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BIOFERTILIZER AND REDUCTION OF WATER LOSSES IN SOIL CULTIVATED WITH TOMATO IRRIGATED WITH MODERATELY SALINE WATER

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Abstract
In semi-arid regions, agricultural production is often limited due to scarcity and rainfall irregularities, and, therefore, the production system depends on irrigation. In this direction, the research aimed to evaluate the influence of the reduction of water losses in the soil through the coating of the lateral faces of the planting furrows with plastic film, by lateral infiltration of water and bovine biofertilizers for growth in height, production, and chlorophyll responses of tomato cv. Fascínio F1 irrigated with moderately saline water. The experiment was carried out in randomized blocks, in a 2 × 3 factorial scheme, with 4 replicates and 21 plants per plot. Different conditions were used and compared with each other: the furrow had side coating or not, and the soil received a common biofertilizer (fresh lactating bovine manure), chemically enriched fertilizer (common biofertilizer, milk, molasses, and gypsum), or no fertilizer at all. The variables evaluated were soil moisture, plant height, *a*, *b,* and total chlorophyll content, number and average fruit mass, tomato production, and productivity. The enriched bovine biofertilizer associated with the lateral furrow coating increased the synthesis of chlorophyll pigments, the number of fruits per plant, and the productivity of tomato cv. Fascínio F1. Protecting the faces of the furrows against water losses from the root environment of plants keeps the soil moist, stimulates the synthesis of chlorophyll, and increases the average mass of the fruits. The common bovine biofertilizer promotes greater growth in plant height, and the chemically enriched biofertilizer increases the average weight of tomato fruits.

Keywords: Organic Input. Plastic Film. *Solanum lycopersicum* L. Water Salinity.

1. Introduction

Tomato (*Solanum lycopersicum* L.) is a horticultural species originating in the Andes region in South America; currently being cultivated worldwide, with food functions for consumption *in natura*, or processed in the form of sauce (Agius et al. 2022). The culture is explored in almost all regions of Brazil. In northeast Brazil it is cultivated by small and medium producers in the states of Bahia, Ceará, and Pernambuco with relevant socioeconomic importance for the region (Gama et al. 2020).

In the Brazilian semi-arid regions, in addition to the limitations of climatic factors—such as irregular rainfall, low rainfall, and high air temperatures—the quality of surface and underground water sources often presents levels of salts that restrict the agricultural production of many crops, including tomato (Cavalcante et al. 2005; Zörb et al. 2019; Oliveira et al. 2022). Regarding salinity, tomato is considered moderately sensitive, presenting losses in production when irrigated with water of 2.3 dS m^{-1} or higher (Ayers and Westcot 1999; Paiva et al. 2018).

In an attempt to reduce the problem of water deficit and the deleterious effects of salts, techniques must be adopted to reduce water losses from the soil associated with the use of substances exerting a mitigating action from salts to plants. In this sense, the lateral furrow coating reduces water losses in the root environment, keeping the soil more humid for the dilution of salts into plants (Lima Neto et al. 2013). Biofertilizers of bovine origin, according to Alves et al. (2019), mitigate the depressive effects of salt stress, promoting the growth and productive capacity of plants.

The practice of reducing water losses from the soil, keeping it moist, and using the lining of the pits and furrows with plastic film has shown promise in the cultivation of yellow passion fruit *Passiflora edulis* Sims (Cavalcante et al. 2005) and the pepper *Capsicum annuum* (Lima Neto et al. 2013, 2021). The main benefits of plastic film in soil for plants are the reduction of nutrient losses—mainly nitrogen and potassium (Guo et al. 2019), water losses through lateral flow (Zhao et al. 2018; Lima Neto et al. 2021), and maintenance of a wetted soil in the root absorption zone, promoting greater absorption of water and nutrients, with productivity gains (Dukare et al. 2021; El-Beltagi et al. 2022).

Organic inputs in the soil, such as bovine biofertilizers, can contribute to a greater attenuation of salinity in plants due to the humic substances present in their composition, providing an osmotic gradient between the roots and the soil solution that is favorable for the absorption of water and nutrients (Alves et al. 2019). In addition, bovine biofertilizers can improve the chemical, physical, and biological properties of the soil (Cavalcante et al. 2019; Cajamarca et al. 2019), with positive actions on the nutritional status of plants (Santos et al. 2019; Diniz et al. 2020) and the production of cultures (Lima et al. 2018; Sales et al. 2019; Santos et al. 2019; Lima Neto et al. 2021; Pereira et al. 2021).

Due to the benefits of the plastic film and the bovine biofertilizer, both applied simultaneously should contribute to the improvement of soil properties, leading to greater tomato growth and productivity. The objective of this study was to evaluate the influence of plastic film on the reduction of water losses from the soil and bovine biofertilizers on growth, chlorophyll synthesis, and the productive capacity of tomato hybrid cv. Fascínio F1 irrigated with moderately saline water.

2. Material and Methods

The experiment was carried out from September 2016 to February 2017 at the Estrondo site located in the municipality of Nova Floresta, State of Paraíba, Brazil. The municipality is georeferenced by the coordinates: 6° 26′ 40″ South and 36° 12′ 04″, West and is located at an altitude of 669 m. The region's climate is classified As, according to Köppen (Alvares et al. 2013), corresponding to hot and dry, with concentrated rains between March and July.

