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Effect of Organic Fertilization on Watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai.) Fruit Production in Open Field

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ABSTRACT

A study on organic watermelon production was conducted at the experimental field of the Technological University of Culiacán.

Objective: The objective of this study was to evaluate different doses of organic fertilization in two watermelon varieties, "Peacock Improved" and "Sugar Baby."

Design/Methodology: A randomized complete block design with four replicates and five treatments was employed: 1) Biol-70 mL, 2) Biol-90 mL, 3) Earthworm leachate-30 mL, 4) Earthworm leachate-60 mL, and 5) Control. The following variables were assessed: 1. Fruit length, 2. Width, 3. Weight, 4. Rind thickness, 5. Pulp thickness, 6. Degrees Brix, and 7. Firmness.

Results: The analysis of variance revealed highly significant differences ($P<0.05$) in most characteristics, except for pulp thickness and fruit width, which did not exhibit a significant effect between varieties. Nevertheless, a significant effect was observed among treatments and blocks for most traits, indicating notable differences among fruits and varieties. The "Peacock Improved" variety exhibited greater variation in fruit size, whereas "Sugar Baby" showed lower average values; however, the latter produced fruit with greater rind thickness. With respect to soluble solids and firmness, the "Peacock Improved" variety was particularly noteworthy. The Biol-70 and Biol-90 treatments produced heavier watermelons, whereas the Earthworm Leachate treatment resulted in lighter fruit compared with the control. The Biol-90 treatment produced fruit with higher soluble solids content, while the Earthworm Leachate treatment yielded lower values than the control. However, the Lix-30 treatment produced firmer fruit, whereas the remaining treatments resulted in fruit with a less firm texture.

Limitations/implications: The effect of organic fertilization on watermelon exhibited statistically significant differences; however, its field implementation affected productivity, as nutrient concentrations, particularly potassium and nitrogen, were low during the flowering and fruiting stages.

Conclusion: It is concluded that the Biol doses used produced fruit with characteristics favorable to yield and fruit quality in open-field watermelon production.

Keywords: *Citrullus lanatus*, variety, firmness, leaching, organic production.

INTRODUCTION

Watermelon (*Citrullus lanatus*) is an annual vegetable crop in which the fruit constitutes the harvested organ. In Mexico, a production of 953,244 tons was reported in 2013, with a national average yield of 28.41 t ha^{-1} (FAOSTAT, 2017). Watermelon production is concentrated mainly in five regions of the country: the Pacific region, accounting for 45.3%; the North-Central region, 29.1%; the Gulf region, 19.2%; and the Yucatán Peninsula, 6.4% (INIFAP, 2003). Reported national average yields range from 22.04 t ha^{-1} (Espinoza *et al.*, 2006) to 26.7 t ha^{-1} (Cenobio-Pedro *et al.*, 2006), which underscores watermelon as a high-yield crop. Its cultivation is well suited to warm climates and has driven the search for genetic materials with greater market potential, particularly those exhibiting superior performance in fruit size, weight, and soluble solids content measured as degrees Brix (Palma Romero and Menéndez Baque, 2012). Fertilization and its method of application constitute fundamental pillars for improving nutrient use efficiency by the plant and, consequently, reducing production costs. In this regard, the nutrient uptake curve makes it possible to define an appropriate fertilization program for the crop, considering both the amount of fertilizer and the optimal timing for its application (Sancho, 1999; Misle, 2006). Nevertheless, intensive fertilization practices aimed at maximizing yields often promote environmental degradation, loss of soil organic matter, erosion, and the need to use large quantities of herbicides, fungicides, and pesticides (Valenzuela *et al.*, 2012). Organic fertilizers are generally considered environmentally safe compared with chemical fertilizer forms (Ali *et al.*, 2019; Espinosa-Palomeque *et al.*, 2020). For this reason, the use of organic amendments in fertilization has gained considerable importance in agricultural practices (Nieto-Garibay *et al.*, 2002). Among the fertilizers produced through biological transformation methods of organic residues into relatively stable products, compost, vermicompost, and anaerobic decomposition are particularly noteworthy (Claassen and Carey, 2004). The productive capacity and physicochemical conditions of soil benefit in the long term from the incorporation of organic fertilizers, owing to the mineralization of organic matter into nutrients assimilable by plants (Hernández *et al.*, 2010), since this process increases the enzymatic activity of microorganisms (Fuentes *et al.*, 2006), especially when temperature and moisture conditions in the soil arable layer are appropriate (León-Nájera *et al.*, 2006). A recent alternative for agricultural development is the use of Biol, as it contributes to improving plant growth and development. This biofertilizer promotes better root, leaf, flower, and fruit development; it is rapidly absorbed by plants due to its high content of plant growth hormones, amino acids, and vitamins; it enhances crop vigor; and it enables plants to withstand more effectively pest attacks, diseases, and adverse climatic effects (Álvarez, 2010). At present, many countries have shifted toward the consumption of organic products because of the benefits associated with producing food free of toxic pesticide residues or heavy metals (Calizaya, 2013). In this context, the use of organic fertilizers represents an opportunity to develop and expand the productive potential of soils while providing foods of high nutritional quality without harming the environment (Bizzozero, 2006). The aim of the present study was to generate information on the effect of organic fertilizers on watermelon fruit development (*Citrullus lanatus*) under open-field cultivation conditions, in a crop established on the grounds of the Technological University of Culiacán, Sinaloa, Mexico. The application of these inputs seeks to contribute to the generation of a more sustainable and efficient production system by evaluating their direct impact on watermelon crop quality and yield.

