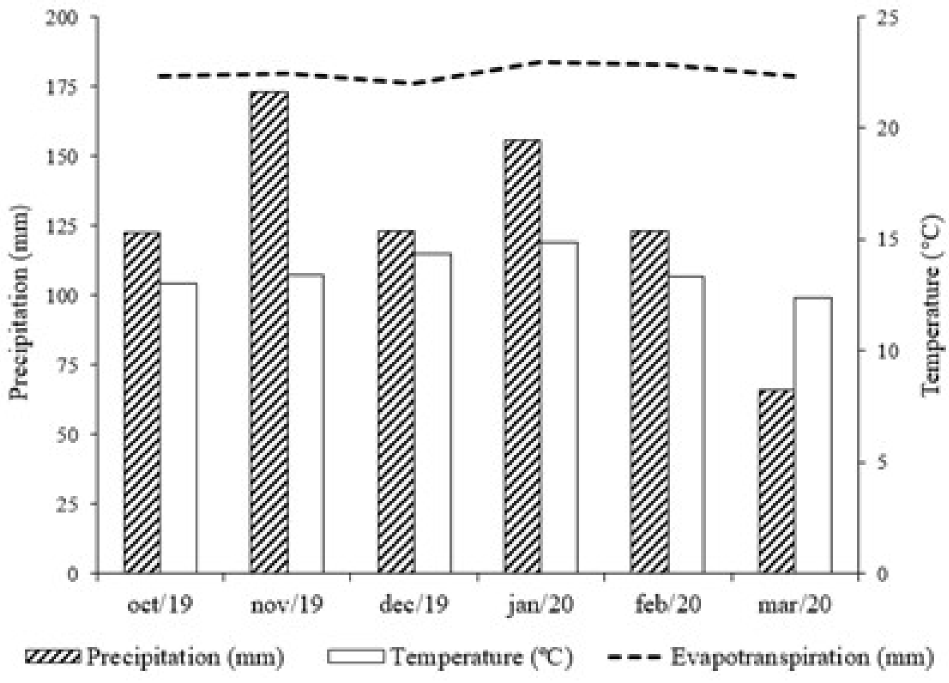

Figure 2: Precipitation (mm), temperature (°C) and evapotranspiration (ETo) during the experimental period for the municipality of Pato Branco – PR.
Source: Paraná Meteorological System (Simepar, 2020).

The Pioneer P2719VYH corn hybrid, with the Leptra® biotechnology, was sown at a spacing of 0.45 m between rows and sowing density of 80,000 plants ha^{-1}. The hybrid has an early cycle and resistance to the herbicide glyphosate and some pest insect species. The base fertilization consisted of the application of 450 kg ha^{-1} of the 08-26-16 formulation, with expected productivity of up to 15 t ha^{-1}. Corn sowing was conducted on October 24, 2019, using a Vence Tudo® SA 14600 precision seed drill for NTS, with mechanical seed metering, five planting rows spaced at 0.45 m from each other, and speed of 5.0 km h^{-1}.

The herbicide Primatop® (atrazine + simazine) was applied at a dose of 6.0 L ha^{-1} after 12 days of corn emergence stabilization (V4 to V5) to control weeds such as hairy beggarticks (*Bidens pilosa* L.), asthmaweed (*Conyza bonariensis* (L.) Cronquist), and pearl millet (*Pennisetum glaucum* (L) R. Br.). Topdressing fertilization was carried out between the vegetative stages V5 and V6 using 200 kg ha^{-1} of urea with 45% nitrogen in its formulation.

Evaluated parameters

Amount of straw: analyzed by collecting the vegetation cover mass using a frame with a known area of 0.25 m^2 (0.50 × 0.50 m). Then, the collected material was dried in an oven at 70 °C up to constant weight, followed by weighing and conversion of the obtained value into kilogram of dry matter per hectare.

Maximum furrow depth, furrow width, and tilled soil area: the survey of the tilled soil profile was conducted using a wooden profilometer with vertical rulers graduated in centimeters, arranged every 2 cm transverse to the sowing row, and used in the three central sowing rows of each experimental unit. Three profiles were surveyed in each experimental unit: natural soil surface profile, final soil surface profile, and internal tilled soil profile. The maximum depth of the fertilizer furrow openers was obtained considering the highest difference between the original and internal soil surface profiles in the seed furrow. The surface width of soil tillage in the seed furrow was obtained by determining the distance between the ends of the soil surface tillage generated by the fertilizer furrow opener.

