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Cattle manure and liquid biofertilizer for biomass production of yellow passion fruit seedlings

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This study aims to evaluate the production of biomass of different cattle manure, and biofertilizer concentrations. The experiment was conducted between April and June 2014 in a greenhouse at the seedling production nursery of the State University of Paraíba (UEPB), Catolé do Rocha, Paraíba (PB) state. The experiment was completely randomized in a 5 x 2 factorial design corresponding to five levels of cattle manure (0, 20, 40, 60 and 80% of the substrate volume) in the absence, and the presence of a biofertilizer. The propagation material was giant yellow passion fruits with 95 to 100% of purity purchased in the local market. After 60 days, the following variables were evaluated: root dry matter (RDM), plant dry matter (PDM), root biomass (RB), shoot biomass (SB), plant biomass (PB), biomass percentage (BP), effective leaf area (ELA) and leaf area ratio (LAR). The interaction between cattle manure and fertilizer concentrations was significant for root dry matter, mass of total plant dry matter, root biomass, shoot biomass and total plant biomass. In turn, cattle manure affected significantly biomass percentage, effective leaf area and leaf area ratio. Cattle manure and biofertilizer make the production of yellow passion fruit seedlings feasible.

Key words: *Passiflora edulis Sims f. flavicarpa Degener*., alternative sources, propagation, protected environment.

INTRODUCTION

The genus Passiflora contains the highest number of species in the *Passifloraceae* family, with approximately 400 species. 20 of them are restricted to Australia, China, India, Oceania Islands and neighboring regions, and Southeast Asia. Argentina, Chile and the United States account for the remainder species (Santos et al., 2012).

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Brazil has about 120 species, making it the country with the highest number of native species (Bernacci et al., 2003).

In order to obtain a satisfactory production of yellow passion fruits, good quality seedlings are needed. They must be vigorous, present good physiological characteristics and a well-developed root system, and have an adequate size. According to Costa et al. (2011), the use of appropriate techniques in seedling production is very important to promote healthy and vigorous plants for the formation of orchards, such as an improved production microclimate, volume of containers, substrates, irrigation and nutrition.

Among the techniques used in the development of seedlings, seedling production through organic inputs stands out because such inputs are low cost and easy to find, and meet the needs of the plants. According to Artur et al. (2007), organic inputs are sources of nutrients improving physical attributes and stimulating microbial processes. Among organic inputs, cattle manure and biofertilizers stand out.

Cattle manure not only improves physical, chemical and biological properties of the substrate, but also improves soil conditions. Studies were conducted aiming to quantify the optimal dose for the formation of seedlings of several cultures (Jiang et al., 2014).

Furthermore, cattle manure not only improves physical, chemical and biological properties of the substrate, but also improves soil conditions. It is therefore an important option to maintain sustainable agricultural practices (Larney and Angers, 2012). Studies were conducted aiming to quantify the optimal dose for the formation of seedlings of several cultures. Mesquita et al. (2012) concluded that, for the production of papaya seedlings, 80% of cattle manure should be incorporated into the substrate. Oliveira et al. (2009) found a better development of castor bean seedlings by using approximately 30% of cattle manure.

Biofertilizers based on cattle manure are also viable alternatives for seedling production. According to Bezerra et al. (2007), biofertilizers are considered metabolic activators, stimulating root growth and the development of plants. Biofertilizers are organic inputs that affect soil conditioning acting as microbial inoculant and corrective fertilizers (Gondim et al., 2010). Cavalcante et al. (2009) concluded that biofertilizers applied before sowing were effective in the early growth of yellow passion fruit seedlings by decreasing soil electrical conductivity. Martins et al. (2015) found that cattle manure alone, or its interaction with biofertilizers and/or inoculants, replaces mineral fertilization.

The quantification of cattle manure and biofertilizer concentrations may positively affect the formation of seedlings by enabling biomass production, and providing beneficial effects for the substrate (such as increase in organic matter, and favorable conditions for the development of the root system).

In this sense, the objective was to evaluate different concentrations of bovine manure in the presence and absence of biofertilizers in the biomass production of yellow passion fruit seedlings.

MATERIALS AND METHODS

Place of experiment

The experiment was conducted between April and June 2014 in a greenhouse at the seedling production nursery of the State University of Paraíba (UEPB), campus IV, Catolé do Rocha, Paraíba (PB) state (6°2'38" S, 37°44'48" W; altitude: 275 m). The nursery was set with shading, allowing 50% of light inside. The experiment was completely randomized in a 5 x 2 factorial design and five replications corresponding to five levels of cattle manure (0, 20, 40, 60 and 80% of the substrate volume) in the absence and the presence of a biofertilizer. The propagation material was giant yellow passion fruits with 95 to 100% of purity purchased in the local market.

