e-ISSN:2706-6800
INSTITUTO TECNOLÓGICO CORPORATIVO EDWARDS DEMING

Effects of organic fertilization on the morphometry and productivity of Sarchimor 4260 coffee in its second harvest

Efectos de la fertilización ecológica en la morfometría y productividad del café Sarchimor 4260 en su segunda cosecha

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Published
Edwards Deming Higher Technological Institute. Quito - Ecuador

Periodicity
April - June
Vol. 1, Num. 25, 2025
pp. 65-84
http://centrosuragraria.com/index.php/revista

Dates of receipt
Received: January, 2024
Approved: March 10, 2025

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Abstract: With the objective of determining the effect of different sources of organic fertilization on morphology and productivity of Arabica coffee Sarchimor 42 60 *(Coffea arabica L)* in its second harvest. A research plot was evaluated in a completely randomized block experimental design with a 4x3+1 factorial arrangement, factor A identified as fertilization sources; with four levels; Worm humus (HL), mycorrhiza (MZ), agricultural gypsum (YA) and micro essentials (ME), and factor B the doses, in which three doses of each treatment were tested; several variables of morphological character were analyzed, as well as productive. The results obtained determined at the morphological level, that plant height, stem diameter, number of nodes per branch, leaf length and leaf diameter, that MZ in doses of 0.5 g/plant, HL in doses of 50 and 150 g/plant, and YA in doses of 50 and 100 g, all with the inclusion of 25 g urea were those with the best performance. The productive results, based on the variables: weight of 100 ripe fruits in g, weight of production/plant, yield to gold coffee kg/ha, and yield to gold coffee qq/ha, showed that the best treatments were HL at a dose of 50 g/plant and YA at a dose of 50 g/plant; it was concluded that the treatments with organic fertilization performed better than the treatments in which only chemical fertilizers were applied.

Key words: Production, fertilizer, evaluation, organic, fruit.

Resumen: Con el objetivo de determinar el efecto de diferentes fuentes de fertilización ecológica sobre morfología y la productividad del café arábigo Sarchimor 42 60 *(Coffea arabica L)* en su segunda cosecha. Se evaluó una parcela de investigación que fue impementado en un diseño experimenta de bloques completamente aleatorios con arreglo factorial 4x3+1, el factor A identificado como fuentes de fertilización; con cuatro niveles;

Humus de lombriz (HL), micorriza (MZ), yeso agrícola (YA) y micro esenciales (ME), y el factor B las dosis, en las que se probaron tres dosis de cada tratamiento; se analizaron varias variables de caracter morfológico, así como productivas. Los resultados alcanzados, determinaron a nivel morfológico, que la altura de planta, diámetro de tallo, numero de nudos por ramas, longitud de hoja y diámetro de hojas, que la MZ en dosis de 0,5 g/planta, HL en dosis de 50 y 150 g/planta, y el YA en dosis de 50 y 100 g, todos con la inclusión de 25 g urea fueron los de mejor comportamiento. Los resultados productivos, sustentados en las variables: Peso de 100 frutos maduros en g, peso de la producción/planta, rendimiento a café oro kg/ha, y rendimiento a café oro qq/ha, plantearon como mejores tratamientos HL en dosis de 50 g/planta y al YA en dosis de 50 g/planta; Se concluye que los tratamientos con fertilización ecológica contaron con mejor comportamiento que los tratamientos en los que solo se aplicó fertilizantes químicos.

Palabras claves: Producción, fertilizante, evaluación, ecológico, frutos.

Introduction

Ecuadorian coffee is one of the best produced in South America for its quality, which motivates to be requested in Europe; it was introduced since 1830 in the province of Manabí in the Jipijapa canton, and given the country's own microclimates it is basically grown in all provinces including Galapagos and it is because of this climatic diversity that Ecuador is one of the few countries that grows arabica and robusta coffee; it currently represents 4% of employment of the economically active population (Pozo, 2011; Aspiazu *et al*., 2009); and in this sense Cañas (2014), points out that coffee represents 3.34% of non-oil exportable foreign exchange; for their part Janeth-Menéndez, and Valverde Lucio (2024), mention that coffee is of ecological importance due to the type of system with which the crop is managed.