Emergence rate index (ERI): evaluated over a length of five meters in the three central sowing rows. The seedling count was performed daily until the number of emerged seedlings was constant. Each plant was considered to have emerged from the moment it broke the soil and could be seen with the naked eye from any angle.

Seed deposition depth: obtained in plants from the three central sowing rows in each experimental unit. The plant shoot was cut close to the soil with pruning shears and the part buried in the soil was removed with a spatula. A ruler was used to measure the epicotyl length from the soil surface up to the seed, corresponding to the seed deposition depth. This parameter was determined when corn seedlings were approximately 5 cm tall, between the development stages V2 and V3.

Initial and final plant stand: this variable consisted of measuring the stands, counting the existing plants in the useful area in five meters of each seeding row in the three central rows of each experimental unit, whose result was extrapolated to the number of plants per hectare. The evaluation of the initial stand was conducted after the crop emergence stabilization, while the final stand was evaluated at the physiological maturation stage of the crop.

Stem diameter, plant height, and first ear insertion height: The initial plant height was measured at stage V10 using a ruler graduated in centimeters. The initial stem diameter was determined using a digital caliper by measuring the first internode above the soil also at stage V10. The final plant height and stem diameter measurements were performed again in the period of physiological maturation of the crop (R3), adopting the same initial procedures. All these evaluations were carried out on 10 plants present in the useful area of each experimental unit.

Corn yield components: ten ears were collected from each experimental unit and the following yield components were evaluated: mean number of grain rows per ear, mean number of grains per row, ear length, and ear diameter. The thousand-grain weight was determined after manual threshing of the ears used to evaluate the yield components, using eight samples of 100 grains taken at random from each plot, which were submitted to weighing.

Grain productivity: productivity (kg ha^{-1}) corresponded to the weighing of grains in the useful area and extrapolation to one hectare, with moisture correction to 13%. The harvest was carried out manually and the threshing was carried out using a cereal beater.

Statistical analysis of data

The results were subjected to analysis of variance by the F-test at a significance of 5% probability, using the GENES statistical program (Cruz, 2013). The means of traits in which the F-test presented a significant value at 5% probability were compared by Tukey's test.

RESULTS AND DISCUSSION

The lowest means of oat dry matter (DM) (Table 1) obtained with the crushed management (3,582.75 kg ha^{-1}) are due to the straw fragmentation after management, associated with factors that affect straw decomposition, such as particle distribution and size, as the more fractioned the material, the larger the surface susceptible to the attack by microorganisms, making degradation faster (Sgarbossa *et al.*, 2022). Also, the knife roller management (4,960.17 kg ha^{-1}) led to the sectioning of the plant stem, lodging it and keeping it intact on the soil surface, while chemical desiccation (4,356.17 kg ha^{-1}). The values are below what is considered the ideal minimum DM for NTS, which is 6,000 kg ha^{-1} (Nunes *et al.*, 2006). However, the management practices were carried out 30 days before sowing, leading to a reduction in DM compared to management practices carried out closer to the sowing day. These values are interesting although they are below ideal, as large amounts of straw in NTS provide not only good levels of soil cover and weed suppression by allelopathy but may cause problems during sowing (clogging and irregular seedling emergence) when they have an inadequate distribution, leading to a poor plantability of the main crop (Cyrino *et al.*, 2019).

The higher furrow depth (6.4 cm) obtained with the use of a shank furrow opener (Table 2) may be related to its construction shape, which normally presents better ease in breaking compacted soil surface layers (Souza *et al.*, 2019). It allows the placement of fertilizers at higher depths, avoiding direct contact between seed and fertilizer, which can impair seed water absorption, germination, and plant vigor (Shang *et al.*, 2019). Modolo *et al.* (2019) studied corn plantability with furrow opener mechanisms (shank and double disk) conducted under an Oxisol and also obtained a higher furrow depth using a shank furrow opener, with a mean of 9.41 cm, while the double disk had a mean of 5.52 cm.