Sowing and analysis

The seeds were sown in polyethylene bags with a capacity of 1 dm^3. Five seeds were sown per bag at 1 cm depth. The thinning was performed 24 days after sowing. Weed control was performed by hand weeding. The soil was classified as a eutrophic Fluvic Neosol (Embrapa, 2011), whose analysis, performed at the 0 to 20 cm layer, presented the following chemical characteristics: pH in H_2O: 8.2, EC: 1.53 dSm^{-1}, P: 3.27 cmolc dm^{-3}, K: 0.26 cmolc dm^{-3}, Ca: 5.09 cmolc dm^{-3}, Mg: 1.66 cmolc dm^{-3}, Al: 0.0 cmolc dm^{-3}, Na: 0.26 cmolc dm^{-3}, and 1.19% of organic matter.

Cattle manure, from the Cattle Production Sector of UEPB, campus IV, Catolé do Rocha, PB, was tanned for 35 days. The analysis revealed the following chemical properties: N: 12.76 g kg^{-1}, P: 2.57 g kg^{-1}, K: 16.79 g kg^{-1}, Ca: 15.55 g kg^{-1}, Mg: 4.02 g kg^{-1}, Na: 5.59 g kg^{-1}, Zn: 60 mg kg^{-1}, Fe: 8,550 mg kg^{-1}, Mn: 325 mg kg^{-1}, soil organic matter: 396 g kg^{-1}, organic carbon: 229.7 g kg^{-1}, and C/N ratio: 18:1.

The material used for the production of the organic biofertilizer consisted of 70 kg of green manure of cows in lactation, 120 L of water, 4 kg of rock flour (MB4), 5 kg of legumes (beans), 3 kg of wood ash. 5 L of milk and 5 kg of sugar were also included to accelerate the metabolism of anaerobic bacteria for 35 days (SANTOS, 1992). The chemical composition of the biofertilizer was analyzed from the dry matter at the Soil Fertility Laboratory (LFS) of the Federal Rural University of Pernambuco (UFRP), and presented the following results: pH in H_2O: 5.25, EC: 7.1 dS m^{-1}, N: 0.8%, P: 403.4 mg dm^{-3}, K: 1.78 $cmol_c$ L^{-1}, Mg: 6.0 $cmol_c$ L^{-1}, and Ca: 5.4 $cmol_c$ L^{-1}.

The water supply was supplied twice a day, at 07:00 and 17:00, using a watering can of 16 L. The chemical analysis of the water used for irrigation showed the following attributes: pH: 8.13, EC: 0.99 dS m^{-1}, Ca: 1.305 mmol L^{-1}, Mg: 1.48 mmol L^{-1}, Na: 5.5 mmol L^{-1}, K: 0.49 mmolc L^{-1}, CO_3^{-2}: 0.44 mmolc L^{-1}, HCO_3^{-}: 3.67 mmolc L^{-1}, chlorides: 4.97 mmolc L^{-1}, and RAS: 3.29. The water was classified as C_3 according to Richards (1954).

Analyzed variables and statistical program

60 days after sowing, the following variables were evaluated: root dry matter (RDM), plant dry matter (PDM), root biomass (RB), shoot biomass (SB), plant biomass (PB), biomass percentage (BP),

effective leaf area (ELA) and leaf area ratio (LAR).

Root dry matter and plant dry matter were measured using the mass of dry matter of both variables by drying in a forced-air circulation oven at 65°C for 48 h. Then, it was weighed on an analytical balance according to the methodology adopted by Silva et al. (2006). Root biomass, shoot biomass and total plant biomass were determined by the difference between the fresh weight and the dry matter of the respective variables. Subsequently, the parameters specific leaf area, and leaf area ratio were determined according to Benincasa (2003), using the formulas:

$$ELA = \frac{TPLA}{LDM}$$

$$LAR = \frac{TPLA}{PDM}$$

SLA: Specific leaf area;
TPLA: Total plant leaf area;
LDM: Leaf dry matter;
LAR: Leaf area ratio;
PDM: Plant dry matter.

The data were submitted to analysis of variance using the F test $P<0.05$, and subsequently linear and quadratic regressions using the statistical analysis software SISVAR® (Ferreira, 2014).

