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Short communications

Productivity and phytotechnical parameters of corn grown on different cover plants

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Abstract

Brazilian agriculture faces the challenge of adopting sustainable practices that reduce costs and mitigate environmental impacts. The use of cover crops stands out as an efficient alternative to improve soil conditions and increase the productivity of subsequent crops. This study aimed to evaluate the effects of different cover crops on the productivity and phytotechnical characteristics of corn. The experiment was carried out in a completely randomized design, with four replicates, considering the following treatments: sorghum (*Sorghum* sp.), brachiaria (*Brachiaria ruziziensis*), crotalaria (*Crotalaria juncea*), fallow and no cover. The production of green mass of the covers, plant height, stem diameter, number of grains per ear, 1000-grain weight and productivity were evaluated. Sorghum showed the highest biomass production (96,498.5 kg ha^{-1}), while fallow was the least efficient. Cover crops provided better corn performance in height, number of leaves, stalk diameter, productivity and thousand-grain weight, compared to areas without cover or fallow. Sunn hemp stood out for biological nitrogen fixation, while brachiaria and sorghum reduced weed infestation and improved water retention. In fallow or uncovered areas, corn had a stalk diameter up to 6.42 mm smaller and productivity reduced by up to 3,827.47 kg ha^{-1}, compared to the best treatments. The results demonstrate the benefits of cover crops, promoting sustainable management and increasing corn productivity and resilience, especially in regions with edaphoclimatic challenges.

Keywords: Plant biomass, soil management, cover crops, corn productivity, agricultural sustainability, *Zea mays* (L.).

Introduction

Brazilian corn (*Zea mays* (L.)) grain production has undergone significant changes over the years, with a significant increase in production during the 2nd harvest (winter) and 3rd harvest (off-season), to the detriment of the 1st harvest (summer harvest). Between the 2013/14 and 2023/24 harvests, there was a 44.57% increase in total corn production. During this period, production of the 1st harvest suffered a reduction of approximately 8.69 million tons, while the 2nd harvest showed an increase of 41.86 million tons. Production of the 3rd harvest, recorded since the 2019/20 harvest, grew by 42.54% (Companhia Nacional de Abastecimento [CONAB], 2025a).

For the 2023/24 harvest, production is estimated at 22.96 million tons in the 1st harvest, 90.26 million tons in the 2nd harvest and 2.48 million tons in the 3rd harvest (CONAB, 2025b). Although corn production is significant, sandy soils, which account for 20% of the areas undergoing agricultural expansion in Brazil, present specific challenges. These soils have low water retention capacity, low fertility and high susceptibility to erosion (Santos, Viana, Batista, Resende, & Albuquerque-Filho, 2023; Loro et al., 2024; Santos et., 2024).

States such as Mato Grosso, Tocantins, Piauí and Bahia, which make up the region known as MATOPIBA, play a crucial role in this agricultural expansion. In 2023/24, the states of Piauí and Bahia together accounted for 14% of the national corn production of the 1st harvest, while Mato Grosso was responsible for 52% of the production of the 2nd harvest, and Bahia contributed with 48% of the production of the 3rd harvest (United States Department of Agriculture [USDA], 2024). Much of the agricultural expansion in this region occurs in areas of cerrado, characterized by sandy and low-fertility soils, combined with a lower water regime with more frequent presence of dry spells.

Increased production combined with changes in seasonal patterns, with greater concentration in periods of greater climate risk, brings new challenges to crop sustainability. Water stress is one of the main limiting factors, negatively affecting corn growth, development and productivity (Silva et al., 2023).

In this context, management technologies, such as straw cultivation, have emerged as efficient solutions to mitigate these problems. *Brachiaria ruziziensi*, used as a cover crop, is an excellent option for improving soil attributes. It is a rustic species with a high biomass production capacity, which increases the soil's organic matter content, improving its health and fertility (Serafim et al., 2023).

