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Yield of 'Gigante' cactus pear cultivated under biofertilizer doses and application intervals[1]

Rendimento de palma forrageira 'Gigante' cultivada sob doses e intervalos de aplicação de biofertilizante

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HIGHLIGHTS:

Application of biofertilizer prepared from cattle manure influences cactus pear yield.
Higher doses of biofertilizer promote a reduction in the dry matter content of cactus pear cv. Gigante.
Reduction of plant dry matter percentage and increase in dry biomass yield are due to the increase in green biomass yield.

ABSTRACT: Due to the water restriction, associated with the high cost of fertilizers, and the need to produce forage in the semi-arid regions, studies using biofertilizers in cactus pear production tend to become impactful. The aim of this study was to evaluate the morphometric characteristics and yield of 'Gigante' cactus pear cultivated under doses and application intervals of bovine manure biofertilizer. The experimental design was in randomized blocks, in a 2 × 5 factorial scheme, with two biofertilizer application intervals (14 and 21 days) and five biofertilizer doses (0, 15, 30, 45 and 60 m^3 ha^{-1}). Three replicates were used, totaling 30 experimental units. The following variables were evaluated: plant height, number of cladodes, cladode length, cladode width and cladode area index, dry biomass percentage, and green and dry biomass yields. The use of 60 m^3 ha^{-1} of liquid cattle manure biofertilizer increased the yield of 'Gigante' cactus pear. The application of 60 m^3 ha^{-1} of biofertilizer at the interval of 14 days increased the yield of 'Gigante' cactus pear.

Key words: *Opuntia ficus-indica*, semi-arid region, organic fertilization

RESUMO: A restrição hídrica associada ao elevado custo de fertilizantes, bem como, a necessidade de produzir forragem na região semiárida faz com que estudos utilizando biofertilizantes na produção de palma forrageira tendam a se tornarem impactantes. Objetivou-se com o presente estudo avaliar as características morfométricas e o rendimento de palma forrageira 'Gigante' cultivada sob doses e intervalos de aplicação de biofertilizante de esterco bovino. O delineamento experimental foi em blocos casualizados, no esquema fatorial 2 × 5, sendo dois intervalos de aplicação de biofertilizante (14 e 21 dias) e cinco doses de biofertilizante (0, 15, 30, 45 e 60 m^3 ha^{-1}). Foram utilizadas três repetições, totalizando 30 unidades experimentais. Foram avaliadas as seguintes variáveis: altura da planta, número de cladódios, comprimento, largura e índice de área de cladódio, percentagem de matéria seca, produtividade de biomassa verde e seca. A utilização de 60 m^3 ha^{-1} de biofertilizante de esterco bovino liquido incrementa o rendimento da palma forrageira 'Gigante'. A aplicação de 60 m^3 ha^{-1} de biofertilizante no intervalo de 14 dias incrementa o rendimento da palma forrageira 'Gigante'.

Palavras-chave: *Opuntia ficus-indica*, semiárido, adubação orgânica

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Introduction

Cactus pear (*Opuntia ficus-indica* Mill) cultivation is an activity of paramount relevance for the maintenance of herds in the semi-arid region, given its morphophysiological characteristics of adaptation to the adverse conditions of this region.

The development of a sustainable agriculture model must ensure the correct use of natural resources, without compromising their availability for future generations and without negative effects on the environment (Tavera-Cortés et al., 2018). Thus, organic fertilization is an important management technique to consolidate a productive and sustainable system for cactus pear.

Organic fertilization with bovine manure enables increments in cactus pear growth (Barros et al., 2016; Salazar-Sosa et al., 2018), yield (Donato et al., 2016; Silva et al., 2016) and nutritional quality (Donato et al., 2014b) characteristics.

Despite the several positive results of fertilization with bovine manure in cactus pear cultivation, it is necessary to evaluate other sources of organic fertilization for this crop. Among these sources, there is the biofertilizer of bovine manure, which has beneficial effects on soil physical, chemical and biological properties, as well as on plant nutrition, phytosanitary control and physiology (Cavalcante et al., 2019). In addition, it is environmentally friendly, poses no danger to the environment and ensures the sustainability of agriculture (Ghany et al., 2013).

In this context, the objective of this study was to evaluate the morphometric characteristics and yield of 'Gigante' cactus pear cultivated under doses and application intervals of bovine manure biofertilizer.

Material and Methods

The experiment was conducted in the Beira Rio community, Morrinhos district, located in the municipality of Guanambi, Microregion of Serra Geral, Southwestern Bahia, Brazil, located at 14° 10' 17" S latitude, 42° 39' 06" W longitude, 810 m altitude, with annual rainfall of 680 mm (528.25 mm accumulated in the period) and mean temperature of 26 °C (mean temperature of 26.95 °C, during the experimental period).

