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Effect of three organic fertilizers with shrimp exoskeleton inclusion on the agro-morphological characteristics of coffee (*Coffea arabica* L.) sarchimor 4260 at the nursery stage

Efecto de tres abonos orgánicos con inclusión de exoesqueleto de camarón sobre las características agro morfológicas del café (*Coffea arabica* L.) sarchimor 4260 en etapa de vivero

Bolívar Mendoza Marcillo[1]
María Chiquito Ormaza[2]
Joffre Pincay Menéndez[3]
Yhony Valverde Lucio[4]
Jessica Moran Moran[5]
Pedro Peñafiel Molina[6]

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Correspondence author
bolivar.mendoza@unesum.edu.ec

[1] Master's Degree in Agronomy with a specialization in Sustainable Agricultural Production. Full Time Professor Universidad Estatal del Sur de Manabí. Email: bolivar.mendoza@unesum.edu.ec. ORCID: https://orcid.org/0000-0003-0812-2232.

[1] Agricultural Engineer. Professional graduate from the Universidad Estatal del Sur de Manabí, Jipijapa, Ecuador. Email: chiquito-maria9828@unesum.edu.ec https://orcid.org/0009-0002-8135-5171.

[1] Master's Degree in Agronomy with a specialization in Sustainable Agricultural Production. Full Time Professor Universidad Estatal del Sur de Manabí. Email: joffre.pincay@unesum.edu.ec. ORCID: https://orcid.org/0000-0002-4664-8983

[1]D. in Agrifood Biosciences. Full Time Professor at Universidad Estatal del Sur de Manabí. Email: yhonny.valverde@unesum.edu.ec. ORCID: https://orcid.org/0000-0002-9792-9400.

[1]Master's Degree in Sciences, mention in Microbiology. Full Time Professor Universidad Estatal del Sur de Manabí. Email: jessica.moran@unesum.edu.ec. ORCID: https://orcid.org/0000-0002-6487-1038

[1]Master's Degree in Agronomy with a specialization in Sustainable Agricultural Production. Technician of the Ministry of Agriculture and Livestock, Ecuador. Email:ppenafielregion4@gmail.com http://orcid.org/0009-0007-5124-1575.

Abstract: With the objective of evaluating the agro morphological characteristics of coffee sarchimor 4260 under the application of organic fertilizers with the inclusion of shrimp exoskeleton (EC) in the nursery stage, an experimental methodology was used with the use of ANOVA with a completely randomized design (DCA) and separation of means according to Tukey's test ($p<0.05$) where 7 treatments and 10 replications were considered. The results indicate that there was a statistical difference in each of the treatments studied , however for the variable number of leaves there was no statistical difference, it only showed better behavior, presenting the best results for: plant height, T6 (Agricultural soil +Bocashi+Shrimp exoskeleton in proportions 3.1.1) with 11.34 cm, this treatment coincided for stem diameter with 3.02 mm at 120 days, root length 13.56 cm at 120 days, root diameter with 3.22 mm at 120 days .

Key words: sarchimor 4260 coffee, organic fertilizers, shrimp exoskeleton, agro morphology.

Resumen: Con el objetivo de evaluar las características agro morfológicas del café sarchimor 4260 bajo la aplicación de abonos orgánicos con inclusión de exoesqueleto de camarón (EC) en etapa de vivero, se empleó una metodología de orden experimental con la utilización del ANOVA con un diseño completamente aleatorio (DCA) y separación de medias de acuerdo con la Prueba de Tukey al ($p< 0,05$) donde se consideraron 7 tratamientos y 10 repeticiones. Los resultados indican que existió diferencia estadística en cada uno de los tratamientos estudiados, sin embargo para la variable número de

hojas no se presentó diferencia estadística, solo mostro mejor comportamiento, presentándose los mejores resultados para: altura de planta, el T6 (Suelo agrícola +Bocashi+Exoesqueleto de camarón en proporciones 3.1.1) con 11.34 cm, este tratamiento coincidió para diámetro de tallo con 3.02 mm a los 120 días, longitud de raíz 13.56 cm a los 120 días, diámetro de raíz con 3.22 mm a los 120 días.

Palabras clave: café sarchimor 4260, abonos orgánicos, exoesqueleto de camarón, agro morfología.