In Ecuador coffee production has suffered a dizzying fall since the 1990s and from which it has not been able to recover to date, the causes are associated with a limited ability to associate by small producers, lack of knowledge of new coffee genotypes, technological limitations, difficulties in accessing bank loans (Venegas *et al...)*, 2018); a problem that has motivated producers to replace the crop with others, such as corn, sugar cane, citrus, rice, and in some sectors the substitution has been by livestock (Hernández, 2015). In this

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sense, the International Coffee Organization (ICO, 2019), seeks to improve Ecuador's competitiveness in relation to other countries, motivating an increase in the productivity of quality coffee, thus creating the need to encourage Ecuadorian producers to increase the areas of coffee planted and harvested within the territory, improving the competitiveness of the coffee sector in the producing areas.

Álvarez Indacochea *et al.* (2017), indicate that in the southern Manabita zone they do not choose to compete with other markets because there is no technification to improve the yield; in this sense Ramos and Elein (2014) mention that an efficient alternative to raise the productivity of coffee plantations would be necessary the application of fertilizers, using organic or organo-mineral fertilizers replacing those of common use since they are a source of quite high expenses for the producer, similarly Quijije (2019), points out that the good quality of a coffee plant depends on proper nutrition. Sandoval Estrada *et al*. (2016), adds that fertilizers such as humus and agricultural gypsum improve soil permeability, texture and soil structure, increasing nutrient retention capacity, releasing them progressively as the plant requires them. Ayón *et al*. (2023) point out that mycorrhizae participate in the transport and absorption of nutrients, especially those that are difficult to assimilate such as copper, zinc and ammonium, accelerating the process up to 40 times.

According to Bedoya and Salazar (2014), the proper use of fertilization techniques reduces production costs, while Valverde *et al*. (2024), states that fertilizers combined with organic fertilizers influence the morphological development and productivity of the coffee crop.

The Universidad Estatal del Sur de Manabí "UNESUM" in the last decade has been carrying out several investigations tending to contribute with solutions to the coffee problems, among which include the use of fertilizers and fertilizers in a combined manner; Research aimed at increasing coffee productivity, as well as the quality of the bean, and for this reason the creation of the University Network for Coffee Research and Development (REDUCAFÉ), which is made up of eleven universities, the National Association of Coffee Exporters (ANECAFÉ), the National Institute of Agricultural Research INIAP and the companies Solubles Instantáneos C.A. and Dublinsa S.A (Duicela *et al*., 2018; INIAP, 2019).

The objective of the research is to identify the best alternative of ecological fertilization during two harvests of the arabica coffee crop

Sarchimor 42 60, a hybrid preferably cultivated in the south of Manabi.

Methodology

Location of the study area

The experiment was developed in the Andil Experimental Farm belonging to the State University of Southern Manabi, located at kilometer 5 of the Jipijapa -Noboa road, the farm is located at an altitude of 378 masl; with a georeferencing of 17 M 0551229 and UTM 9851068 (GAD Jipijapa, 2015), the climate is local steppe considered BSh, a variant of dry subtropical climate and warm semi-arid, the average annual temperature is 23.7 °C, the average precipitation is 537 mm (Gobierno provincial de Manabí, 2019).

Research level and experimental design

The research carried out was of the experimental type, for the research trial 480 Sarchimor 4260 coffee plants of 3 years of age were taken, and two harvests were considered, those of the third and fourth year. For the study 93 plants that represented the edges were not taken into account, leaving 387 useful plants. Three replications were considered, with nine plants per replication. The experiment had 13 treatments, leaving 39 experimental units defined. The experimental design applied was that of completely randomized blocks with a 4 x 3 factorial arrangement in two harvests (Gabriel Ortega *et al*., 2022), factor A was defined as the types of fertilizers or biostimulants , and factor B the corresponding doses according to the type of fertilizer or biostimulants. The treatments are described in Table 1.

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Table 1. *Research treatments*

Treatments	FACTOR A Ecological fertilizers	FACTOR Application rate
1	Urea - Mycorrhiza	0.5 g mycorrhiza/plant+25g urea/plant
2	Urea - Mycorrhiza	1.0 g mycorrhiza/plant+25g urea/plant
3	Urea - Mycorrhiza	1.5 g mycorrhiza/plant+25g urea/plant
4	Urea - Worm Casting Humus	0.5 kg humus/plant+25g urea/plant
5	Urea - Worm Casting Humus	1.0 kg humus/plant+25g urea/plant
6	Urea - Worm Casting Humus	1.5 kg humus/plant+25g urea/plant
7	Urea - Agricultural Gypsum	50 g gypsum/plant+25g urea/plant
8	Urea - Agricultural Gypsum	100 g gypsum/plant+25g urea/plant
9	Urea - Agricultural Gypsum	150 g gypsum/plant+25g urea/plant
10	Urea - Micro essential	40 g micro essential/plant+25g urea/plant
11	Urea - Micro essential	80 g micro essential/plant+25g urea/plant
12	Urea - Micro essential	120 g micro essential/plant+25g urea/plant
13	Urea witness	25 g urea/plant

Pearson's correlation analysis was applied to determine the relationship between two variables analyzed (Gabriel Ortega *et al.*, 2022), and the statistical differences found in the analysis of variance were analyzed using Tukey's 5% significance test. The parametric studies carried out were based on a previous analysis of the data, determining that they had a normal distribution and homogeneous variance.