MATERIALS AND METHODS

Study area. The present study was conducted at the "Lote Arroyo" experimental field of the Technological University of Culiacán, within a suburban plot belonging to the Ciudad Educadora del Saber, located on the left margin of kilometer two of the Culiacán-Imala highway, Los Ángeles neighborhood, Culiacán de Rosales, Sinaloa (Figure 1).

Seeds of the "Peacock Improved" and "Sugar Baby" varieties were sown on September 9, 2024, in germination trays containing Kekkila Professional substrate moistened to field capacity in order to ensure adequate germination, growth, and seedling development. Once sowing was completed, the trays were covered with black plastic to prevent desiccation. Prior to sowing, land preparation was carried out between September 6 and 9, 2024. First, double harrowing was performed to improve soil aeration and drainage; subsequently, leveling and bed formation were conducted using a bed shaper. Four beds, each 40 m long and 1.20 m wide, were established, delimiting an area of 550 m^2.

A drip irrigation system was installed to provide uniform and optimal irrigation for the watermelon varieties evaluated. Once the beds had been prepared with the irrigation tapes, mulching was applied using plastic film 1.5 m wide and 100 microns thick, with perforations arranged according to the planting densities recommended for watermelon cultivation. This technique makes it possible to optimize irrigation efficiency, create a favorable microclimate for root development, and reduce the incidence of weeds and pests. The watermelon seedlings were transplanted on October 9, 2024, considering planting densities of 1.20 m between plants and 1.50 m between rows. Prior to transplanting, irrigation was applied to facilitate seedling establishment under open-

Figure 1. Location of the Ciudad Educadora del Saber within the suburban landscape of the city of Culiacán.

field conditions and to minimize transplant stress. Finally, seedling transplantation was carried out between 16:00 and 18:00 h at a depth of 5 cm in the middle section of each bed, under strict care to avoid mechanical damage and dehydration. During plant growth, pruning practices were performed, consisting of cutting secondary stems at the pollination stage in order to promote improved fruit set in watermelon plants. A randomized complete block design with four replicates and five treatments was applied: 1) 70 mL organic Biol, 2) 90 mL organic Biol, 3) 30 mL earthworm leachate, 4) 60 mL earthworm leachate, and 5) Control. The following variables were evaluated: 1. Fruit length, 2. Fruit width, 3. Fruit weight, 4. Rind thickness, 5. Pulp thickness, 6. Degrees Brix, and 7. Firmness. Likewise, the watermelon plants were grouped into homogeneous blocks (furrows), and the organic fertilization treatments were randomly assigned within each block. The purpose of using this design was to reduce experimental variability and increase experimental precision. InfoStat 2020 statistical software was used to perform the analysis of variance and Duncan's multiple mean comparison test at a significance level of $P<0.05$.