The experiment was conducted from September 2016 to May 2018 in an Ultisol whose physical-chemical characterization before the experiment is presented in Table 1, following the recommendations and guidelines of EMBRAPA (2009).

In this period, the main climate elements were obtained by a meteorological station, located at the Federal Institute of Education, Science and Technology of Bahia, Campus of Guanambi (Figure 1).

Table 1. Chemical and physical characteristics of the soil of the experimental area

Attributes	Unit	Depth (cm)		Attributes	Unit	Depth (cm)	
		0-10	10-20			0-10	10-20
OM	g dm^{-3}	12.0	10.8	ESP	%	0.67	0.60
pH	-	5.4	5.2	Ca/Mg	-	1.63	1.50
P	mg dm^{-3}	5.0	2.6	Ca/K	-	4.16	4.03
K	mmol$_c$ dm^{-3}	4.74	3.98	Mg/K	-	2.55	2.69
Ca	mmol$_c$ dm^{-3}	19.7	16.0	TC	g dm^{-3}	6.96	6.26
Mg	mmol$_c$ dm^{-3}	12.1	10.7	S	mg dm^{-3}	3.0	4.3
Al	mmol$_c$dm^{-3}	0.00	0.00	B	mg dm^{-3}	0.19	0.25
H+Al	mmol$_c$ dm^{-3}	16.0	18.0	Cu^{++}	mg dm^{-3}	0.6	0.8
SB	mmol$_c$ dm^{-3}	36.54	30.67	Fe^{++}	mg dm^{-3}	6.2	7.2
CEC	mmol$_c$ dm^{-3}	52.54	48.67	Mn^{++}	mg dm^{-3}	32.2	40.6
V	%	69.55	63.02	Zn^{+}	mg dm^{-3}	0.4	0.2
K^{+}	%	9.02	8.17	Clay	g dm^{-3}	420	465
Ca^{2+}	%	37.50	32.87	Sand	g dm^{-3}	401	441
Mg^{2+}	%	23.03	21.98	Silt	g dm^{-3}	179	94
	Textural class				Clay		

OM - Organic matter; SB - Sum of bases; CEC - Cation exchange capacity; V- Base saturation; ESP - Exchangeable sodium percentage; and TC - Total carbon

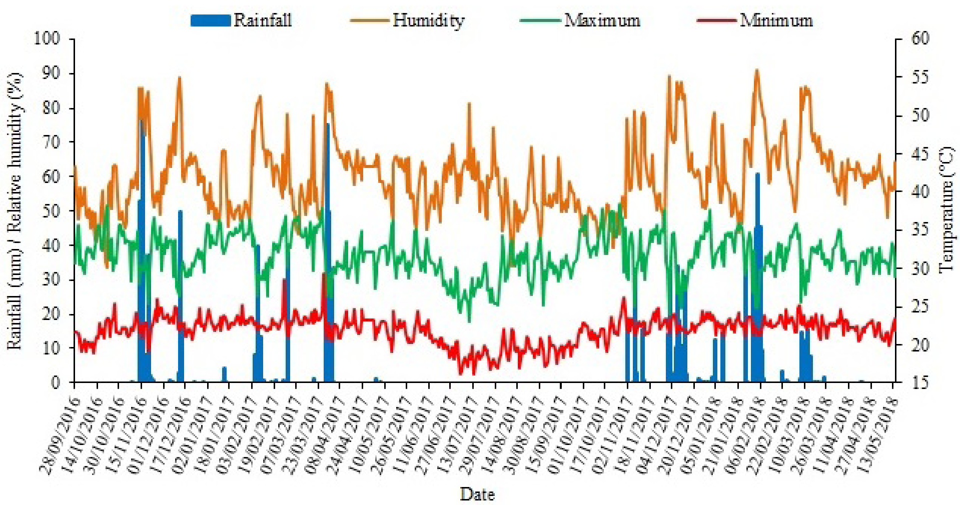


Figure 1. Rainfall, relative air humidity and maximum and minimum temperatures during the experimental period

The treatments were arranged in a randomized block design, in a 2 x 5 factorial scheme, corresponding to two biofertilizer application intervals (14 and 21 days) and five biofertilizer doses (0, 15, 30, 45 and 60 m^3 ha^{-1}). Three repetitions were used, totaling 30 experimental units.