The distribution of the treatments was randomized, drawing the location of the types of organic fertilizers, their doses, as well as their respective replications,

Variables evaluated

The variables analyzed as part of the experiment were; at the morphological level: Plant height "AL", stem diameter "DT", crown diameter "DC", number of branches "NR", Leaf length "LH", leaf diameter "DH", leaf apex size "TAH", Number of nodes per branch "NNR" ; at the productive level weight in grams of 100 ripe fruits, which were harvested by piping; production weight g/plant, parchment, was obtained from the average of harvested plants per repetition; weight in grams of 100 dry parchment coffee fruits/plant, 100 dry fruits were weighed at 11% humidity, for this procedure, ripe fruits were used that were previously harvested and weighed, and that went through the process of processing until they were dried, then they were weighed to obtain the difference between fresh and dry weight, defining the lost weight; conversion of cherry coffee to gold coffee., was obtained by dividing the result of the 100 grains of parchment coffee by the 100 grains of cherry coffee; yield to gold coffee kg/ha without adjustment, the average production of a plant was weighed and multiplied by 3300 plants that are planted in a hectare under the agroforestry system; yield to gold coffee qq/ha without and with adjustment to the coefficient 0.25.

The measuring instruments used were: a Jontex © digital scale with a maximum capacity of 40 kg and a minimum of 200 g (e=d= 5 g), and a Want brand 1000g/1cg digital scale; and for the morphological measurements of the plants, a tape measure and a RexBeti brand digital vernier caliper of 0-150mm 0.01mm were used.

Data collection and management of the experiment

The application of fertilizers was carried out at the beginning of the rainy season (January), and at the end of this period (May) only the application of urea was repeated in all treatments. The corresponding technical maintenance was also carried out, and weed control was carried out manually every 15 days or as required by growth.

Data collection began in July with the start of the harvest and ended in the first half of September; in the first month the harvest was carried out three days a week, then two days, and finally only once a week; it should be noted that ripe fruit was always harvested. Data were taken at each harvest, repeating the process on several occasions.

The data obtained were entered into the database prepared in the Excel office, for later processing in the statistical software Infostat, where the statistical calculations were made and the results were obtained.

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Results

The data were initially analyzed and it was shown that they have a normal distribution, with skewness around zero, and kurtosis with values less than one, on the other hand, the kolmogorov test indicates that there is homogeneous variance in the variables analyzed (statistic>0.05), thus justifying the application of the parametric design proposed in the methodology.

The study was carried out in the second harvest when the crop was 4 years old the results are presented separately in tables three and four as follows:

Table 2. *Mean squares of morphological variables analyzed.*

		Mean squares							
F.V.	gl	AP	DT	DC	NR	DH	LH	TAH	NNR
Repetition	2	0,05	0,28	0,01	1,04	0,42	0,37	0,29	0,0037
Treatment	12	0,14	0,45	0,17	4,11	1,49	6,89	0,82	8,8
FACTOR A	3	0,18**	0,95**	0,28	6,37	2,07**	4,46**	1,91**	3,05**
FACTOR B	2	0,19**	0,38*	0,15	4,42	1,13*	15,53**	0,5	18,01**
FACTOR A*FACTOR B	6	0,08*	0,14	0,14	0,53	1,56**	6,1**	0,44	8,34**
Treatments vs. control	1	0,34**	0,93**	0,09	1,09	0,01	1,68	0,44	10,32**
Error	24	0,03	0,14	0,07	1,04	0,22	0,42	0,21	0,9
Total	38								
CV		17,45	21,42	35	16,45	7,01	4,43	9,57	11,89

*DT: diameter of stems, DC: crown diameter, number of branches, LH: length of leaves, DH: leaf diameter, TAH: size of daughter apex, NNR: number of nodes per branch.

The analysis of variance determined statistical differences in most of the variables studied; the exceptions were the crown diameter and number of branches, where soil fertilizers had no statistical influence.

Table 3 shows the performance of the different treatments, and it is evident that the best performing treatments are those where there is a combination of fertilizers with urea. Thus, agricultural gypsum in its dose 2 combined with 25 g of urea had the best performance in terms of plant height, and gypsum in its dose 1 had the best result in stem diameter.