The soil in the experimental area was classified as an Oxisols (Santos et al. 2018). Before the installation of the experiment, simple soil samples were collected at depths of 0.0–0.15 and 0.15–0.30 m, homogenized, and transformed into a composite sample to evaluate physical and chemical attributes regarding fertility (Teixeira et al. 2017) and salinity (Richards, 1954) (Table 1).

The experiment was carried out in randomized blocks, in a 2 × 3 factorial scheme, including soil without biofertilizer, with common biofertilizer, and with enriched biofertilizer. Grooves with and without lateral protection against water losses with black polyethylene plastic film were used, with 4 replicates and 21 tomato plants per experimental unit, totaling 504 experimental units.

The plant material was tomato (*Lycopersicon esculentum* Mill.) hybrid cv. Fascínio F1, which presents a harvest point varying from 80 to 110 days, a determined growth habit, resistance or tolerance to ToMV, ToTV, F-0-1, V, Va, Vd, N, Ma, Mi, Mj, and TYLCV. It possesses various post-harvest characteristics: fruit mass ranging from 150 to 180 g, excellent flavor, a high ºBrix, a productivity of approximately 30 t $ha^{-1,}$ and suitable for commercialization in the fresh fruit market.

Table 1. Chemical attributes regarding soil fertility, salinity, and physics in the experimental area.

Chemical attributes						
Depths (m)	pH	P	K^+	Ca^{2+}	Mg^{2+}	Na^+
	H_2O (1:2.5)	mg dm^{-3}	----	cmol$_c$ dm^{-3}	----	
0.00–0.15	6.44	25.48	0.29	3.25	1.00	0.40
0.15–0.30	6.49	9.56	0.84	2.85	0.85	0.16
Depths (m)	H^++ Al^{3+}	Al^{3+}	CEC	SB	V	OM.
	----	cmol$_c$ dm^{-3}	----		%	mg dm^{-3}
0.00–0.15	1.40	0.00	6.35	4.95	77.95	10.27
0.15–0.30	1.73	0.00	5.78	4.05	70.12	6.81
Physical attributes						
Depths (m)	Sd	Pd	Tp	Sand	Silt	Clay
	----g cm^{-3}----		m^3 m^{-3}	----	g kg^{-1}	----
0.00–0.15	1.64	2.68	0.39	580	135	285
0.15–0.30	1.66	2.68	0.38	617	192	191
Depths (m)	DF	DI	CDW	U_{fc}	U_{pwp}	Aw
	----%----		----	g kg^{-1}	----	
0.00–0.15	72.3	27.7	79	83.2	33.2	50.0
0.15–0.30	86.4	13.6	26	95.7	38.7	57.0
Classification	Sandy clay loam					

pH = Hydrogen potential; P and K^+ = Phosphorus and potassium, Mehlich-1 extractor; Ca^{2+}, Mg^{2+}, Na^+ = Calcium, magnesium, and sodium, KCl extractor 1 mol L^{-1}; H^+ + Al^{3+} and Al^{3+} = Potential acidity and exchangeable aluminum, calcium molate extractor 0.5 mol L^{-1}; Potential acidity and exchangeable aluminum, calcium molate extractor 0.5 mol L^{-1} pH 7.0; SB = Sum of bases (Ca^{2+} + Mg^{2+} + K^+ + Na^+); CEC = Cation Exchange Capacity [SB + (H^+ + Al^{3+})]; V = Percentage of exchangeable base saturation [V = (SB/CEC)×100]; OM = Organic matter, Walkley-Black method; Sd = Soil density; Pd = Particle density; Tp = Total porosity; DF = Degree of flocculation; DI = Dispersion index; CWD = Clay dissolved in water; U_{fc} = Soil moisture at field capacity; U_{pwp} = Soil moisture at permanent wilt point; AW = Available water.

The seedlings were prepared in polyethylene trays in the second half of September 2016 and transplanted 28 days after sowing, with a spacing of 1.5 m between rows and 0.5 m between plants, corresponding to 21 plants per plot, the 10 central plants being considered as a "useful" plot.

Before the installation of the experiment, 2 harrows were made after plowing in the soil of the experimental area; then, the furrows were opened 10 m long, 0.3 wide, and 0.3 m deep and spaced 1 m apart. After placing the black polyethylene film on the side faces of the grooves, leaving the lower part free for water drainage, the pits were prepared in the dimensions of 0.30 × 0.30 × 0.30 m and 3.87 kg of bovine manure provided per pit, with 5% humidity, to raise the average organic matter content of the soil from 8.54% to 9.00%, in the 0–0.30 m layer.

The preparation of the common biofertilizer consisted of anaerobic fermentation of 100 L of fresh lactating cow manure and 100 L of nonsaline and nonchlorinated water in a biodigester with a capacity of 240 L. The chemically enriched biofertilizer was prepared in the same proportions of fresh bovine manure and nonsaline and nonchlorinated water as the common biofertilizer, adding 2 kg of agricultural gypsum (28% CaO and 17% S), 2 kg of MB-4 rock powder (5.9% CaO, 17.8% MgO, 1.4% Na_2O, and 0.84% K_2O), 4 L of cow milk, and 4 L of sugarcane molasses.

To release the methane gas produced during fermentation, a thin hose was connected at the top of the biodigester, and the other end of the hose was submerged in a plastic container containing water to prevent other gases from entering the biodigestion system. Biofertilizers were applied to the soil in liquid form; they were analyzed chemically (Richards, 1954) as if they originated from water for irrigation (Table 2).