The area was plowed and harrowed for subsequent planting of cactus pear (*Opuntia ficus-indica* Mill), Gigante cultivar, on September 28 and 29, 2017. The planting furrows were made with a hoe at depth of 20 cm, where the cladodes were placed. The spacing used was 0.20 m between plants and 1 m between rows, arranged in triple rows, spaced apart by 3.0 m, which led to a population density of 30,000 plants ha^{-1}. Each experimental unit consisted of three 8-m-long rows, and the evaluated plants were located in the central 4 m of the three rows. The plot area was 40 m^2 (8 x 5 m), with a usable area of 20 m^2 (4 x 5 m) and a total area of 1,200 m^2. Cactus pear seedlings for the experiment were acquired in the community.

To produce the biofertilizer, a biodigester was built using a fiber tank with capacity of 3,000 L, which has an inlet box to receive the waste and an outlet box to store the biofertilizer, as described by Mattos (2011). A mixture of fresh bovine manure and water at 1:1 proportion was placed every day in the inlet box. The fresh bovine manure used came from the cattle farm of the community where the experiment was installed.

After fermentation, the biofertilizer was collected in the outlet box of the biodigester, filtered to remove the coarse parts and stored in another box with capacity of 2,000 L. The biofertilizer was diluted in water, at a proportion of 1:1, for application in the respective treatments. Table 2 presents the characterization of the biofertilizer, analyzed according to the methodology of EMBRAPA (2009).

The biofertilizer was applied using an open-impeller electric motor pump, which drew the diluted material and conducted it by a one-inch-diameter hose, coupled to a ¾-inch-diameter flow meter at the system outlet (biofertilizer dispenser in each treatment). Through this system, it was possible to apply the biofertilizer dose within the specific area for each treatment. Biofertilizer application began at 198 days after planting, when rainfall stopped in the region and the dry season started. The biofertilizer was applied in the period between April 16 and December 24, 2017, totaling 252 days. According to the frequencies of applications, the total volume of biofertilizer and nutrient supply in each treatment at the end of the application period were measured (Table 3).

Table 2. Chemical characterization of biofertilizer without dilution used in the experiment

Variables	Unit	Result
Total N	%	0.06
Total P_2O_5	%	0.04
K_2O water	%	0.04
Total Ca	%	0.06
Total Mg	%	N/D
Total B	%	0.004
Total Cu	%	N/D
Total Mn	%	N/D
Total Zn	%	N/D
Electrical conductivity at 25 °C	dS m^{-1}	0.3
pH	-	6.6
Total organic C	%	0.8

N/D - Not detected

The water balance during the 252 days of the experiment is described in Table 4.

Cultural practices were carried out whenever necessary to maintain the conditions for plant development. For weed control, manual weeding was performed using a hoe.

Evaluations were performed at 590 days after planting. The morphological characteristics evaluated were: plant height, number of cladodes per plant, cladode length, cladode width and cladode area index. For evaluation, six plants were randomly selected in the central 4 m of the experimental plot, totaling 180 plants evaluated. Plant height, cladode width and cladode length were determined using a tape measure graduated in millimeters. Plant height was considered as

Table 3. Total volume of bovine manure biofertilizer applied and nutrient supply at the end of the 252 days of application

Determinations	Volumes of application for each application interval (days)							
	15 m^3 ha^{-1}		30 m^3 ha^{-1}		45 m^3 ha^{-1}		60 m^3 ha^{-1}	
	14	21	14	21	14	21	14	21
Total volume of biofertilizer applied (m^3 ha^{-1})	285	195	570	390	855	585	1140	780
Total N (kg ha^{-1})	171	117	342	234	513	351	684	468
Total P_2O_5 (kg ha^{-1})	114	78	228	156	342	234	456	312
Total K_2O (kg ha^{-1})	114	78	228	156	342	234	456	312
Total Ca (kg ha^{-1})	171	117	342	234	513	351	684	468
Total B (kg ha^{-1})	11.4	7.8	22.8	15.6	34.2	23.4	45.6	31.2
Organic C (kg ha^{-1})	2280	1560	4560	3120	6840	4680	9120	6240

Table 4. Summaries of the crop water balance in all treatments, referring to the 252 days of their application