RESULTS AND DISCUSSION

The data analysis of fruits from the watermelon varieties "Peacock Improved" and "Sugar Baby" harvested under open-field conditions is presented below. The analysis of variance indicated highly significant differences among treatments ($P<0.05$) for all characteristics studied, with the exception of the variable "pulp thickness" (Table 1).

The watermelon varieties exhibited significant differences among the means of the reproductive traits, with the exception of fruit width and pulp thickness. Regarding the measured variables, the "Peacock Improved" variety produced higher fruit performance, whereas "Sugar Baby" showed lower average values, except for rind thickness, for which it recorded a higher value than "Peacock Improved." With respect to soluble solids (°Brix) and firmness, the fruits of the "Peacock Improved" variety stood out by exhibiting superior values (Table 2).

Significant variation was observed among treatments and blocks for most traits of the watermelon varieties, except for pulp thickness and soluble solids (°Brix), which did not show significant effects (Table 3). All treatments, including the control, were highly significant for most of the traits evaluated in the varieties under study.

Table 1. Analysis of variance of watermelon varieties under open-field conditions (Duncan, $\alpha=0.05$).

Source of variation	DF	SS	MS	F	P	R^2	CV
Fruit length	13	1482.52	114.35	11.66	<0.0001	0.90	15.47
Fruit width	13	651.25	50.10	3.89	0.0060	0.76	25.40
Fruit weight	13	260.43	20.03	39.72	<0.0001	0.97	22.71
Pulp thickness	13	2.43	0.19	0.80	0.2377	0.39	36.33
Rind thickness	13	7.63	0.59	3.06	0.0184	0.71	49.90
°Brix	13	36.76	2.83	1.14	0.0163	0.48	26.33
Firmness	13	2.203	1.704	3.19	0.0032	0.72	34.18

Means followed by the same letter are not significantly different ($P>0.05$).

Table 2. Average values per watermelon variety in open field.

Variety	Fruit length	Fruit width	Fruit weight	Pulp thickness	Rind thickness	°Brix	Firmness
Sugar Baby	16a	12.93a	1.17a	1.22a	1.08a	5.22b	0.021a
Peacock Improved	24.47b	15.33a	5.08b	1.44a	0.67b	6.77a	0.031b
Error	9.8030	12.8885	0.5044	0.2340	0.1918	2.4900	0.0001
DF	16	16	16	16	16	16	

Means followed by the same letter are not significantly different (P>0.05).

Table 3. Results of significant sources of variation between blocks and treatments ($\bar{x}$) of watermelon varieties in open field.