The bovine biofertilizers—common and enriched—were applied manually at 16 L m^{-2} (Cavalcante et al. 2019) via the soil after a 1:1 dilution in water at 1 L plant^{-1} in 0.06 m^2. Two applications were made; the first one was a week before transplanting the seedlings and the second one at 60 days after transplanting (DAT), which coincided with the beginning of plant flowering. In conditions with no biofertilizer, water was applied in a volume equivalent to the mixture of bovine biofertilizers and water.

The plants were irrigated daily using the drip irrigation method: drip tape with emitters spaced 0.2 m apart at a flow rate of 7.5 L h^{-1} m^{-1}. The irrigation was supplied based on the evaporation of the class "A" tank installed at the experiment site. The amount of water applied in all treatments was equal to the evaporated layer on the previous day. The evapotranspiration of the culture was determined using the equation: ETc = Kc × ETo, where Kc represents the cultivation coefficient of the culture and ET_0 is the reference evapotranspiration. The tomato crop coefficients were 0.37 in the initial phase, 0.72 in the development phase, 1.03 in the intermediate phase, 1.10 in the final phase, and 0.75 at fruit harvest (Santana et al. 2011).

Table 2. Chemical characterization of irrigation water and biofertilizers applied to the soil in liquid form.

Chemical attributes							
	pH	EC	K^+	Ca^{2+}	Mg^{2+}	Na^+	Cl^-
		dS m^{-1}	mmol$_c$ L^{-1}				
Water	3.52	1.48	0.52	0.80	2.05	10.91	13.35
CB	6.77	6.19	11.19	22.25	18.25	11.22	43.83
EB	6.81	6.21	36.74	34.25	29.25	14.87	52.50
	CO_3^{2-}	HCO_3^-	SO_4^{2-}	SC	AS	SAR	Class
	mmol$_c$ L^{-1}					(mmol L^{-1})$^{0.5}$	
Water	A	A	0.78	14.28	14.13	9.17	C_2S_2
CB	9.19	A	8.84	62.91	61.86	2.49	C_4S_1
EB	3.84	12.49	45.86	111.11	114.69	2.64	C_4S_1

pH = Hydrogen potential; EC = Electric conductivity; A = Absence; SC = Sum of cations; SA = Sum of anions; RAS = Sodium adsorption ratio, SAR = $[Na^+ (Ca^{2+} + Mg^{2+})/2]^{1/2}$; ** = Classification according to Ayers and Westcot (1999); C_2 and C_4 = Medium and high risk of salinizing the soil, respectively; S_1 andS_2 = Low and medium risk of increasing soil sodicity, respectively.

Moisture was monitored weekly and directly on the soil, at a depth of 15 cm, 24 h after irrigation, using a portable digital meter type MP406 Moisture Probe at 3 points in each plot. Each point consisted of a station made of 50 mm PVC pipe with an internal diameter, fixed to the ground at a preestablished depth, located in the space between 2 plants.

At 70 DAT, height was measured with a millimeter ruler from the neck to the apex of the plants. At this age, when the plants were in full bloom, the diagnostic leaf was collected (Malavolta et al. 1997) to determine the concentrations of *a*, *b*, and total chlorophyll.

Subsequently, the sheets were packed in aluminum foil envelopes, refrigerated in a thermal container, and sent to the laboratory. Afterward, samples of vegetable tissue were taken from the middle third of each leaf with a hollow and obtained from fresh matter using a precision (p) analytical balance (p < 0.001 g). Next, the material was macerated and placed in aluminum foil-lined containers, adding 25 mL of 80% acetone and kept refrigerated at 8 °C for 24 h, and then the extracts were filtered on filter paper for 5 min (Arnon, 1949).

The absorbances of the extracts were obtained in an absorption spectrophotometer at the wavelengths of 470 (A_{470}), 647 (A_{647}), and 663 nm (A_{663}), using 80% acetone for the blank. In determining the concentrations of *a*, *b*, and total chlorophyll (Chl*a*, Chl*b*, Chl*t*, respectively), in mg g^{-1} of fresh matter. The equations described by Lichtenthaler (1987) were used:

$$\text{Chlorophyll } a \text{ (Chl}a) = (12.25 * A_{663})–(2.79 * A_{647})$$
$$\text{Chlorophyll } b \text{ (Chl}b) = (21.50 * A_{647})–(5.10 * A_{663})$$
$$\text{Chlorophyll } total \text{ (Chl}t) = (7.15 * A_{663}) + (18.71 * A_{647})$$

The harvest was done twice a week during the entire productive cycle of the tomato. The production components were the number of fruits per plant, average fruit mass, production per plant, and productivity.

The data were submitted to analysis of variance by the *F* test ($p \leq 0.05$), and the mean for bovine biofertilizers and the lateral furrow covering were compared by Tukey's test at a 5% probability level. The data were processed using the statistical software Sisvar version 5.6 (Ferreira 2019).

3. Results

The lateral furrow covering interfered significantly ($p < 0.05$) with the soil's volumetric moisture at a depth of 15 cm, increasing the volumetric water content in the soil by 2.2% with protection against water losses (Figure 1).