Treatments	ETo (mm)	Kc	ETpc	P	I + P – ETpc	ETc	DEF	SUR	I	ETc/ ETpc
			(mm)							
Without application					-261.74	322.45	-465.41	257.63	0.00	0.41
15 m^3 ha^{-1} (14 days)					-126.64	433.17	-354.68	277.06	135.00	0.55
15 m^3 ha^{-1} (21 days)					-171.72	479.68	-313.18	151.25	90.00	0.61
30 m^3 ha^{-1} (14 days)					8.27	597.81	-190.04	224.54	270.00	0.76
30 m^3 ha^{-1} (21 days)	1575.71	0.50	787.86	526.12	-86.72	541.52	-251.34	207.97	180.00	0.69
45 m^3 ha^{-1} (14 days)					143.27	1066.44	278.58	282.50	405.00	1.35
45 m^3 ha^{-1} (21 days)					3.28	628.99	-163.86	181.94	270.00	0.80
60 m^3 ha^{-1} (14 days)					278.27	3017.46	2229.60	357.65	540.00	3.83
60 m^3 ha^{-1} (21 days)					93.28	803.99	11.13	233.97	360.00	1.02

ETo - Reference evapotranspiration; Kc - Crop coefficient; ETpc - Potential crop evapotranspiration; P - Rainfall; I - Irrigation; ETc - Crop evapotranspiration; DEF - Water deficit; SUR - Water surplus the distance from the soil to the tip of the highest cladode. Length and width of cladode were measured considering the region with the highest value.

Cladode area index was estimated with the obtained data of length and width of cladode. First, cladode area was determined according to the method used by Barros et al. (2016).

The area of cladodes of the plant was used to calculate the cladode area index (CAI). CAI is the sum of the total area of cladodes of the plant, considering the two sides of the cladodes, and divided by the ground area occupied by the plant (m^2 of cladode area m^{-2} of soil), thus determining the photosynthetically active area of the plant.

Prior to harvest, cladode tissue samples were collected to determine the dry biomass percentage, according to the method proposed by Detmann et al. (2012). The samples were collected according to the method proposed by Donato et al. (2017a), which consists in removing the tissue with a hole saw, coupled to a battery-charged drill. The samples were taken in cladodes distributed in the different positions on the plant.

At harvest, all plants of the usable plot were harvested using a knife, by cutting all cladodes and preserving only the "mother" cladode (cladode used in planting). The cut was performed at the junction between the cladodes in order not to cause damage to the preserved cladode. All cladodes collected in the plot were placed in boxes for weighing and determination of green biomass yield (GBY) (Mg ha^{-1}).

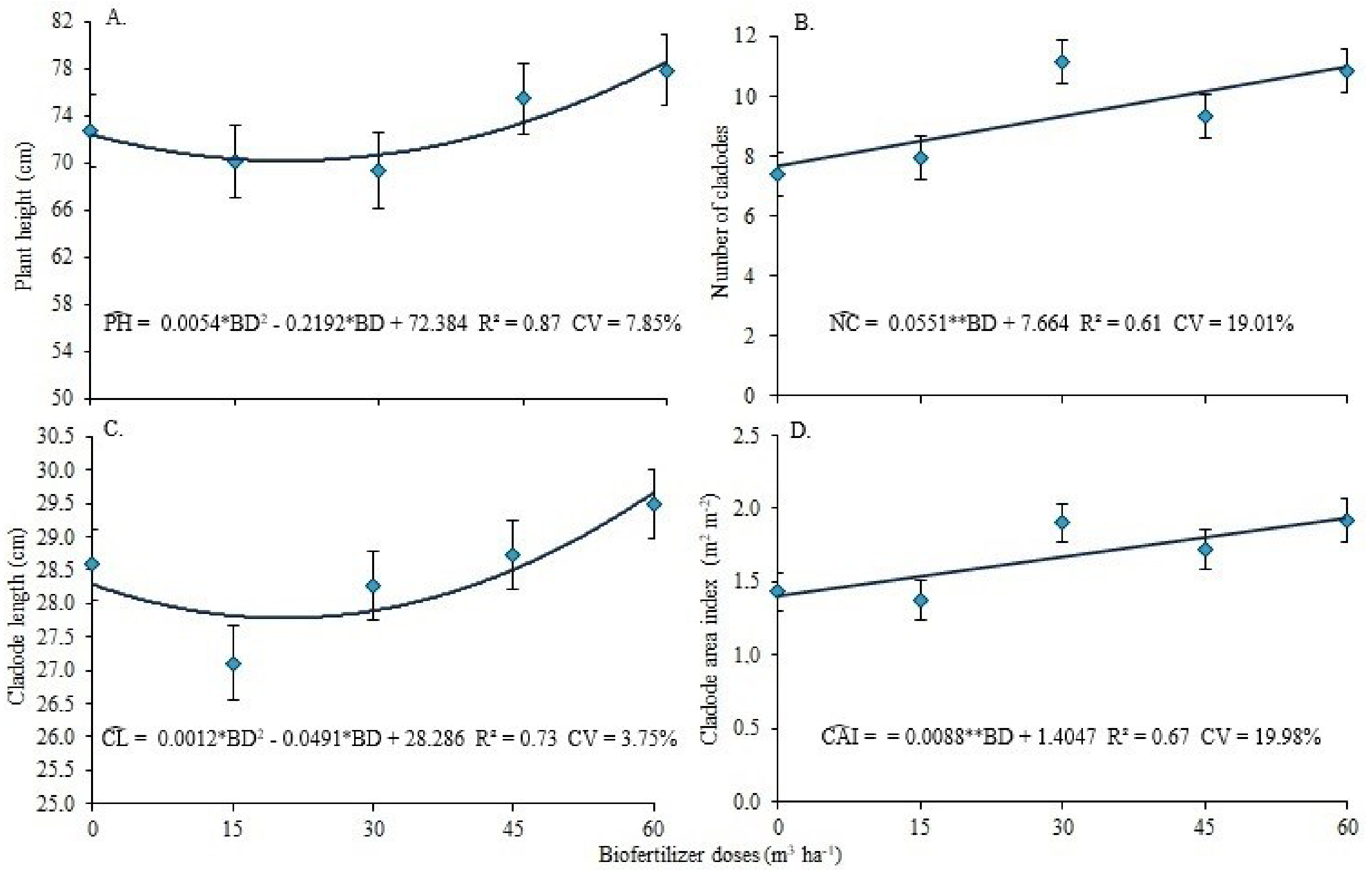
Dry biomass yield (DBY) was determined as a function of the dry biomass percentage multiplied by the green biomass yield (GBY), thus obtaining the DBY (Mg ha^{-1}).