Table 3 . *Statistical differences morphometric variables Tukey 5%.*

Treatments	Stockings	Tukey 5% Tukey	Treatment	Stockings	Tukey 5% Tukey	Treatment	Stockings	Tukey 5% Tukey
Plant height			Blade diameter			Number of knots per branch		
Gypsum D2	1,15	A	Mycorrhiza D1	6,92	A	Humus D1	11,1	A
Gypsum D1	1,13	A	Gypsum D1	6,9	A	Mycorrhiza D1	9,92	A B
Humus D1	1,11	A	Gypsum D3	6,89	A	Gypsum D1	9,4	A BC
Humus D3	1,08	A	Humus D3	6,74	AB	Humus D3	9,3	A BC
Mycorrhiza D1	1,05	A	Humus D1	6,54	ABC	Gypsum D2	9,28	A BC
Mycorrhiza D2	0,83	A B	Gypsum D2	6,23	ABCD	Micro D2	8,72	A BCD
Gypsum D3	0,83	A B	Micro D2	6,13	ABCD	Micro D1	7,57	BCDE
Micro D1	0,83	A B	Witness	6,02	ABCD	Mycorrhiza D2	7,12	CDE
Humus D2	0,78	A B	Mycorrhiza D2	5,89	ABCD	Micro D3	6,73	DE
Micro D2	0,7	A B	Mycorrhiza D3	5,47	BCD	Gypsum D3	6,57	DE
Micro D3	0,69	A B	Micro D1	5,3	CD	Witness	6,5	E
Witness	0,54	B	Micro D3	5,07	D	Humus D2	6,07	E
Mycorrhiza D3	0,53	B	Humus D2	4,98	D	Mycorrhiza D3	5,87	E
Stem diameter			Blade length			Leaf apex size		
Gypsum D1	2,2	A	Humus D3	16,47	A	Mycorrhiza D1	5,65	A
Humus D3	2,1	A	Micro D1	16,38	A	Gypsum D1	5,43	AB
Humus D1	2,03	AB	Gypsum D2	15,97	A	Gypsum D2	5,3	AB
Gypsum D2	1,97	AB	GypsumD1	15,96	A	Gypsum D3	5,19	AB
Gypsum D3	1,7	AB	Mycorrhiza D1	15,86	A	Humus D3	5,09	AB
Mycorrhiza D1	1,67	AB	Humus D1	15,17	AB	Mycorrhiza D2	4,99	AB
Humus D2	1,53	AB	Gypsum D3	14,89	ABC	Humus D1	4,95	AB
Micro D1	1,5	AB	Witness	13,87	BCD	Mycorrhiza D3	4,4	AB
Micro D2	1,4	AB	Mycorrhiza D2	13,78	BCD	Witness	4,43	AB
Mycorrhiza D2	1,4	AB	Mycorrhiza D3	13,59	BCD	Micro D1	4,32	AB
Mycorrhiza D3	1,27	AB	Micro D3	13,09	CD	Humus D2	4,26	B
Witness	1,07	B	Micro D2	12,33	D	Micro D2	4,2	B
Micro D3	1	B	Humus D2	12,25	D	Micro D3	4,14	B

It was also observed that mycorrhiza in its dose 1, presented the best results both in the size of the apex and in the diameter of the leaf. And earthworm humus presented a better response in the number of nodes per branch in its dose 1; and humus in its dose 3 stood out in the length of the leaf.

Regarding the analysis of the control versus treatments, it can be seen that urea applied alone with organic amendments has a lower response than in soils with the fertilizers studied.

Table 4 shows the statistical results obtained from the ANOVA for the analysis of the production data for the second harvest.

And it can be seen that in the variables weight of 100 g mature coffee, weight of production g/plant, and yield of gold coffee with and without adjustment, statistical differences were found between treatments, but not in the variables Weight 100 g of dry parchment coffee/plant and the variable Conversion cherry coffee to gold coffee.