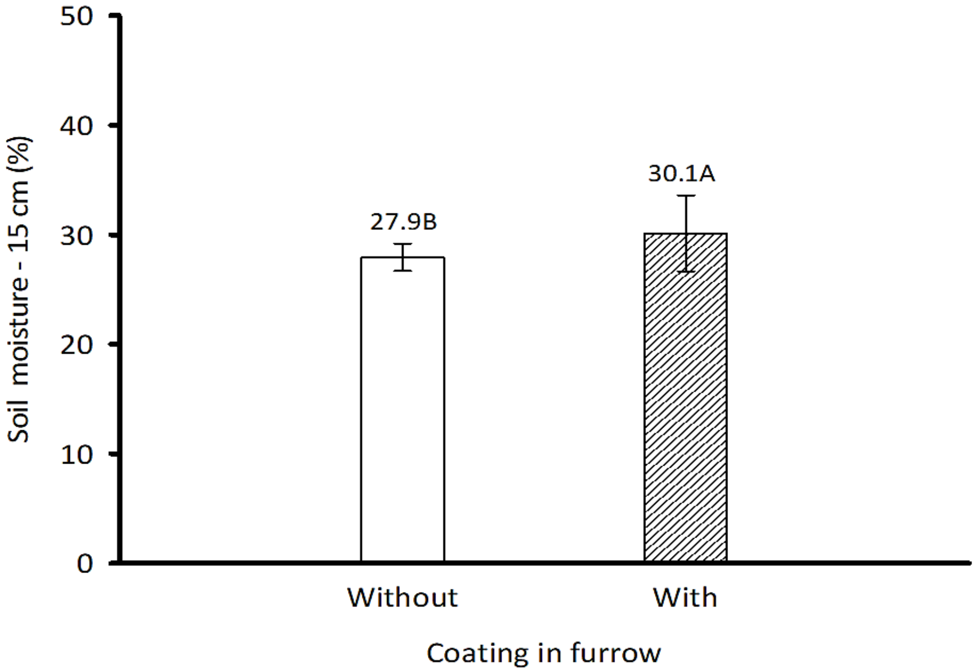

Figure 1. Volumetric moisture of soil cultivated with tomato hybrid cv. Fascínio F1 at a depth of 15 cm with and without lateral furrow covering.

The chemically enriched biofertilizer, despite containing milk, gypsum plaster, and sugarcane molasses, inhibited the growth of tomato plants compared to the soil with common biofertilizer that contains only fresh bovine manure and water and the control soil that had no fertilizer (Figure 2). Plants grown on soil with common biofertilizer or no fertilizer displayed a height of 19.8% and 10.8% superior to plants grown on soil with enriched fertilizer, respectively.

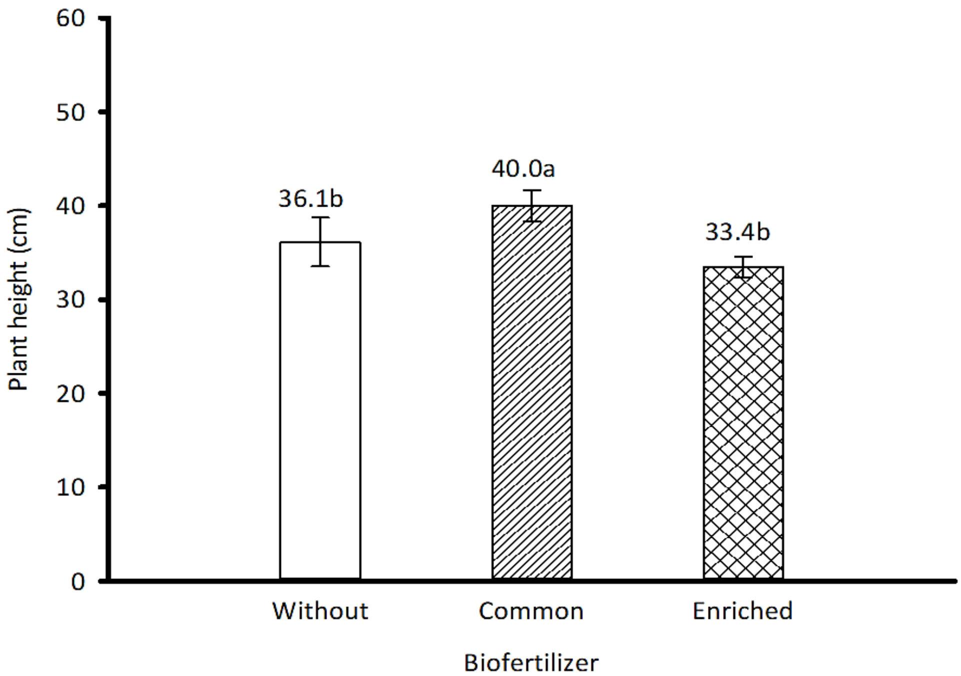

Figure 2. Height of tomato plants hybrid cv. Fascínio F1 on soil without or with bovine biofertilizers.

The chlorophyll contents responded ($p < 0.05$) to the biofertilizer and the lateral lining against soil water losses (Figure 3A). The side coating significantly increased the content of chlorophyll *a* in plants grown on soil with no biofertilizer and with enriched biofertilizer by 18.4% and 15.4%, respectively, compared to soil with no side coating. However, no difference was observed between plants grown on soil with no biofertilizer and those grown on soil with chemically enriched biofertilizer. Plants grown on soil without side coating and treated with common biofertilizer produced 11.5% and 18.4% more chlorophyl, respectively than plants grown on soil with enriched biofertilizer or no biofertilizer.