RESULTS AND DISCUSSION

The interaction of the factors cattle manure x biofertilizer affected significantly mass of root dry matter, total plant dry matter, root biomass, shoot biomass and total plant biomass. In turn, cattle manure affected significantly biomass percentage, effective leaf area and leaf area ratio (Table 1).

60 days after sowing, the interaction between cattle manure and biofertilizer significantly affected root dry matter. An optimal concentration was found in the presence (B_1) and the absence (B_0) of biofertilizer using 55 and 50% of cattle manure, respectively. It is also possible to observe the highest RDMs: 1.69 g in the presence (B_1) and 1.08 g in the absence (B_1) of the biofertilizer. Thus, the presence (B_1) of biofertilizer at a concentration by derivation of 50% of cattle manure provided an increase of 36.09% when compared to the optimal concentration in the absence (B_0) of biofertilizer (Figure 1A).

Mesquita et al. (2012) reported divergent results when compared with the results of this research, which reported for castor bean plants a higher mass of root dry matter (RDM) at a concentration of 80% of cattle manure in a 2 dm^3 container. This higher root dry matter (RDM) of yellow passion fruits can be associated with the genetic potential of the culture because a high value was observed for the level estimated by derivation of concentrations of 55% in B_1 and 50% in B_0, results lower than the values found by Mesquita et al. (2012), that is, there was an economy of 45 to 50% of cattle manure. Passion fruit crops respond well to low concentrations of cattle manure in the substrate.

On the other hand, the interaction of 50% of cattle manure in the presence of the biofertilizer increased RDM, and may be associated with the provision of macro and micronutrients, apportionment of applications and its release during the crop cycle (Sediyama et al., 2014), or there could be a likely decomposition of organic matter by microorganisms present in the biofertilizer, releasing humic substances.

For mass of total plant dry matter (Figure 1B), an increase by 47.08% and 40% of cattle manure, respectively, was observed by derivation up to the optimal concentration in the presence (B_1) and the absence (B_0) of the biofertilizer, favoring 3.49 g and 2.92 g of PDM. Thus, the cattle manure concentration 47.08% used together with the biofertilizer promoted an increase of 0.57 g in PDM, equivalent to 16.33% when compared to the estimated concentration in the absence of the biofertilizer.

Cavalcante et al. (2010) also found a high PDM in the presence of the biofertilizer in relation to 0.5 dS/m³ water for guava seedlings. According to Sousa et al. (2013), the biofertilizer provides an increase in photosynthetic rate and chlorophyll. This results in a greater assimilation and fixation of CO_2, producing mass of total plant dry matter (PDM), which may have occurred in this study. Oliveira et al. (2009) reported a greater mass of total plant dry matter (PDM) at a concentration of 28.88% of cattle manure at the initial growth of castor beans. Rodrigues et al. (2008) studied the agronomic performance of arugula and observed high dry matter at a concentration of 53.20% of cattle manure.

Root biomass increased gradually when subjected to different concentrations of cattle manure in the presence (B_1) and the absence (B_0) of biofertilizer (Figure 1C). As the concentrations of manure increased, an increase in root biomass occurred. A value of 2.88 g was found in B_1 and 2.7 g was found in B_0 at a concentration of 80% of cattle manure. Organic matter favors the release of important nutrients such as nitrogen (N) and sulfur (S) (Araújo et al., 2010). When correlated with other factors, it expands the photosynthetic area, ensures the development of plants by vegetative growth and increases the productive potential of crops (Filgueira, 2000).

Shoot biomass was influenced by the interaction between concentrations of cattle manure x biofertilizer (Figure 1D). The highest value was measured in treatments with 41.66% of cattle manure in the presence (B_1) of the biofertilizer: 10.65 g of SB. On the other hand, the concentration of 50% of cattle manure without the biofertilizer resulted in 8.55 g, that is, a decrease of 19.72% in shoot biomass. Notably, the biofertilizer provided the greatest shoot biomass (SB) at a concentration of 50% of cattle manure. Yang et al. (2016) reported a high yield and a low incidence of pathogens in watermelons regarding the consistent application of cattle

Table 1. Results of analysis of variance of the morphological parameters root dry matter (RDM), shoot dry matter (SDM), root biomass (RB), shoot biomass (SB), total plant biomass (TPB), biomass percentage (BP), effective leaf area (ELA) and leaf area ratio (LAR) of seedlings subject to different cattle manure concentrations in the presence (B_1) and the absence (B_0) of biofertilizer in yellow passion fruit plants.