The variables were subjected to analysis of variance using the PROC GLM procedure of the statistical package SAS® (Statistical Analysis System), version 9.2 for Windows® (SAS, 2008). The obtained data were subjected to normality tests and, after verifying the normal distribution, the analysis of variance was performed at $p \leq 0.05$. For the significant interactions, regression models were fitted to the data of biofertilizer doses within the application intervals. In the absence of interactions, the effects of the main factors were studied, with conclusive F test for the application intervals and regression analysis for biofertilizer doses. The models were chosen considering the significance of the beta coefficients by the t-test, the magnitude of the coefficient of determination, the significance of the mean square of the regression, the smallest difference between adjusted R^2 and R^2, and the adequacy of the model to the biological phenomenon studied.

Results and Discussion

The lowest value of plant height (70.16 cm) was obtained with bovine manure biofertilizer dose of 20.29 m^3 ha^{-1} (Figure 2A). After this minimum value, there was a 12.13% increase of height up to the biofertilizer dose of 60 m^3 ha^{-1}. This result indicates that plant height is little influenced by the application of bovine manure biofertilizer doses below 20.29 m^3 ha^{-1}, with a variation of only 3.07% up to this dose.

The increase in plant height values with the application of higher doses of biofertilizer may be related to the higher availability of water and nutrients. As cactus pear has high



**;* - Significant at $p \leq 0.01$ and at $p \leq 0.05$ by F test; R^2 - Coefficient of determination

Figure 2. Plant height (A), number of cladodes (B), cladode length (C) and cladode area index (D) of 'Gigante' cactus pear as a function of bovine manure biofertilizer doses

water use efficiency, and a superficial root system that allows the absorption of a minimum amount of water, the application of higher doses of biofertilizer promoted a water availability for the crop that, besides meeting its need in terms of water, contributed to making available and facilitating the absorption of nutrients.

Water availability is an important factor to be considered in plant nutrition, constituting a natural vehicle for the movement of ions in the soil through the mechanisms of absorption by mass flow and diffusion. The lack of adequate water levels in the soil can lead to nutrient deficiency (Novais et al., 2007).

The number of cladodes increased linearly as a function of the increase in the biofertilizer doses applied (Figure 2B). The fitted model estimates an increase of 0.83 in the number of cladodes for every 15 m^3 ha^{-1} of biofertilizer applied. There was a 43.14% increase in the number of cladodes as compared to the control (0 m^3 ha^{-1}) for the highest dose of biofertilizer applied (60 m^3 ha^{-1}). This result was greater than that obtained by Cortázar et al. (2001), who verified in a study carried out with cactus pear in Chile under average rainfall conditions of 330 mm per year, with biofertilizer from guano and tuna, a 13% increase in the number of cladodes at a dose of 60 Mg ha^{-1} per plant. This was possibly due to the dilution of biofertilizer used in water, which enabled greater availability of water and nutrients for the plants during the cycle and, consequently, greater growth with constant production of cladodes.