Furthermore, this crop is resistant to phytonematodes such as *Meloidogyne enterolobii* and *Meloidogyne incognita*, contributing to integrated pest management (Lopes, Pereira, Baquião, Amorin, & Wilcken, 2023). The adoption of cover crops has shown a positive impact on corn yield, promoting greater water retention in the soil and better crop development, even under the same irrigation conditions. In similar production systems, an increase in the productivity of other crops was observed, such as wheat, which showed a 12% increase due to the greater water retention provided by cover crops (Zhang et al., 2023).

In the corn-sorghum cropping system, focused on silage, the use of cover crops during the winter has improved soil health, promoting microbial activity even under adverse conditions, such as high temperatures and water stress (Acharya, Ghimire, & Acosta-Martínez, 2024). In addition, cover crops reduce weed density and, in some cases, have allelopathic properties, as is the case with sorghum (Ullah, 2022).

The use of legumes under straw has also been shown to be effective in increasing soil nitrogen content, resulting in improved production systems and reduced dependence on chemical inputs (Leoni, Lazzaro, Carlesi, & Moonen, 2024). However, in Brazilian systems, where soybean-corn succession is predominant, the use of legumes in the off-season may not be ideal for integrated pest and disease management. Crotalaria, however, emerges as a viable alternative due to its biological nitrogen fixation capacity, biomass production, and antagonistic effect on phytonematodes (Barbosa, Santana, Mauad, & Garcia, 2020).

Therefore, the objective of this study was to evaluate the effects of cover crops on the production components and phytotechnical characteristics of corn.

Materials and Methods

This study was carried out in the experimental area of the Agronomy course at the University of Philadelphia (UniFil), located in the city of Londrina, PR (altitude of 550 meters, latitude 23º39' S and longitude 51º18' W), from December 2017 to August 2018. The climate of the region, according to the Köppen classification, is Cfa, humid subtropical, with rainfall distributed throughout the year, although droughts may occur in winter. The average monthly temperature varies between 25.5 °C in the hottest month and 16.4 °C in the coldest.

The soil of the experimental area is classified as a dystroferric Red Latosol of EMBRAPA, with a very clayey texture and flat relief. In the 0-20 cm layer, the soil contains 140 g kg^{-1} of sand, 120 g kg^{-1} of silt and 740 g kg^{-1} of clay. Initial management of the area included application of the herbicides Select® (0.5 L ha^{-1}), DMA® (1.5 L ha^{-1}) and glyphosate (2 L ha^{-1}), together with mineral oil (0.5% of the application volume), followed by harrowing. After management, soil samples were collected and subjected to chemical analysis, as described in Table 1.

Table 1. Chemical analysis of soil in the 0-20 cm layer.

pH	P	MO	H+Al	Al	Here	Mg	K	SB	T	V
	mg.dm-3	g.dm-3	-------------------------- cmolc.dm-3 ----------------------							%
4.90	5.5	23.18	6.68	0.04	5.12	1.85	0.71	7.68	14.36	53.48

Source: Authors.

The experimental design was completely randomized (CRD), with five treatments and four replicates, totaling 20 plots. Each plot had an area of 25 m² (5 m x 5 m). The treatments consisted of five types of soil cover: sorghum (Sorghum sp.), brachiaria (*Brachiaria ruziziensis*), crotalaria (Crotalaria juncea), fallow and no cover.

Cover crops were sown on December 18, 2017. In the "fallow" treatment, spontaneous vegetation was allowed to grow. In the "no cover" treatment, spontaneous vegetation was controlled by fortnightly weeding. The sowing density was 42 plants per meter for brachiaria, 28 plants per meter for crotalaria and 18 plants per meter for sorghum, all sown manually or with a rattle.

Seventy days after sowing, the production of green mass was evaluated. Collections were made at two random points per plot (1 meter in the sowing line or, in the case of fallow, in areas of 0.5 m x 0.5 m). After weighing, the samples were returned to the respective plots. Management of the covers was concluded with mowing and desiccation using glyphosate (2 L ha^{-1}).