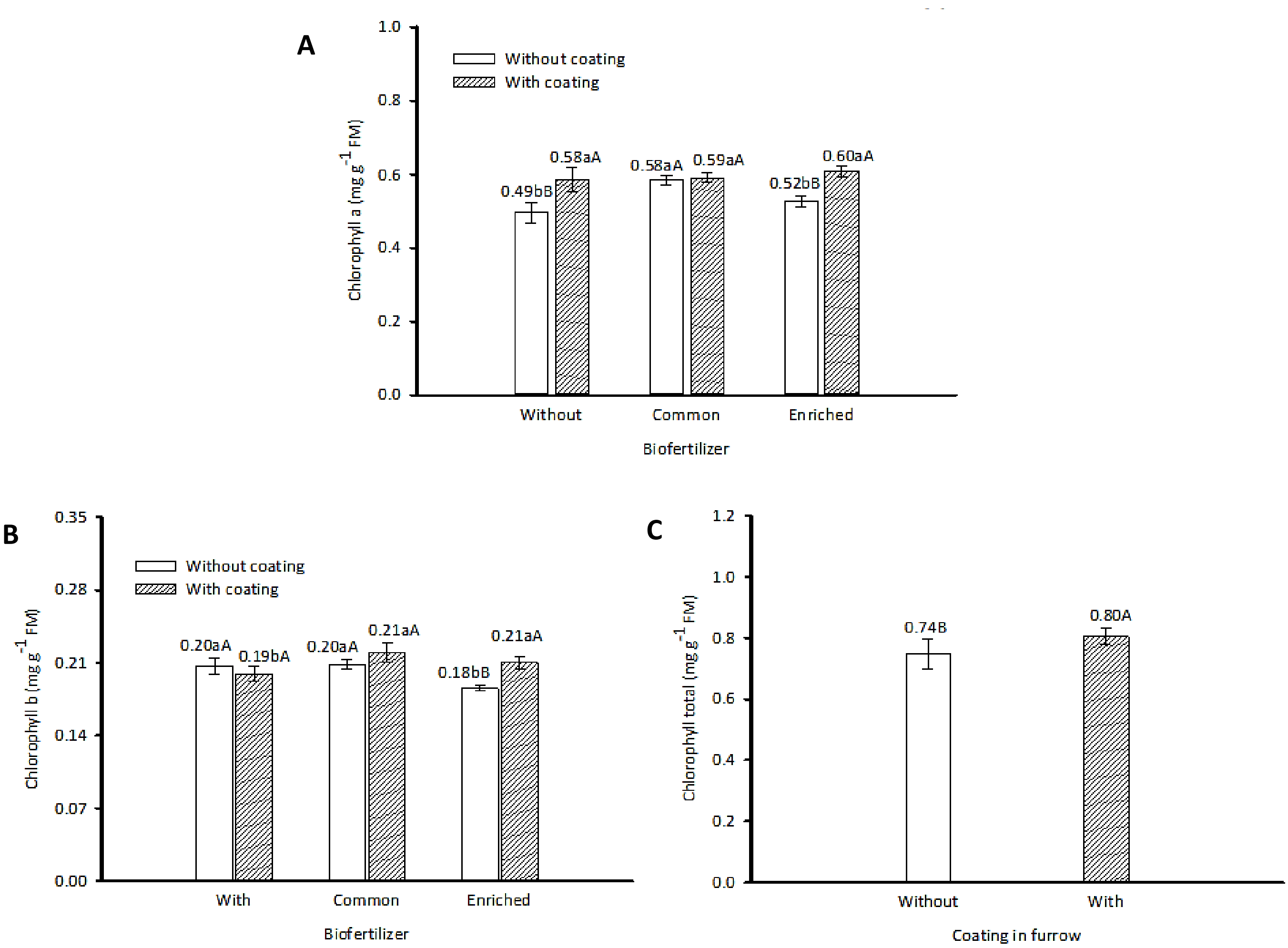

Figure 3. A - Leaf content in chlorophyll *a* and B - *b* of tomato hybrid cv. Fascínio F1 grown on soil with side coating and bovine biofertilizers, and C - total chlorophyll in tomato cultivated on soil with side coating only. Same lowercase letters indicate no significant difference between the biofertilizers within each furrow coating after Tukey's test ($p < 0.05$). Same capital letters indicate no significant difference between the furrow coatings within each bovine biofertilizer after Tukey's test ($p < 0.05$).

A response similar to that of chlorophyll *a* was verified for the contents in chlorophyll *b;* the tomato responded positively to the effects of the biofertilizer × protection against water loss from the soil (Figure 3B). The lateral furrow covering did not have significant effects on plants cultivated on soil with no fertilizer or with common biofertilizer but increased the leaf content in chlorophyll *b* in plants grown on soil with enriched biofertilizer by 16.7%. When comparing the effects of fertilizers on plants with side coating, the common biofertilizer outperformed the enriched biofertilizer by 10.5%. The lateral furrow covering increased the total chlorophyll content in tomato leaves by 8.1% (Figure 3C).

The fruit emission by tomato plants responded positively ($p < 0.05$) to the effects of the interaction between the lateral furrow covering and bovine biofertilizer (Figure 4). Similarly, to the observation made for the production of chlorophyll *a* (Figure 3A), plants grown on soil with common biofertilizer did not display any difference between the absence and presence of lateral covering.