Ramos et al. (2015) evaluated the morphometry of 'Gigante' cactus pear under doses of organic fertilization and verified that the increase in the doses of goat manure promotes an increase in the number of cladodes. The number of cladodes and CAI of 'Gigante' cactus pear express the vegetative growth, characterized by having as main sink the new shoots or primary cladodes, promoted by the higher moisture and nutrient content in the soil (Donato et al., 2017b). In addition, considering that the production of shoots by plants is associated with the functions of growth-promoting substances such as auxins and gibberellins (Taiz et al., 2017), it is verified that the biofertilizer has positive effect on the increase in the number of cladodes.

The lowest value of cladode length (27.78 cm) was obtained with the bovine manure biofertilizer dose of 20.46 m^3 ha^{-1} (Figure 2C). After the minimum value, there was a 6.78% increase in cladode length up to the biofertilizer dose of 60 m^3 ha^{-1}. Application of bovine manure biofertilizer up to the dose of 20.46 m^3 ha^{-1} led to variation of only 1.79% in cladode length values, which indicates little influence on this variable with the application of lower doses. Similar result was found by Donato et al. (2014b), who observed that the increase in bovine manure doses up to 90 Mg ha^{-1} per year promotes an 8% increase in the length of 'Gigante' cactus pear cladode.

The values of cladode area index increased linearly as a function of the applied doses of bovine manure biofertilizer (Figure 2D). The fitted model estimated an increase of 0.13 m^2 m^{-2} in the cladode area index for every 15 m^3 ha^{-1} of biofertilizer applied. There was a 37.59% increase in the cladode area index in comparison to the control (0 m^3 ha^{-1}) at the highest dose of biofertilizer applied (60 m^3 ha^{-1}).

A relationship was observed between the variables number of cladodes, cladode length and cladode area index, with similar response of increase in the values. With the emergence of new cladodes and increase in their length, promoted by the availability of water and nutrients with the application of higher doses of biofertilizer, the plant increases the cladode area index and consequently the ability to intercept photosynthetically active radiation, a factor that indicates higher crop yield (Fonseca et al., 2019).

The vegetative growth of cactus pear with the increase in the applied doses of bovine manure biofertilizer, observed by the increase in plant height, number of cladodes, cladode length and cladode area index, can be associated with the supply of nutrients and water, available in the biofertilizer (Tables 3 and 4), because physiological and biochemical processes (photosynthesis, respiration, transpiration and nutrient absorption) are dependent on the availability of water and nutrients in the soil.

Melém Júnior et al. (2011) highlight the positive effect of organic fertilization, which, besides providing nutrients, stands out for playing a relevant role in the supply of organic matter to improve the physical, chemical and biological properties of the soil, which favor the balance of nutrient availability to plants, an important factor in plant nutrition.

The green biomass yield showed significant difference between the application intervals only for the biofertilizer dose of 60 m^3 ha^{-1} (Table 5). There was a 59.82% increase in the green biomass yield in the application interval of 21 days compared to the interval of 14 days. This result is possibly related to the higher volume of biofertilizer application, which was 46.15% higher than that applied at 21-day interval, and consequently greater supply of nutrients and water in this treatment (Table 3), placing the plant in a more favorable condition of nutrient availability to promote its growth.

The values of dry biomass percentage (Table 5) differed between the application intervals at biofertilizer doses 30 and 45 m^3 ha^{-1}. There were reductions of 14.44 and 13.97% in the values of dry biomass percentage between the application interval of 21 days compared to the interval of 14 days.

Table 5. Mean values of the production characteristics of 'Gigante' cactus pear as a function of biofertilizer doses and application intervals

Variable	Application interval (days)	Application volume (m^3 ha^{-1})					CV (%)
		0	15	30	45	60	
Green biomass yield (Mg ha^{-1})	14	135.58 a	105.95 a	191.30 a	164.64 a	213.07 a	19.47
	21	135.58 a	123.14 a	171.78 a	149.69 a	133.32 b	
Dry biomass percentage (%)	14	8.78 a	8.48 a	7.82 b	7.51 b	7.29 a	6.16
	21	8.78 a	8.67 a	9.14 a	8.73 a	7.79 a	
Dry biomass yield (Mg ha^{-1})	14	11.95 a	8.99 a	12.14 a	15.28 a	15.59 a	23.02
	21	11.95 a	10.65 a	15.67 a	12.98 a	10.42 b	

Means followed by different letters in the column differ by F test at $p \leq 0.05$; CV - Coefficient of variation

Dry biomass yield (Table 5) differed between application intervals only at the biofertilizer dose of 60 m^3 ha^{-1}, with an increase of 49.62% in the values between the application interval of 21 days in comparison to the interval of 14 days.