SV	DF	Mean square			
		RDM	**PDM**	**RB**	**SB**
Manure	4	2.048**	8.109**	4.142**	49.440**
Linear	1	4.084**	7.409**	16.265**	27.457**
Quadratic	1	3.921**	24.411**	0.101**	131.764**
Biofertilizer	1	0.576	0.006^{ns}	0.323**	2.402*
E x F	4	0.267**	1.056**	0.282**	12.153**
Residue	40	0.002	0.006	0.006	0.568
C.V.	-	4.95	3.28	4.16	10.18
Mean	-	1.00	2.45	2.00	7.40

SV	DF	Mean square			
		PB	**BP**	**ELA**	**LAR**
Manure	4	63.714**	686.473**	116,124.047**	51,229.617**
Linear	1	85.988**	2,028.421**	258,260.125**	70,978.017**
Quadratic	1	124.551**	32.198^{ns}	2,748.637^{ns}	11,081.391^{ns}
Fertilizer	1	0.963^{ns}	51.999^{ns}	7,755.853^{ns}	6,695.790^{ns}
E x F	4	12.968**	14.914^{ns}	12,924.060^{ns}	7,357.177^{ns}
Residue	40	0.572	14.986	7,845.311	4,497.752
C.V.	-	8.04	17.31	19.21	22.73
Mean	-	9.40	22.36	461.02	295.06

**, *: Significant at 1 and 5% by F test, respectively; NS: not significant (Source of variation (SV), Degree of freedom (DF), mean square (MS) and coefficient of variation (CV)).

manure in the rotation of Garlic with watermelons. According to the authors, this was due to improvements in the soil biological condition, such as microbial quantity and high levels of enzyme activity. In addition, soil characteristics such as lower levels of phenols, salts and increase in pH also played a relevant role in it. The concentrations of cattle manure affected significantly total plant biomass, biomass percentage, specific leaf area and leaf area ratio. The total plant biomass (Figure 2A) fitted to a quadratic polynomial model, obtaining an optimal point at the concentrations 47.73 and 73.91% in the presence (B_1) and the absence (B_0) of biofertilizer, respectively. It provided a PB of 9.33 g and 10.96 g, respectively. It is possible to observe a rationing of 26.16% of cattle manure when using biofertilizers, in addition to stimulating a high PB.

The highest volume of total plant biomass was obtained in the presence of the biofertilizer. According to Cavalcante et al. (2007), the biofertilizer acts positively because it is a source of bioactive compounds, which favors the release of humic substances and stimulates an increased activity of the enzyme reductase, reducing free amino acids. On the other hand, Freire et al. (2014) found a high potential quantum yield (Fv/Fm) by using biofertilizers based on cattle manure and a low volume of internal CO_2 of passion fruits. This may reflect directly in the production of biomass, as the highest Fv/Fm and the lowest rate of internal CO_2 may mean a high CO_2 fixation as a result of a high biomass.

The percentage of biomass increased with the gradual increase in cattle manure concentrations (Figure 2B). The maximum concentration obtained 29.75% of biomass. As a result, there was an increase of 59.16% when compared to the 0% increase of the organic input. The benefits of cattle manure, according to Oliveira et al. *(*2010), are probably related to the fact that, when supplied in adequate amounts, it may be able to meet the needs of the plants due to an increase in N, P and K contents available, being K the element whose content reaches high values in the soil.

On the other hand, different cattle manure concentrations, regarding SLA and LAR resulted in a decrease as the concentrations of cattle manure increased (Figure 2C and D). This was expected because the obtained biomass percentage presented an inverse behavior. Bezerra et al. (2016) evaluating the growth of two genotypes of yellow passion fruit under a salinity condition considering specific leaf area do not support this, as the authors found a positive linear tendency.