However, the use of coating increased fruit emission by 30.3% and 49.9% on soil without biofertilizer and with enriched biofertilizer, respectively. Among plants with lateral protection, fruit production was 15.7% and 18% higher in plants grown on enriched soil compared to those grown on soil without biofertilizer or with common biofertilizer, respectively. This result is similar to what was observed with the chlorophyll *a* content. A 50.6% increase in the number of fruits was measured when side protection was combined with enriched biofertilizer compared with plants grown on soil with side protection but no organic input.

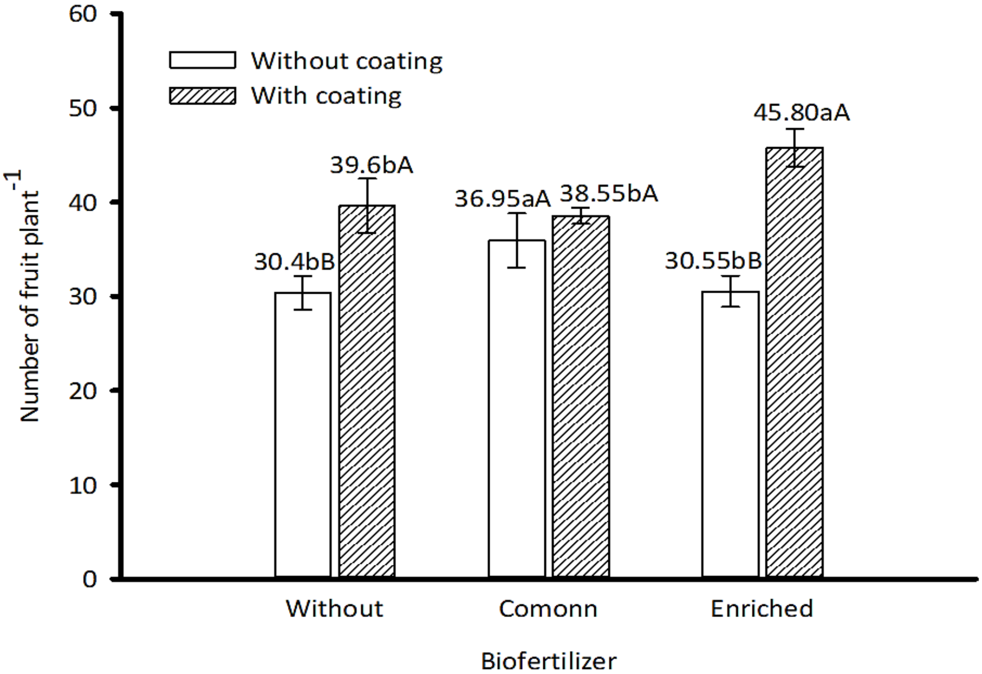

Figure 4. Number of tomato fruits hybrid cv. Fascínio F1 grown on soil with lateral furrow coating and bovine biofertilizers. Same small letters indicate no significant difference between the biofertilizers within each furrow coating after Tukey's test ($p < 0.05$). Same capital letters indicate no significant difference between the furrow coatings within each bovine biofertilizer after Tukey's test ($p < 0.05$).

The average fruit mass responded positively to lateral covering and biofertilizers (Figure 5). Soil protection with plastic film increased the mean weight of tomato fruits by 9.7% (Figure 5A). Among the organic inputs (Figure 5B), the biofertilizers, despite not differing from each other, provided a greater average fruit mass compared to plants grown on soil without any inputs. The mean weight of tomatoes was 12.7% and 9.8% higher on soil with common biofertilizer compared to plants grown on soil with no fertilizer or enriched biofertilizer.

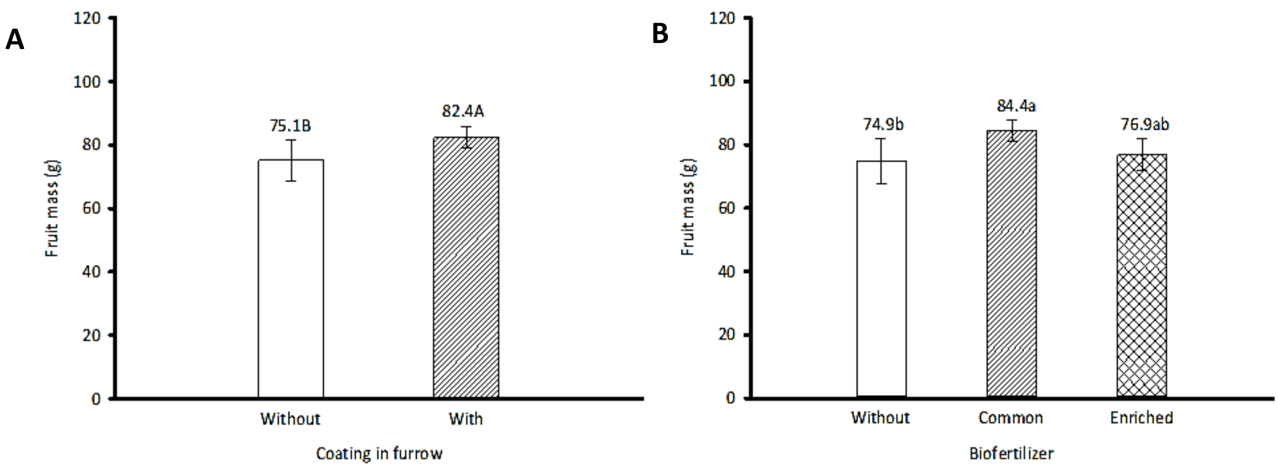

Figure 5. Fruit mass of tomato hybrid cv. Fascínio F1 grown on soil with A - lateral furrow covering, B - without and with bovine biofertilizers.