The largest furrow width was obtained when using the shank furrow opener (12.16 cm), differing from the double disk (11.08 cm). This result is also consistent with the greater ability of the rod to disrupt the soil, causing greater furrow width. However, it is desirable that the furrower elements provide a smaller furrow width, in order to avoid the incidence of possible invaders, and their competition with the desired crop, in addition to the possibility of erosion. Moreover, the shank opens larger furrows, reduces the mulch on the soil surface, and harms crop development due to water losses by evaporation (Souza *et al.*, 2019).

The shank also provided a larger tilled soil area (60.29 cm^2), differing statistically from the double disk (46.74 cm^2). The tilled area is directly related to the type of furrow opener, working depth, and furrow width, and the higher these parameters, the larger the tilled soil area. This result was already expected, as the shank worked at a higher furrow depth and width than the double disk. It is associated with the configuration of the shank furrow opener, which aims to open the furrow for fertilizer deposition and breakthrough more compacted soil layers, while the double disk furrow opener mechanism aims to open the seed furrow with minimal soil disturbance (Modolo *et al.*, 2013).

The higher capacity for soil tillage by the shank allows the compacted layers to be broken more easily, improving the aeration capacity by creating a higher volume of macropores and reducing soil density. It reflects less physical limitation to the deeper growth of plant roots, which provides better development for crops (Nunes *et al.*, 2014). However, areas with higher soil tillage are more likely to lose remaining plant residues, as the soil is exposed to physical weathering, which can cause soil loss, leading to erosion and reduced moisture (Cardoso *et al.*, 2013). Furthermore, the higher soil tillage in the sowing row may favor the incidence of weeds due to their viable seed bank in the soil. These weeds are potentially able to compete with cultivated plants or impede their good development (Nichols *et al.*, 2015).

Table 1: Mean values of dry matter (DM) as a function of black oat management methods

Management	DM (kg ha^{-1})
Rolled	4.960,17 a
Desiccated	4.356,17 a
Crushed	3.582,75 b

Means followed by the same lowercase letter in the column do not differ statistically from each other by Tukey's test at a 5% probability of error (F-test, $p < 0.05$).

Table 2: Mean values of furrow depth (FD), furrow width (DW), tilled soil area (TA), and sowing depth (SD) of corn as a function of fertilizer furrow opener mechanisms

Furrow openers	FD (cm)	DW (cm)	TA (cm^2)	SD (cm)
Double disk	5,08 b	11,08 b	46,74 b	4,88 b
Haste	6,04 a	12,16 a	60,29 a	5,16 a

Means followed by the same uppercase letter in the row and lowercase letter in the column do not differ from each other by Tukey's test at a 5% probability of error (F-test, $p < 0.05$).

The highest sowing depth was obtained when using the shank furrow opener (5.16 cm), while the depth using the double disk furrow opener reached 4.88 cm. Similarly, Souza *et al.* (2019) found higher depths using a shank furrow opener when compared to the double disk. In this case, the shank normally has a higher capacity to break through the soil and deposit seeds at higher depths than the double disk. Moreover, the ideal depth in clay soils is between 3 to 5 cm because of their less drainage, which can hinder seedling emergence (Cruz *et al.*, 2010).

Importantly, sowing depth uniformity should allow the emergence of more homogeneous seedlings. Otherwise, seedlings that emerged late are limited by those that emerged earlier, which may reflect a decrease in plant vigor and loss of productivity. This parameter must be at most compatible with the crop, as higher depths generate more energy consumption in the emergence and smaller depths can make the seed susceptible to weathering, such as water stress (Gough, 2020).

Management levels within furrow openers (Table 3) showed that the double disk presents significant differences, with better ERI in the crushed management (9.45), although it is not statistically different from the rolled management (9.07). It is related to the fact that crushed and rolled management practices fragment the straw more than the desiccated management, presenting better rates, providing better light penetration and higher homogeneity of temperature and humidity in the area, and creating a microclimate favorable to crop emergence (Trogello *et al.*, 2013). No significant differences were observed in ERI for the different management practices of cover crops when the furrow opener shank was used.