Sources of significant variation in watermelon							
				Fruit length			
Block	10 (6.5) [a]	4 (16)[b]	9 (17.5) [bc]	8(17.7) [c]	5(23) [cd]	2(23.1) [cd]	3 (26) [d]
Treatment	Testigo (9.83) [a]	Bio-90 (20.2) [b]	Bio-70 (24) [bc]	Lix-60 (21.5) [b]	Lix-30 (25.7) [c]		
Fruit	1 (19)[b]	2 (20.6) [bc]	3 (24.1) [c]	4 (10) [a]			
				Ancho de fruto			
Block	2 (15.1) [b]	3 (16.3) [b]	4 (13.0) [ab]	5 (10) [ab]	8 (13.8) [b]	9 (14.5) [b]	10 (5.5) [a]
Treatment	Testigo (7) [a]	Bio-90 (12.2) [b]	Bio-70 (18) [cd]	Lix-60 (14.2) [bc]	Lix-30 (19.3) [d]		
Fruit	1 (13.8) [b]	2 (14.2) [b]	3 (16.2) [b]	4 (7) [a]			
				Peso de fruto			
Block	2 (7.18) [c]	3 (2.72) [b]	4 (1)[a]	5 (7) [c]	8 (1.36) [ab]	9 (1.17) [a]	10 (0.75) [a]
Treatment	Testigo (1.5) [a]	Bio-90 (4.92) [c]	Bio-70 (5.22) [c]	Lix-60 (1.58) [ab]	Lix-30 (2.42) [b]		
Fruit	1 (2.84) [b]	2 (3.09) [bc]	3 (3.91) [c]	4 (1.75) [a]			
				Shell thickness			
Block	2 (0.47) [a]	3 (0.94) [ab]	4 (0.80) [ab]	5 (0.21) [a]	8 (1.64) [b]	9 (0.70) [ab]	10 (0.70) [ab]
Treatment	Testigo (0.70) [a]	Bio-90 1.27 [a]	Bio-70 0.76 [a]	Lix-60 0.80 [a]	Lix-30 0.85 [a]		
Fruit	1 (1.0) [b]	2 (1.02) [b]	3 (0.69) [ab]	4 (1.75) [a]			
				Firmness			
Block	2 (0.02) [ab]	3 (0.03) [b]	4 (0.02) [a]	5 (0.01) [a]	8 (0.02) [ab]	9 (0.01) [a]	10 (0.02) [ab]
Treatment	Testigo (0.02) [a]	Bio-90 (0.02) [a]	Bio-70 (0.02) [a]	Lix-60 (0.02) [a]	Lix-30 (0.02) [a]		
Fruit	1 (0.02) [b]	2 (0.02) [b]	3 (0.02) [b]	4 (0.01) [a]			

Means followed by the same letter are not significantly different (P>0.05).

Variation in fruit weight, °Brix, and firmness

The Biol-70 and Biol-90 treatments produced fruits with greater weight, whereas the earthworm leachate treatments yielded lighter watermelons relative to the control (Figure 2). With regard to °Brix, the Bio-90 treatment (Biol with 90 mL of organic fertilizer per 20 mL of water) produced fruits with higher soluble solids content, while the earthworm leachate treatments showed lower mean values than the control (Figure 3). Nevertheless, the Lix-30 treatment (30 mL of earthworm leachate per 20 L of water) produced fruits with greater firmness, whereas the remaining treatments resulted in fruits with lower texture quality compared with the control treatment (Figure 4).

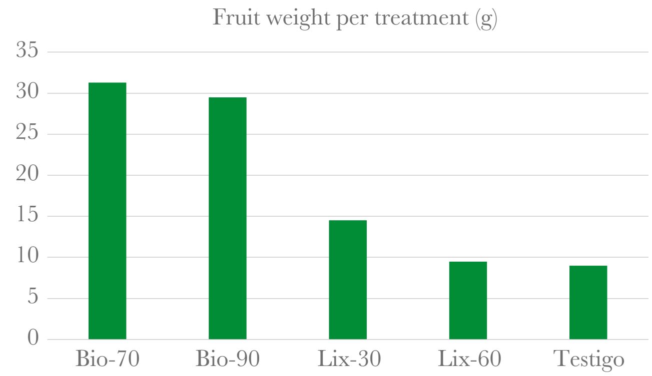

Figure 2. Average fruit weights per treatment of open field watermelon.