The production per plant (Figure 6A) and the productivity (Figure 6B) of tomato cv. Fascínio F1 responded positively ($p < 0.05$) to lateral furrow covering, regardless of whether the soil contained biofertilizer or not (Figure 6). The respective figures show different behavior of production per plant (Figure 6A) between treatments without and with side coating that is transferred to productivity (Figure 6B). The transferred behavior, for each situation, is due to the productivity being obtained by the product between the production per plant and the planting density that is constant between the soil without and with protection against water losses.

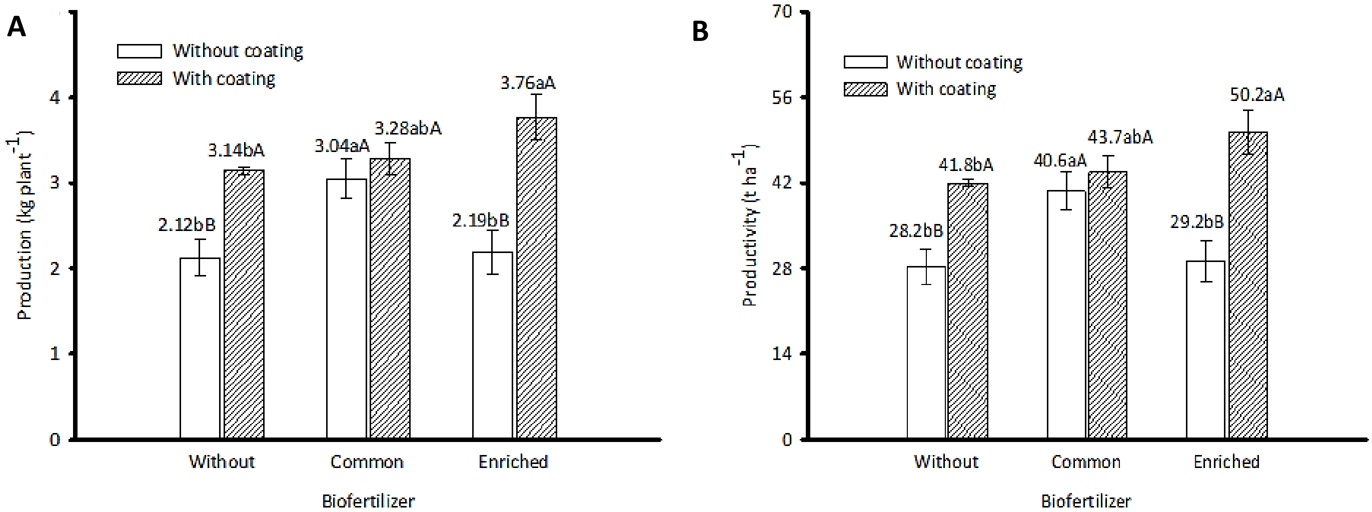

Figure 6. A - Production and B - productivity of tomato hybrid cv. Fascination F1 on soil with lateral furrow covering against water losses, without and with bovine biofertilizers. Same lowercase letters indicate no significant difference between the biofertilizers within each furrow coating after Tukey's test ($p < 0.05$). Same capital letters indicate no significant difference between lateral coatings within each bovine biofertilizer after Tukey's test ($p < 0.05$).

Fruit production (Figure 6A) and fruit yield (Figure 6B) of plants grown on soil without side coating were higher in the presence of common biofertilizer compared to soil without biofertilizer. No difference was observed between plants grown on soil without biofertilizer and with enriched biofertilizer. On the other hand, for plants with lateral protection, no difference was observed among biofertilizers; however, lateral coating provided an increase in production and productivity in the absence of biofertilizer. The protection of the soil against water losses was more significant when associated with the enriched bovine biofertilizer, increasing the production and productivity of plants by 77.4% and 78%, respectively. In the same situations, the common biofertilizer led to an increase in production and productivity by 57.4% and 55.0%, respectively, compared to an absence of organic input.

4. Discussion

The increase of the soil moisture (Figure 1) provided by lateral furrow covering is in line with Lima Neto et al. (2013), who found a similar response in soil cultivated with pepper (*Capsicum annuum* L.). The protection of furrows with polyethylene plastic reduces the lateral flow of water, keeping the soil more humid in the root zone of plants (Zhao et al. 2018). The results (Figure 1) surpass by 14.3% and 16.5%, the 13.6% referring to the volumetric humidity of the soil at the level of field capacity, obtained in samples with deformed structure in the laboratory in the first 15 cm. In addition, they show that the irrigations, despite maintaining the soil with high humidity, display values 29.2% and 22.8% lower than the total porosity of 39% in treatments without and with side coating, respectively.

The highest values in the height of tomato plants with common biofertilizer (Figure 2) may be a response to the components of the input having stimulated the reproduction of microorganisms and provided a great number of nutrients that would be made available to plants in the biometric growth phase (Pereira et al. 2021). Similar behavior was reported by Lima Neto et al. (2018) and Alves et al. (2019) in tamarind tree seedlings (*Tamarindus indica* L.) irrigated with saline water when they found that the plants treated with common biofertilizer grew higher in height than those with no organic input or treated with enriched biofertilizer.