A linear model fitted to the values of dry biomass percentage and green and dry biomass yields in the 14-day application interval, while a quadratic model fitted to values of dry biomass content in the 21-day application interval.

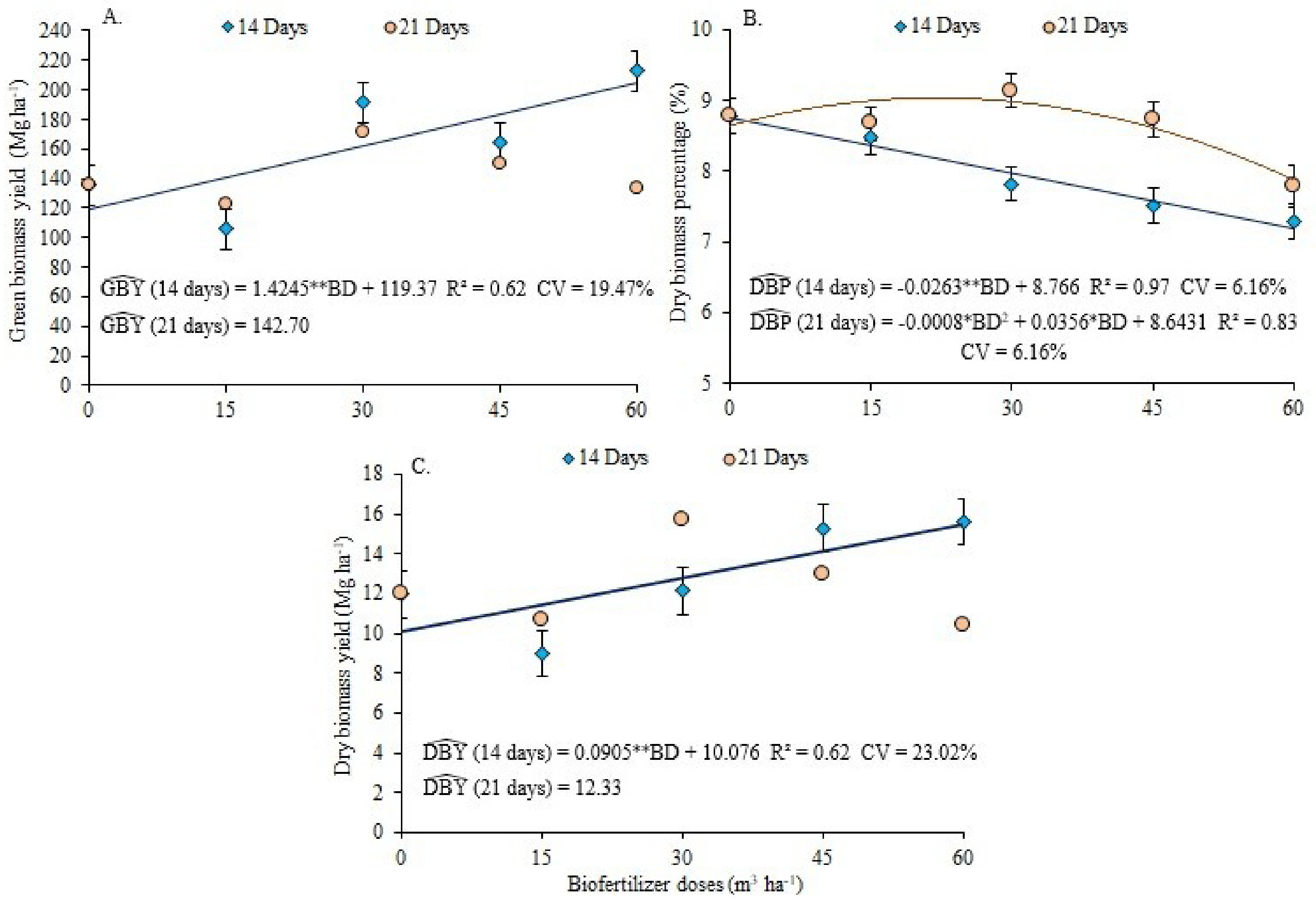
The mean value of green biomass yield (Table 5) was 142.70 Mg ha^{-1} in the 21-day application interval. In the 14-day application interval, green biomass yield increased linearly as a function of the bovine manure biofertilizer doses (Figure 3A). The fitted model estimates an increase of 21.37 Mg ha^{-1} in green biomass for every 15 m^3 ha^{-1} of biofertilizer applied. There was a 71.60% increase in the green biomass yield compared to the control (0 m^3 ha^{-1}) for the highest dose of biofertilizer applied (60 m^3 ha^{-1}).