Introduction

Ecuador has a rich history of coffee growing that began with its introduction to the country in the 1800s, in the first decades of the twentieth century it was the first national export product. The Coffea genus has about 80 species originating in Africa and Asia, but the most commercially important are: *Coffea arabica* and *Coffea canephora*, .

Organic fertilizers are 100% natural products obtained from plant and animal waste, so they do not contain chemicals. It is a material that does not damage agricultural products and is good for plant health. On the other hand, we can say that this fertilizer is totally sustainable, because its own composition is the result of a recycling process. Otherwise, this waste will be useless and will damage the ecosystem. It is important to know that it also improves moisture absorption. It improves the natural properties of soils that have been dried out or damaged by human production, helping to restore them, .

The exoskeleton is a hard outer layer consisting of epidermal cells found in all arthropods such as spiders, insects, crustaceans, etc. . The composition of shrimp exoskeleton has a high content of substances such as: water 10.00%, crude protein 40.60%, ether extract 2.60%, crude fiber 14.20%, nitrogen free extract 2.60%, ash 30.00%, calcium 9.70% and phosphorus 1.57%, .

The use of shrimp exoskeletons has been proposed as a source of raw material for obtaining chitin and chitosan and as a concrete opportunity to improve socioeconomic and environmental conditions .

Based on this background, it was decided to evaluate the agro-morphological characteristics of coffee *(coffea arabica* L.*)* sarchimor

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4260 under the application of organic fertilizers with the inclusion of shrimp exoskeleton in the nursery stage .

Methodology

Location

The research was carried out in the experimental area of the Agricultural Career belonging to the Universidad Estatal Del Sur de Manabí at Km 1½ via Jipijapa-Noboa - Campus Los Ángeles. South of the province of Manabí, geographically located at 01°20'00" south latitude and 80°35'00" west longitude, at an altitude of 287 masl. The average annual temperature is 21°C and an average annual precipitation of 1000mm (Santistevan *et al*., 2016).

Treatments

The treatments for the evaluation of the agro-morphological characteristics of coffee *(coffea arabica* L.*)* sarchimor 4260 under the application of organic fertilizers with the inclusion of shrimp exoskeleton in the nursery stage were distributed as shown in Table 1.

Table 1. Treatments carried out on sarchimor coffee in the nursery stage.

Treatments	Substrates	Acronym
T1	2 parts of agricultural soil + 1 part of Compost + 1 part of shrimp exoskeleton	2SA+1C+1EC
T2	3 parts of agricultural soil + 1 part of compost + 1 part of shrimp exoskeleton	3SA+1C+1EC
T3	2 parts of Agricultural Soil + 1 part of Humus + 1 part of shrimp exoskeleton	2SA+1H+1EC
T4	3 parts of Agricultural Soil + 1 part of Humus + 1 part of shrimp exoskeleton	3SA+1H+1EC
T5	2 parts of Agricultural Soil + 1 part of Bocashi + 1 part of shrimp exoskeleton	2SA+1B+1EC
T6	3 parts of Agricultural Soil + 1 part of Bocashi + 1 part of shrimp exoskeleton	SA3+B1+EC1
T7	Agricultural land	SA (witness)

Experimental design

The type of research used is experimental, in which a completely randomized design (CRD) is applied, with 7 treatments (substrates) (Gabriel *et al*., 2021), in 10 replications considering 70 seedlings as the experimental unit.

The response variables evaluated were: Number of leaves (NH), the number of total leaves per plant was evaluated. Stem diameter (SD). This data was taken in nine plants with the help of a truper digital calibrator and expressed in millimeters. Plant height (PA). nine plants were evaluated with the help of a ruler and this data was generated expressed in centimeters Root length (RL). nine plants were evaluated with the help of a ruler and this data was generated expressed in centimeters.
The present research work was carried out in a nursery, entirely covered with nets to avoid direct sunlight penetration. The perforated plastic bags containing the respective substrates were placed on a 1 m wide by 5 m long plank. The substrates were prepared with the different types of organic fertilizers to be placed in the polyethylene bags, such as: compost, humus, bocashi and shrimp exoskeleton (flour), with the respective identification of each of the treatments. The substrates were disinfected with Captan using 10 g in 1 liter (lt) of water. The coffee seedlings were transplanted into the different types of substrates and treatments.
Irrigation in this stage of the nursery, especially in coffee seedlings, is considered of supreme importance. There should be no deficiency or excess, so it is necessary to perform it according to the different stages. In the germination phase, abundant irrigation was given prior to planting, the covers were covered with plastic material and then watered once or twice a week, depending on the light intensity of the day. Once germinated, irrigation was maintained at a frequency of twice a week, trying to ensure that the plants had the necessary humidity and avoiding excesses; this irrigation system was maintained until the end of the research. Weed control was carried out manually.