The slicing of furrow opener levels within management practices showed no significant differences between furrow openers for the rolled and crushed management practices. However, the shank provided a higher ERI value (10.65) than the disk (7.73) in the desiccated management. This result is related to a combination of the condition of upright straw (desiccated management) and the way the furrow openers work, that is, the double disk cuts the straw and opens a furrow of smaller widths, leaving more shade with straw, while the shank opens the furrow by breaking of soil, increasing tillage and furrow width, leading to better conditions for crop emergence.

Table 3: Emergence rate index (ERI) and final plant stand (FPS) of corn as a function of fertilizer furrow opener mechanisms and black oat management methods

Management	ERI (%)		FPS (plant ha^{-1})	
	Double disk	Haste	Double disk	Haste
Rolled	9,07 ABa	9,86 Aa	90.370,36 ABa	100.370,36 Aa
Desiccated	7,73 Bb	10,65 Aa	81.111,10 Bb	101.851,84 Aa
Crushed	9,45 Aa	9,22 Aa	94.814,80 Aa	94.814,80 Aa
Management	**ED (mm)**		**PROD (kg ha^{-1})**	
Rolled	42,45 Bb	45,30 Aa	7.557,32 Ab	9.330,10 Aa
Desiccated	44,68 Aa	44,93 Aa	8.080,16 Aa	8.210,04 Aa
Crushed	43,29 ABb	45,40 Aa	7.475,93 Ab	9.302,68 Aa

Means followed by the same uppercase letter in the row and lowercase letter in the column do not differ from each other by Tukey's test at a 5% probability of error (F-test, $p < 0.05$).

The double disk furrow opener presents significant differences with a lower final plant stand in the desiccated management and a higher plant stand in the crushed management, which does not differ from the rolled management (Table 3). The use of the shank did not provide statistical differences in the management practices. The rolled and crushed management practices did not differ between furrow openers, but there were significant differences for the desiccated management, which presented a lower stand with the use of the double disk compared to the shank. Importantly, only this treatment showed the expected final plant stand (around 80,000 plants ha^{-1}). The other treatments had plant stands above expectations. Probable explanations for these results may be related to the good distribution of rainfall during the corn crop cycle, causing all seeds deposited in the soil to germinate, thus allowing for a final plant stand higher than expected.

The final plant height did not show significant differences for the applied treatments, with a mean height of 2.43 m. According to Pioneer data, the hybrid studied here (P2719VYH) can present a mean plant height and an ear insertion height of 2.30 and 1.20 m, respectively. We found higher means for both plant height and ear insertion height, which may be associated with favorable water conditions for the crop.

The final stem diameter showed no significant differences for the applied treatments, with a mean of 22.82 mm. The stem diameter has an important role for corn plants, because it acts in the storage of soluble solids that will be used later in the formation of grains (Souza *et al.*, 2016).

A thin stem is an undesirable characteristic in the corn crop, which facilitates the breakage and lodging of plants when associated with higher plant heights. According to Pereira *et al.* (2020), the smaller stem diameter is unfavorable to grain productivity, as this is a reserve organ of the plant that accumulates nutrients that will later be translocated to the grain filling in the ear.

Ear insertion height was not influenced by the applied treatments, with a mean of 1.41 m. This component was probably more subject to physiological and morphological changes in the plant, showing a correlation between ear insertion height and plant height so that taller plants also have higher ear insertions (Silva & Dalchiavon, 2020). Thus, it is natural that ear insertions in this experiment are higher since the plants reached 2.43 m in height.

Plant height and ear insertion height are responsible for an increase in lodging and broken plants, which can reduce grain yield. Thus, a lower ear insertion height and plant height are desirable characteristics for the corn crop, providing better plant balance and preventing stem breakage and lodging (Kappes *et al.*, 2014). However, Borghi *et al.* (2013) pointed out that taller plants with a higher ear insertion height are better for mechanized harvesting.

The number of rows per ear (NRE) and the number of grains per row (NGR) showed no significant differences for the applied treatments, with mean values of 13.85 rows per ear and 37.10 grains per row. Valderrama *et al.* (2011) observed that the number of rows per ear and the mean number of grains per row were not influenced by seasons and black oat management practices, demonstrating that these components of corn production are less dependent on management and more subject to the crop genetic potential, as probably observed in the present study.