According to the authors, ELA is an indicator of leaf

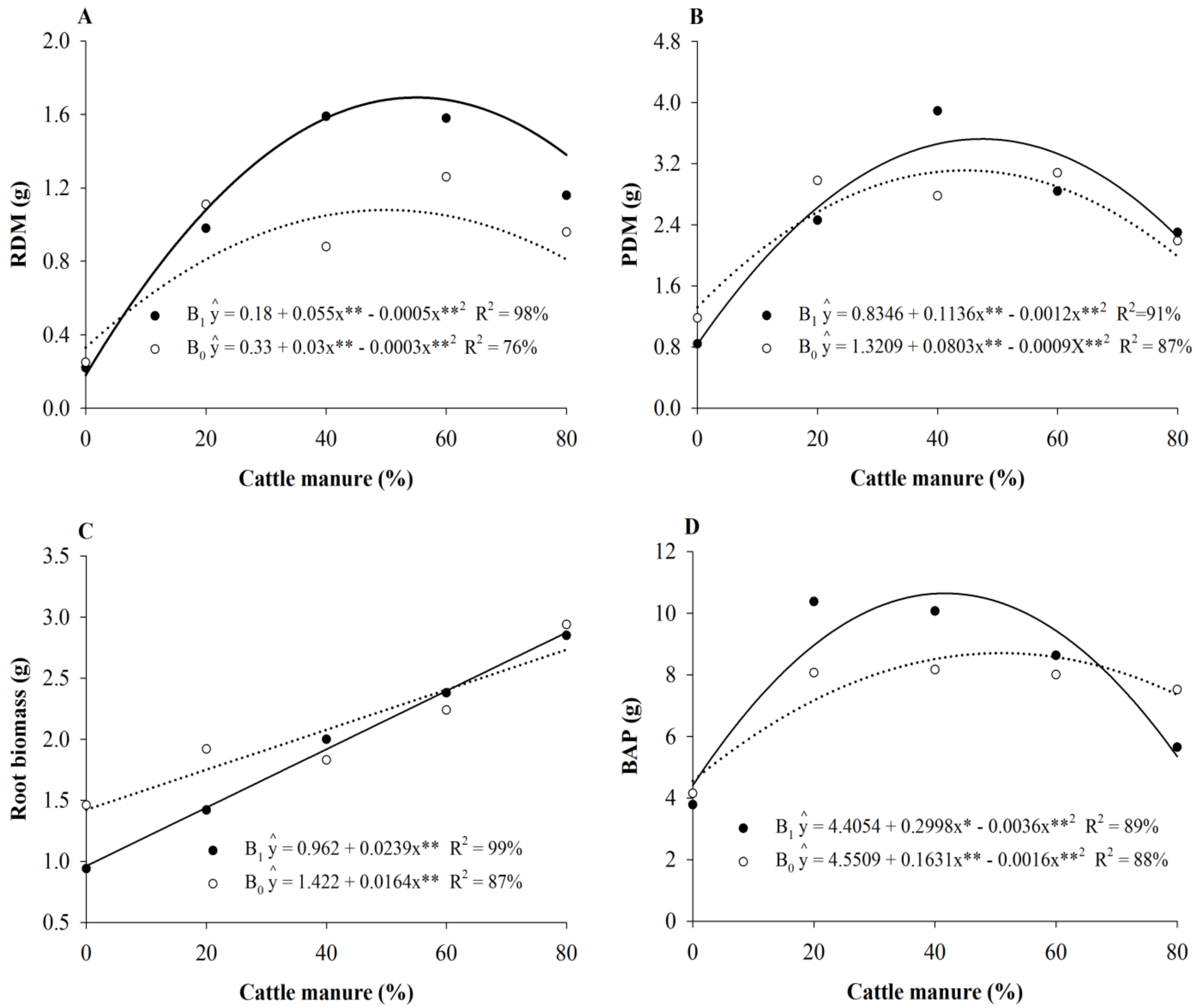

Figure 1. (A) Root dry matter (RDM), (B) plant dry matter (PDM), (C) root biomass, and (D) Biomass of the aerial part (BAP) in function of cattle manure concentrations in the presence (B_1) and absence (B_0) of the biofertilizer in yellow passion fruit plants.

thickness, the lower the value, the thicker the leaf. It indicates a small leaf area and a greater leaf dry matter, making it advantageous because leaves become more resistant to light intensity and more efficient in the absorption of photons and CO_2, resulting in high net photosynthesis and biomass production. SLA is given by the ratio between total leaf area and leaf dry matter (Dias-Filho, 1997).

LAR expresses the useful leaf area for photosynthesis. It is a morpho-physiological component for it is the ratio between leaf area (area responsible for intercepting light energy and CO_2) and total dry matter (a result of photosynthesis) (Silva et al., 2006). The decreasing linear tendency of leaf area ratio means that more mass was distributed on stems and roots, making it a positive point, because the allocation of dry matter to roots enables a greater absorption and translocation of humic substances from cattle manure.