A monthly evaluation was made for each of the treatments at 30, 60, 90 and 120 days, measuring stem diameter with a digital caliper, plant height with a ruler and the number of leaves.

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Statistical analysis

Prior to the normality analysis, the experimental results were subjected to the following statistical analyses: Analysis of Variance (ANOVA) and separation of means according to Tukey's Test at ($p< 0.05$) probability. The ANOVA variance scheme is specified in the following table:

Table 2 Analysis of variance

Source of variation	Degrees of freedom
Treatments (T-1)	6
Experimental Error t(r-1)	63
Total (rt-1)	69

Results

Foliar evaluation

Table 2 shows the mean tables for plant height, stem diameter and number of leaves. In this sense, it is observed that there were no significant differences at $P<0.05$ of probability in plant height at 30, 60, 90 and 120 days after sowing (AP 30, 60, 90 and 120 dds), and there were highly significant differences for stem diameter at 30 days after sowing (DT 30 dds). For stem diameter at 60, 90, 120 days after sowing (DT 60 dds, 90 dds and 120 dds) and leaf numbers at 60, 90, 120 days after sowing (NH 60 dds, 90 dds and 120 dds) was significant at $P<0.01$. The coefficients of variation (CV) were in the range allowed for this type of research (11.20 to 36.54%).

In Table 3, the comparison of means by Tukey's test at $P<0.05$ probability, showed that the variables plant heights at 30, 60, 90 and 120 days after sowing (AP 30, 60, 90 and 120 dds) its treatments are statistically equal, however, numerical differences are observed, presenting the best results the T6 (3SA+1B+EC) with 4.59 cm at 30 days, 5.81 cm at 60 days, 7.93 cm at 90 days and 11.34 cm at 120 days after sowing.

In the stem diameter variable, statistically significant differences were observed according to the Tukey's test ($p<0.05$) among the 7 treatments evaluated. The best results were for T6 (3SA+1B+EC) with 2.30 cm at 30 days after sowing, 2.75 cm at 60 days after sowing, 3.15 cm at 90 days after sowing and 3.02 cm at 120 days after sowing.

In the same sense, for the leaf number variable, statistically significant differences were found among the 7 treatments evaluated, the best results were for T4 (3SA+1H+1EC) at 60 days after sowing with 4.00 mm, at 90 days after sowing with 6.00 mm and 120 days after sowing with 8.89 mm.

Table 2. *Mean squares of the variables plant height cm, stem diameter mm and number of leaves.*

FV	gl	Mean square										
		AP 30 dds	**AP 60 dds**	**AP 90 dds**	**AP 120 dds**	**DT 30 dds**	**DT 60 dds**	**DT 90 dds**	**DT 120 dds**	**NH 60 dds**	**NH 90 dds**	**NH 120 dds**
Trat	6	1.51 ns	1.99 ns	5.65 ns	12.37 ns	0.35**	0.22 *	0.27 *	0.48 *	3.57 *	4.33 *	9.90 *
Error	56	0.80 ns	1.42 ns	2.41 ns	7.45 ns	0.05**	0.09 *	0.10 *	0.16 *	1.37 *	2.51 *	2.93 *
total	62											
CV		21.90	23.56	22.35	28.14	11.20	12.10	11.41	13.26	36.54	30.70	22.29

AP: Plant height, **DT:** Stem diameter, **NH**: Number of leaves, NH: Number of leaves.