Ear length (EL) showed significant differences only for furrow openers, standing out the use of shank, which presented a mean of 17.33 cm, while the double disc had a mean of 16.26 cm. Larger ear lengths are usually found in smaller plant populations due to less competition for water, light, and nutrients. However, it was not observed in this experiment since the use of shank provided the largest plant stands. It is possibly associated with the fact that the shank had a higher tilled area and seed deposition depth, improving soil-seed contact conditions, favoring better root development, and leading to a better plant establishment and development, which positively affected this component.

Ear length is one of the components that can influence the number of grains per row and grains per ear, affecting corn productivity, as the larger the ear length, the higher the potential number of grains to be formed (Goes *et al.*, 2012). In this experiment, the number of grains per row and grains per ear were not influenced by treatments or specific components, such as ear length in this case. However, ear length acted positively on productivity.

The desiccated management had the largest ear diameter (44.68 mm) when using the double disk furrow opener, not significantly differing from the crushed management (43.29 mm) (Table 3). Significant differences were not observed between management practices with the use of shank. The slicing of furrow openers within management practices showed no statistical difference between shank and double disk for the desiccated management. However, the rolled and crushed management practices showed significant differences, with higher means when using the shank.

The highest means of ear diameter were observed under the use of shank, reaching better indices for the crop development, supported by the factors that also caused the ear length component to be higher with this furrow opener. The desiccated management under the use of double disk also did not differ from the shank, as this treatment presented the lowest plant stands, reducing competition between plants, which generates a compensation mechanism.

The thousand-grain weight (TGW) was not significant for the applied treatments, with a mean of 299.19 g. Brachtvogel *et al.* (2009) observed that the plant stand can lead to a reduction in the thousand-grain weight of corn due to intraspecific competition by the plants. In this study, plant stands showed significant differences for the used furrow openers, but they were not factors that acted on the thousand-grain weight.

Non-significance of the weight of a thousand grains as a function of the treatments may be related to the precipitation that was well distributed in all stages of the crop, and this contributed to the excellent performance of the phenological indices of corn, as shown in Figure 2. According to Kopper *et al.* (2017), this component is directly affected by the number of grains in the ear, being inversely proportional, with a higher allocation of photoassimilates to the remaining grains as the number of grains in the ear decreases, providing higher weight. However, the experimental conditions showed no effect on the number of grains per ear, thus not influencing the thousand-grain weight.

The double disk showed significant differences for productivity in the management practices, with higher productivity for the desiccated management, while the rolled and crushed management practices had the lowest means, not differing from each other (Table 3). The shank provided no statistical differences in the management practices but provided the highest means of productivity.

The evaluation of the furrow openers within management levels showed that the desiccated management did not present differences for the furrow openers, while rolled and crushed management practices provide higher productivity when using the shank relative to the double disk. It is associated with the fact that the shank also presented the best sowing conditions (higher TA and SD), which allowed a better penetration of the roots into the soil at higher depths, enabling higher absorption of water and nutrients. The shank provided even better initial plant development, with higher ERI and FPS, which allowed the corn to reach higher productivity compared to the double disk when associated with the largest ear length and ear diameter.

The use of a double disk associated with the desiccated management also achieved productivity that did not differ from the shank. It is related to the fact that this treatment pointed to the lowest stands, which allowed the plants to develop without intraspecific competition, producing a compensation mechanism and generating gains at the end of the crop cycle.

The use of shank led to productivity close to that of the State of Paraná, with a value of 9,484 kg ha^{-1} in the 2019/2020 season (Conab, 2020). A limiting factor that influenced productivity was the final stand, which was much higher than expected, leading to competition between plants for light, water, and nutrients.

Mello *et al.* (2003) reported that the shank furrow opener mechanism increased grain productivity by 11.3% for corn compared to the double disk furrow opener mechanism, justifying the result by the ability of the shank to break through the soil more easily, reducing soil density and penetration resistance and increasing macroporosity. Modolo *et al.* (2013) worked with corn and also observed higher productivity trends with the use of a shank compared to the disk.

CONCLUSIONS

The shank furrow opener presented a higher influence on the furrow depth, furrow width, tilled area, and sowing depth than the double disk.

The crop development components were not influenced by furrow opener mechanisms and oat straw management practices.

The crop was more influenced when using the shank furrow opener, showing better conditions for crop development and establishment, with higher productivities.

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Authors declare there is no conflict of interests in carrying the research and publishing this manuscript.

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