The enriched biofertilizer, due to its higher electrical conductivity and sodium and chloride content than the common biofertilizer and moderately saline water (Table 3), may have increased soil salinity and inhibited plant growth by reducing water absorption caused by the osmotic effect (Lima Neto et al. 2018; Zörb et al. 2019; Oliveira et al. 2022). Another possibility is that the addition of components in the preparation of the enriched biofertilizer has caused antagonism between nutrients, contributing to the imbalance in soil fertility and plant nutrition due to a decline of absorption by plant roots and transport to other plant organs (Cavalcante et al. 2019; Diniz et al. 2020; Oliveira et al. 2022). Alternatively, the common biofertilizer (fresh bovine manure + water) positively influenced the growth in height of the tomato, and the increase can be a response to the chemical composition, which, despite being low in relation to the enriched one (Table 3), is in a more balanced proportion and readily available to plants (Santos et al. 2019; Mesquita et al. 2020).

The association of organic inputs with the lateral protection of the furrows against soil water losses resulted, in most cases, in a greater formation of photosynthetic pigments (Figures 3A and 3B). These results are due to the maintenance of wet soil for a longer time between irrigation intervals, provided by the use of the lateral coating of the furrows (Lima Neto et al. 2013; Lima Neto al. 2021) (Figure 1) and possibly due to the greater availability of nutrients to plants via biofertilizers, mainly magnesium (Table 3)—a structural element of the chlorophyll molecules *a* and *b* (Chen et al. 2018). The application of lateral protection caused positive effects on contents in total chlorophyll (Figure 3C). This technique helps maintain soil moisture (Lima Neto et al. 2013), thus favoring greater synthesis of leaf pigments in the capture of light to be used in the production of photoassimilates during the photosynthetic process.

The positive effect of side coating on the fruit number per plant (Figure 4) is consistent with previous results (Silva et al. 2019) that indicated a 12.9% increase in tomato cv. Italian production by the maintenance of soil moisture and the reduction of water losses via irrigation and nutrients. It is also in agreement with Lima Neto et al. (2013), who registered a 5% increase in the number of fruits emitted by cv. Interprise. The authors attributed the increases in plant production to higher moisture and nutrient availability due to improved soil fertility in response to the addition of the chemically enriched biofertilizer (Pereira et al. 2021; El-Beltagi et al. 2022). The chemically enriched bovine biofertilizer promoted an increase in the number of fruits, which is due, in addition to the improvement of soil fertility (Sales et al. 2019; Lima Neto et al. 2021), to the increase in microbial activity beneficial to plants and a greater availability in nutrients in the soil attributed to organic input (Cavalcante et al. 2019). This fact agrees with what was observed by Matos et al. (2021) when evaluating the effect of irrigation and organic fertilization as an alternative to chemistry and finding that increasing the water depth enhanced the yield of cherry tomato fruits and organic fertilization is an alternative to chemical without losses in culture yield.

The increase in the mass of tomato cv. Fascínio F1 (Figure 5A) was due to the maintenance of more humid soil by lateral protection (Figure 1) that contributed to greater absorption of water and nutrients by plants for the production of fruits (Dukare et al. 2021; Mendonça et al. 2021). A similar situation was also verified by Lima Neto et al. (2013), who observed that lateral coating led to an increased mean mass of sweet pepper fruits from 71.30 to 75.46 g, promoting a gain of 5.8% compared with fruits grown on soil with no side protection.

The addition of milk, sugar cane molasses, and agricultural plaster to the components of the common biofertilizer (fresh bovine manure and water) did not result in an increase in the fruit mass (Figure 5B). This inconvenience may be a response to the high salinity of the enriched biofertilizer (Table 1) added to the irrigation with moderately saline water (1.4 dS m^{-1}). Both treatments may have elevated the saline situation of the soil and inhibited the growth of the fruits increased by treatment with common biofertilizer. In contrast, Lima Neto et al. (2021) found no influence of the application of chemically enriched bovine biofertilizer on the mean mass of bell pepper fruits.

The increase in the productive capacity of the tomato (Figure 6) is due to the higher humidity in the soil provided by the plastic film in the planting furrow (Figure 1). Under these conditions, the plants absorbed more water and nutrients, mainly due to the treatments with chemically enriched biofertilizer (Table 3), reflecting a greater productive capacity of the culture (El-Beltagi et al. 2022). The results are similar to those observed on other cultures; in yellow passion fruit (*Passiflora edulis* Sims), Cavalcante et al. (2005) found that the lateral coating stimulated the productive capacity of the culture irrigated with water of much higher salinity (3.2 dS m^{-1}) in relation to the present study; in sweet pepper (*Capsicum annuum* L.) cv. Interprise, when evaluating the combination of lateral protection and bovine biofertilizer, Lima Neto et al. (2013) found that only side protection caused a significant effect, increasing the productive capacity of plants by 17.0% compared to those grown without plastic film.

5. Conclusions

The application of enriched bovine biofertilizer associated with the side coating of the pits increases the synthesis of chlorophyll pigments, the number of fruits, and the productivity of tomato cv. Fascínio F1.

The coating with plastic film in the pits keeps the soil moister, stimulating the synthesis of chlorophyll and increasing the mean weight of the tomato fruits.

The common bovine biofertilizer stimulates the growth in height of the plants, while the enriched biofertilizer raises the mean mass of tomato fruits cv. Fascínio F1.

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