*: Significant at P<0,05, **: Highly significant at P<0,01

Table 3. *Analysis of means of the variables plant height cm, stem diameter mm and number of leaves.*

Treatment	AP 30 dds	AP 60 dds	AP 90 dds	AP 120 dds	DT 30 dds	DT 60 dds	DT 90 dds	DT 120 dds	NH 60 dds	NH 90 dds	NH 120 dds
T1 2 SA+1 C+1 EC	4.27 a	4.95 a	6.02 a	8.46 a	2.06 a b c	2.43 a b	2.79 a b	3.00 a b	2.33 b	4.11 b	6.78 a b
T2 3 SA+1 C+1 EC	3.91 a	4.95 a	7.81 a	10.14 a	1.95 b c	2.41 a b	2.67 b	2.88 b	3.00 b	5.33 a	7.00 a b
T3 2 SA+1 H+1 EC	3.57 a	4.92 a	7.15 a	10.45 a	1.78 c	2.25 b	2.62 b	2.81 b	3.11 a b	5.11 a	7.67 a b
T4 3 SA+1 H+1 EC	3.57 a	4.26 a	6.16 a	9.69 a	1.80 c	2.37 a b	2.80 a b	3.02 a b	4.00 a b	6.00 a	8.89 a
T5 2 SA+1 B+ EC	4.36 a	5.24 a	6.26 a	7.93 a	2.18 a b	2.34 a b	2.80 a b	2.79 b	2.67 b	4.44 b	6.22 b

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76 3 SA+1 B+ EC	4.59 a	5.81 a	7.93 a	11.34 a	2.30 a	2.75 a	3.15 a	3.48 a	3.33 a b	5.22 a	8.67 a b
T7 Witness SA	4.38 a	5.26 a	7.24 a	9.86 a	2.17 a b	2.48 a b	2.69 a b	2.98 a b	4.00 a	5.89 a	8.56 a b
Tukey 0.05% Tukey 0.05% Tukey 0.05% Tukey 0.05% Tukey 0.05	1.30	1.71	2.23	3.93	0.32	0.42	0.45	0.57	1.70	2.30	2.46

SA: Agricultural Soil, **C:** Compost, **EC:** Exoskeleton of shrimp, **H:** Humus, **B:** Bocashi

Root evaluation

Table 4 shows that the mean squares of the variables root length and root diameter submitted to the analysis of variance, according to the results indicate that there were highly significant differences at P<0.05 of probability in the different treatments for root length, and there were no significant differences in the variable root diameter.

Table 4. *Mean squares of the variables root length cm and root diameter mm.*

FV	gl	Root length cm	Root diameter mm
		120 dds	120 dds
Treatment	6	0.32**	59.44ns
Error	56	0.24**	17.67ns
Total	62		
C. V.%		17.09	42.72

Table 5 shows the comparisons of means by means of the Tukey test at P<0.05 of probability, of the variable root length and root diameter; in this sense the best results obtained for root length were for T6 (3SA+1B+1EC) at 120 days after sowing with 13.56 cm. As for the root diameter variable, the averages of the evaluated treatments were statistically equal, however, numerical differences were observed for T6 (3SA+1H+1EC) at 120 days with 3.22 mm.

Table 5. *Analysis of means of the variables*

Treatments	Root length cm 120 dds	Root diameter mm 120 dds
T1 2SA+1C+1EC	7.22 b	2.79 a
T2 3SA+1C+1EC	9.67 a b	2.74 a
T3 2SA+1H+1EC	10.89 a b	2.92 a
T4 3SA+1H+1EC	12.44 a b	2.93 a
T5 2SA+1B+EC	7.00 b	2.66 a
T6 3SA+1B+EC	13.56 a	3.22 a
T7 Witness SA	8.11 a b	2.74 a
Tukey 0.05% Tukey 0.05% Tukey 0.05% Tukey 0.05	6.06	0.70

Conclusions

It was determined for the variable number of leaves that its treatments are statistically equal, for: plant height with 11.34 cm, and for stem diameter with 3.02 mm at 120 days in T6 (3SA+1B+EC) statistically presented the best values.

Treatment T6 was the best for root length (3SA+1B+1EC) at 120 days after planting with 13.56 cm. Regarding the root diameter variable, the averages of the evaluated treatments were statistically equal, however, numerical differences were observed for T6 (3SA+1H+1EC) at 120 days with 3.22 mm.

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