Barros et al. (2016) found fit of a positive linear model for the green biomass yield of 'Gigante' cactus pear with bovine manure applications up to the dose of 90 m^3 ha^{-1}. This result reinforces the contribution of fertilization with organic sources to the increase in cactus pear yield.

The dry biomass percentage decreased linearly in the 14-day application interval as a function of the bovine manure biofertilizer doses (Figure 3B). There was a reduction of 18.00% in the dry biomass percentage in comparison to the control (0 m^3 ha^{-1}) at the highest dose of biofertilizer applied (60 m^3 ha^{-1}), with a reduction of 0.39% in the dry biomass percentage for every 15 m^3 ha^{-1} of biofertilizer applied. In the 21-day application interval, the maximum value of dry biomass percentage (9.04%) was obtained with the biofertilizer dose of 22.25 m^3 ha^{-1}. After the maximum value, there was a reduction of 12.62% in the dry biomass percentage up to the biofertilizer dose of 60 m^3 ha^{-1}.

The decrease in dry biomass percentage with the increase in biofertilizer doses is related to the condition of constant growth of the plant in these treatments, where the plant did not need to use the water reserves present in the large vacuoles of the cladodes to maintain metabolic processes, due to the availability of water promoted by the application of higher doses of biofertilizer. In addition, plant nutrition, especially in relation to nitrogen, promotes the production of new cladodes, which leads to lower dry biomass contents in the tissues (Donato et al., 2014b).

Dry biomass yield in the 21-day application interval averaged 12.33 Mg ha^{-1} (Figure 3C). In the 14-day application interval, the values of dry biomass yield increased linearly as a function of the doses of bovine manure biofertilizer applied. The fitted model estimates an increase of 1.36 Mg ha^{-1} in the dry biomass for every 15 m^3 ha^{-1} of biofertilizer applied. There was a 53.89% increase in the values of dry biomass yield compared to the control (0 m^3 ha^{-1}) at the highest dose of biofertilizer applied



**; * - Significant at $p \leq 0.01$ and at $p \leq 0.05$ by F test; CV - Coefficient of variation; R^2 - Coefficient of determination

Figure 3. Green biomass yield (A), dry biomass percentage (B) and dry biomass yield (C) of 'Gigante' cactus pear as a function of bovine manure biofertilizer doses and application intervals

(60 m^3 ha^{-1}). Given the reduction of dry biomass percentage with the application of the highest doses of biofertilizer, this result of increase in dry biomass yield is strongly related to increase in green biomass yield.

The higher values of height, number of cladodes and increase in CAI in treatments with the highest application of bovine manure biofertilizer expresses the stimulating function of this liquid organic source with essential nutrients, associated with the vegetative growth of cactus pear, which directly influence the final yield of the crop.

Donato et al. (2014a) also observed an increase in the dry biomass yield of cactus pear with the application of bovine manure up to the dose of 71.8 Mg ha^{-1} per year. It is pertinent to highlight that the increase in yield with the use of biofertilizer can be explained by the fact that the application of organic fertilizers in liquid form promotes greater movement of the nutrients necessary to the plants (Diniz et al., 2011). The excellent contribution of the use of organic sources to plant nutrition is observed in the studies carried out by Padilha Junior et al. (2020), who verified that fertilization with bovine manure enabled an increase in the values of organic matter, P, K, Ca, Mg, SB, CEC, T, and V in the soil, and Donato et al. (2017), who verified an increase in nutrient extraction by 'Gigante' cactus pear when fertilized with bovine manure.

The nutritional quality, with regard to the quantity and availability of nutrients to plants and the biological richness of organic sources of fertilization, such as bovine manure biofertilizer, make it possible to improve the chemical and biological qualities of the soil (Penteado, 2007). In addition, bovine manure biofertilizer does not have humic substances, which promote more balanced mineral nutrition for plants, induce root growth and stimulate enzymatic activity in metabolic processes, as discussed by Taiz et al. (2017).

All these contributions provided by the use of organic sources, specifically bovine manure biofertilizer, which was used in the present study, enable a series of advantages to obtain increase in growth and yield variables of cactus pear.

Conclusions

1. The use of up to 60 m^3 ha^{-1} of liquid cattle manure biofertilizer increased the growth and yield of 'Gigante' cactus pear.

2. The application of 60 m^3 ha^{-1} of biofertilizer at the interval of 14 days increased the green biomass yield of 'Gigante' cactus pear.

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