On March 24, 2018, the corn hybrid MG 30A37® PW was sown. The row spacing was 0.45 m, with a final population of 55,000 plants ha^{-1} after thinning. The base fertilization included 400 kg ha^{-1} of NPK (10-15-15), while the topdressing was carried out with 1,000 kg ha^{-1} of ammonium sulfate, divided equally between the V3 and V7 vegetative stages.

The variables analyzed in corn included plant height, number of leaves, stalk diameter, number of rows per ear, number of grains per ear, productivity and weight of 1,000 grains. Statistical analysis was performed in using R software (R Core Team, 2024), using the Scott-Knott test (5% probability), after validation of the assumptions for ANOVA.

Results and Discussion

The use of sorghum, brachiaria or crotalaria as ground cover positively impacted the vegetative characteristics of the studied corn hybrid and resulted in increased productivity compared to cultivation in soil without plant cover or in fallow areas. The most common spontaneous plants under these conditions were: black beggarticks (*Bidens pilosa*), rubim (*Leonorus sibiricus*), bitter grass (*Digitaria insularis*), morning glory (*Ipomea* sp.) and horseweed (*Conyza bonariensis*).

There was a statistically significant difference in green mass production among the tested soil covers (Table 2), with sorghum cultivation accounting for the highest mass production (96,498.50 kg ha^{-1}). On the other hand, fallow resulted in the lowest mass production among the treatments, while brachiaria and crotalaria did not differ from each other, but differed from the other treatments. This difference in biomass production among the covers was expected due to the intrinsic differences between the species tested.

Table 2. Green mass produced by different treatments (kg ha^{-1}).

Cover plant	Green Mass (kg ha-1)
Sorghum	96,498.50 a[1]
Brachiaria	56,277.25 b
Crotalaria	51,627.00 b
Fallow	12,111.00 c
CV (%)	27.23

[1]Means followed by different lowercase letters in the same column differ from each other by the Scott-Knott test at 5% probability.

In the variables related to the vegetative growth of the corn hybrid (plant height, number of leaves and stem diameter), a statistically significant difference was observed (Table 3). The treatments with sorghum, brachiaria and crotalaria cover presented better results and did not differ from each other, while fallow and the absence of cover were inferior, except for the stem diameter, which was significantly lower in the fallow.

Table 3. Vegetative indicators of corn hybrid under different soil covers.

Treatments	Plant height (m)	Number of sheets	Culm diameter (mm)
Sorghum	1.91 a[1]	14.04 a	19.17 a
Brachiaria	1.93 a	14:00 a	18.12 a
Crotalaria	1.96 a	14.21 a	19.25 a
Fallow	1.52 b	13.46 b	12.83c
Lack of coverage	1.51 b	13.50 b	14.29 b
CV (%)	6.93	2.44	4.41

[1]Means followed by different lowercase letters in the same column differ from each other by the Scott-Knott test at 5% probability.

The results suggest that greater green mass production alone does not guarantee improvements in corn cultivation, as evidenced in the case of sorghum, which, although it produced greater biomass, did not differ from other cover crops in the vegetative variables evaluated. Thus, biomass quality and chemical composition play a crucial role. Studies indicate that crotalaria has a high concentration of nitrogen, a result of biological fixation in its vegetative structures. According to Barbosa et al. (2020), *Crotalaria juncea* and *C. spectabilis* accumulate nitrogen in all parts of the plant, in addition to being rich in potassium and phosphorus, which, during decomposition, benefits crops such as corn, which require high levels of these nutrients.

The reduction in stem diameter and plant height in fallow areas or areas without vegetation cover was expected, as these conditions expose the soil to adverse environmental factors and reduce microbial activity. According to Frasier, Quiroga and Noellemeyer (2016), in systems with low addition of plant residues, soil degradation is accelerated, but it can be minimized with the use of cover crops that improve the physical and biological attributes of the soil.

The results of this study show that corn grown in fallow soil showed a reduction of up to 6.42 mm in stem diameter compared to corn grown under crotalaria cover, both under the same management conditions. This corroborates the findings of Wick et al. (2017), who stated that soil covers improve soil health by favoring water infiltration, aggregate formation and decompaction, in addition to increasing microbial activity.