Conclusion

The use of cattle manure isolated and/or interacting with liquid biofertilizers becomes feasible for the production of yellow passion fruit seedlings. Concentrations between 40 and 50% of cattle manure provide high root dry matter, plant dry matter, shoot biomass and biomass percentage in yellow passion fruit plants.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

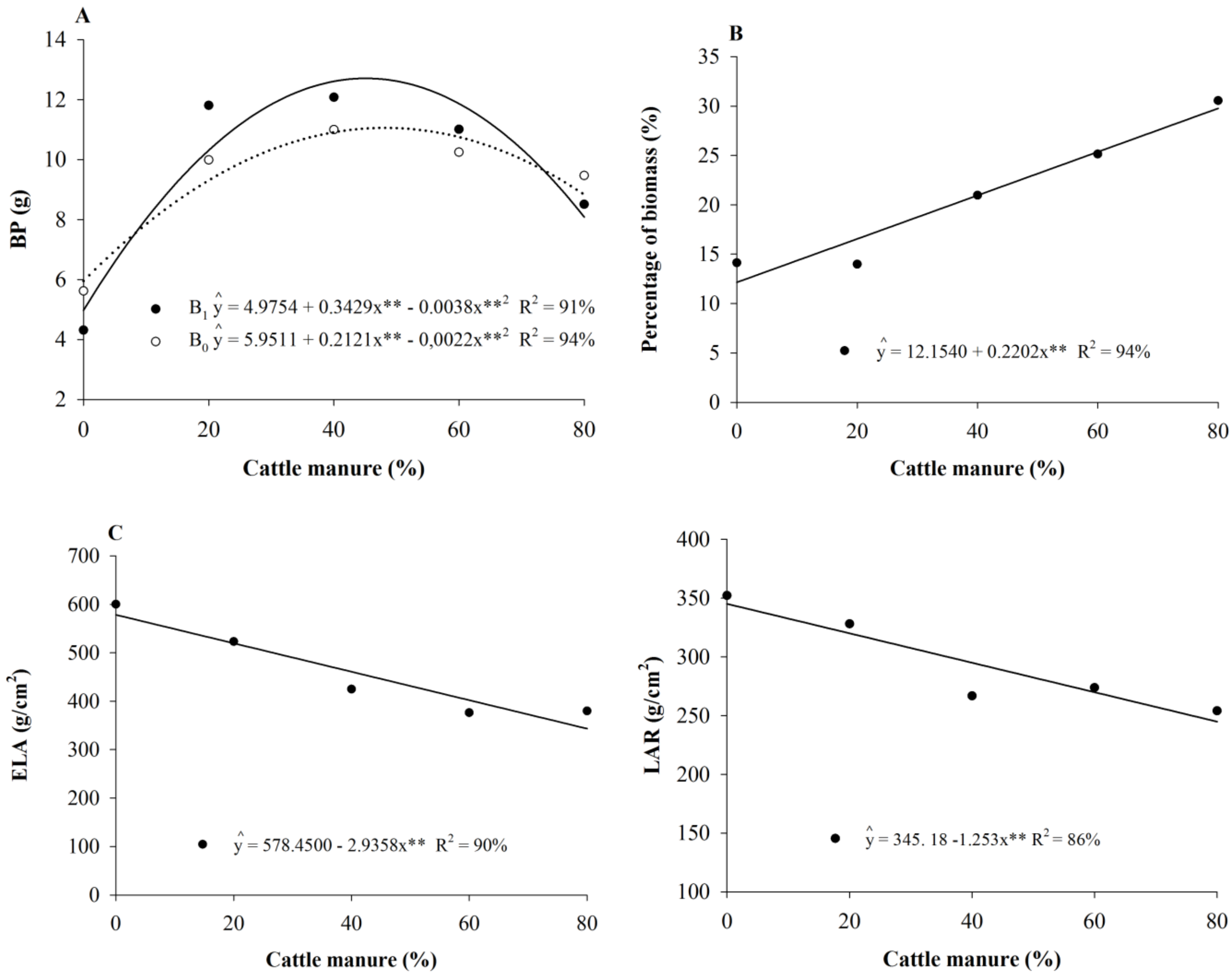

Figure 2. (A) Total plant biomass (TPB), (B) biomass percentage (BP), (C) specific leaf area (SLA), and (D) leaf area ratio (LAR) in function of cattle manure concentrations in the presence (B_1) and the absence (B_0) of the biofertilizer in yellow passion fruit plants.

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