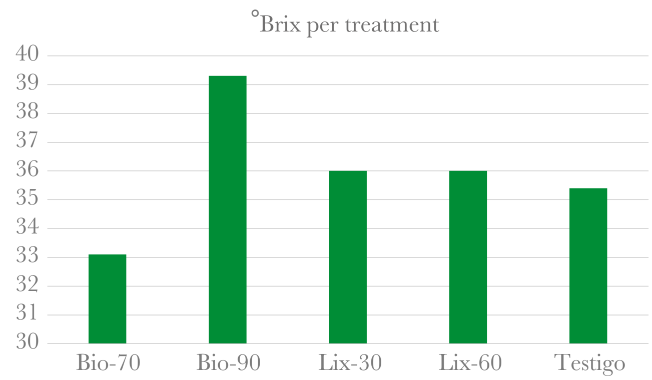

Figure 3. Average °Brix values per treatment of open field watermelon.

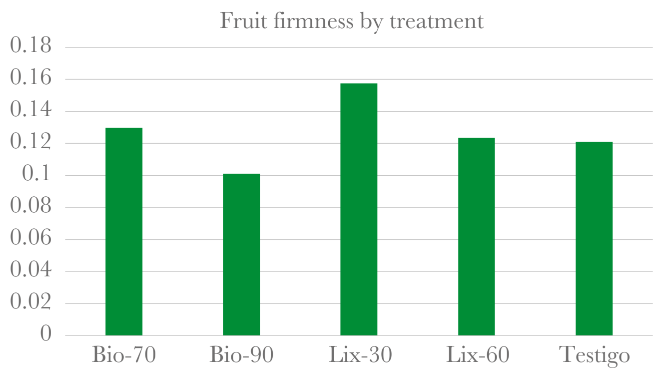

Figure 4. Average firmness by treatment of open field watermelon.

The analysis of variance (Duncan's test, P>0.05) indicated significant differences for the variable total soluble solids (°Brix), with a mean value of 6.77 in watermelon fruit under the Biol-90 mL treatment. However, this value is considerably lower than that reported by Sarmiento-Sarmiento *et al.* (2019), who obtained 11 °Brix in watermelon. The results obtained in the present study also differ from those reported by Aguilar (2014), Anquise (2016), Soto Cartagena and Soto-Martínez (2017), and Sánchez (2018), who did not find statistically significant differences in total soluble solids (TSS) content when applying organic and chemical fertilizer sources in different watermelon varieties. This discrepancy may be explained by the fact that organic fertilizers contain very low amounts of calcium and potassium, which are essential macronutrients for increasing soluble solids in the fruit. The variation in Biol treatment levels was reflected in the values of total soluble solids. This finding is consistent with the work of Mainga, Saha, and Mwololo (2018), who reported significant differences in this variable under treatments with different manure concentrations, indicating that as application levels increase, the total soluble solids of watermelon fruit also increase. Likewise, Quispe Ascuña (2020) provides a solid basis for the study of watermelon (*Citrullus lanatus*) cultivation through the use of organic bioles. In that study, statistical similarity was reported at low concentrations and statistically significant differences at higher concentrations, indicating that at higher Biol doses, the "Santa Amelia" watermelon variety produces larger fruits. On the other hand, the results for the non-significant variables in this study, namely pulp thickness and fruit width, are consistent with those reported by Jiménez-López (2010), who found no significant differences among treatments for quality-related variables such as equatorial diameter, pulp thickness, and soluble solids (°Brix).

CONCLUSIONS

Organic fertilization produced a greater effect in the "Peacock Improved" variety in terms of fruit size, weight, soluble solids, and firmness; therefore, its cultivation under open-field conditions is recommended. Likewise, the application of the same fertilization had a positive effect on the "Sugar Baby" variety, producing fruits with greater rind thickness, which represents an advantage for postharvest handling. Regarding the effects of Biol-based treatments (70 and 90 mL), the first produced watermelon fruits with greater weight, whereas the second, in addition to producing heavier fruits, also exerted greater effects on soluble solids (°Brix). This represents a significant improvement in production and quality, which is an important aspect for fruit commercialization. Based on the results obtained from the effects of Biol-based treatments on the agronomic fruit variables of the watermelon varieties "Peacock Improved" and "Sugar Baby," their use is recommended for open-field cultivation.

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