In the present experiment, although the interactions between the root system of cover crops and the soil were not evaluated, there was an increase of up to 0.40 m in the height of corn plants under sorghum cover compared to soil without cover. Studies such as that by Thapa, Ghimire, Acosta-Martínez, Marsalis and Schipanski (2021), carried out in a semiarid environment, indicated positive interactions between the soil microbiota and winter cover crops, showing benefits compared to fallow areas.

Regarding the production components, there was no statistically significant difference for the number of rows of grains per spike between treatments (Table 4). However, other characteristics, such as the number of grains per row, number of grains per spike, weight of 1,000 grains and productivity, were significantly higher in the treatments with sorghum, brachiaria and crotalaria, with no difference between them. On the other hand, fallow and absence of cover presented inferior results and did not differ from each other.

Table 4. Corn hybrid production indicators under different treatments.

Treatments	NFE	NGF	NGE	P1000G (g)	PROD (kg ha-1)
Sorghum	15.17 a[1]	33.33 a	506.61 a	305.53 a	7,962.69 a
Brachiaria	15.75 to	33.04 a	520.10 a	287.01 a	7,588.24 a
Crotalaria	15.42 a	34.04 a	524.75 a	287.46 a	7,711.88 a
Fallow	15.00 to	21.29 b	321.56 b	257.76 b	5,173.15 b
Lack of coverage	14:00 a	21.00 b	294.07 b	241.15 b	4,135.22 b
CV (%)	4.99	6.10	8.45	5.47	12.42

[1]Means followed by different lowercase letters in the same column differ from each other by the Scott-Knott test at 5% probability.

The number of rows of grains per ear did not show significant difference between treatments, which is justified by the fact that this characteristic is a genetic characteristic of the hybrid used. According to Morgan (2025), hybrid 30A37 has between 14 and 16 rows of grains, which was observed in the experiment. However, soil cover with sorghum, brachiaria or crotalaria resulted in a greater number of grains per row, reflecting in a greater number of grains per ear, with consequently greater productivity.

The improvement in vegetative and production characteristics resulted in a significant difference in corn productivity, with an increase of 3,827.47 kg ha^{-1} between the sorghum treatment and the control without cover. This highlights the benefits of using efficient covers, which promote better use of soil nutrients, including those left by previous crops. During straw decomposition, these nutrients are gradually released for the subsequent crop. Leite et al. (2024) observed that, in soybean and cover crop succession systems, covers increase the availability of phosphorus at depth, due to the decomposition of the plant root system.

In general, with the exception of the number of rows of grains per ear, the corn hybrid showed lower performance in the vegetative and production variables in the treatments with fallow soil, with only weeds, and in the soil without plant cover. It was expected that the soil without cover would show lower performance than the other treatments, due to the lack of protection and the reduction of the physical and biological attributes provided by the straw. However, the results indicated that the fallow, although with weeds forming a small layer of straw, did not differ statistically from the soil without cover.

A possible explanation for this fact is the presence of allopathic substances in weeds. According to Santos and Cury (2011), the black beggartick has polyacetylene in its biomass, and its roots release several organic acids such as oxalic, citric, malic, butyric and acetic, which can generate allopathic substances that are harmful to the system. During the development and decomposition of these plants, these substances can harm the growth of the subsequent crop. In the present experiment, a statistically significant difference was observed in the stem diameter between the soil under fallow and the other treatments, with the diameter being smaller in the fallow, which confirms the negative effect of the presence of weeds.

Conclusions

Sorghum produced the highest biomass, followed by Brachiaria and Crotalaria, with fallow presenting the lowest production. Cover crops improved the vegetative characteristics of corn, such as height, number of leaves and stem diameter, compared to fallow and the absence of cover. Crotalaria stood out for nitrogen fixation.

Corn grown under fallow or without cover had inferior performance, with a significant reduction in stalk diameter and productivity. The difference in green mass production between cover crops and fallow was statistically significant.

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