Table 4. *Mean squares obtained in the second harvest productive variables*

F.V.	gl	Weight g. 100 ripe fruits	Yield weight g/plant, parchment	Weight 100 g 100 of dry parchment coffee/plant	Conversion cherry coffee coffee gold coffee	Yield to gold coffee kg/ha without adjustment	Yield to gold coffee qq/ha without adjustment
Repetition	2	0,01	0,06	39,48	0,0014	0,06	0,06
Treatment	12	0,01	0,45	61,61	0,00089	0,45	0,45
FACTOR A	3	0,01	0,45**	55,45	0,00038	0,45**	0,45**
FACTOR B	2	0,0048	0,62**	24,3	0,00078	0,62**	0,62**
FACTOR A vs B	6	0,01*	0,25**	72,34	0,0011	0,25**	0,25**
Treatments vs. control	1	0,01	1,24**	65,26	0,00078	1,24**	1,24**
Error	24	0,0034	0,05	40,21	0,0017	0,05	0,05
Total	38						

*Significant, ** Highly significant

Regarding the variable weight of 100 ripe fruits, Tukey's 5% significance test determined that the best treatment was agricultural gypsum at a dose of 50 g plus 25 g of urea, followed by the treatments with humus and mycorrhiza respectively (Figure 1), resulting in determining as the best treatments those in that used fertilizers combined with fertilizers. The weight of the 100 fruits was 2.19 g for the agricultural gypsum, and in contrast, the urea-only treatment reached a weight of 1.35 g.

In the variable production g/plant in parchment, the statistical difference established humus at a dose of 1.5 kg plus 25 g of urea as the best treatment (Figure 2), followed in order of yields by the treatments with gypsum and mycorrhizae; these results were repeated in the variables gold coffee with kg/ha with and without adjustment. On the other hand, it should be noted that the orthogonal analysis determined that the treatment with the lowest response was the control, to which only urea was applied.

The weight of humus treatment D1 was 1.6 kg, followed by agricultural gypsum with 1.4 kg and in last place the control treatment with 0.15, well below the other treatments.

Figure 1. *Weight 100g ripe fruit*

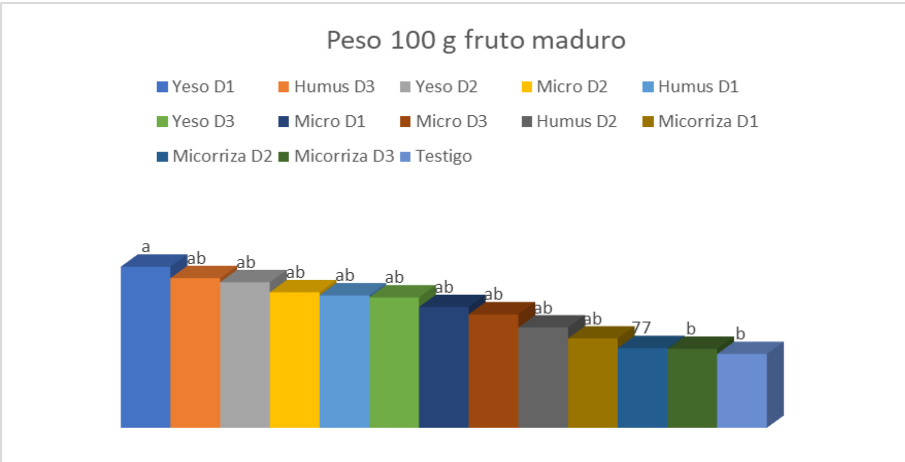

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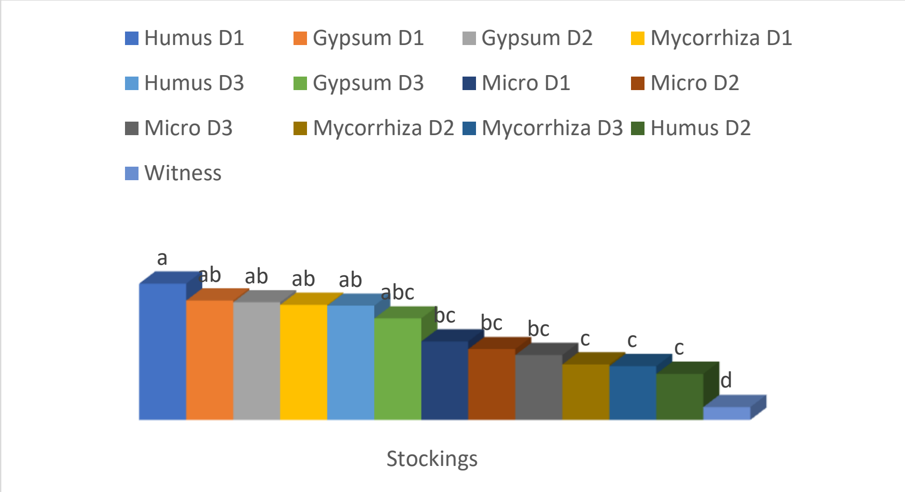
Figure 2. *Production weight g/plant in parchment.*



In the analysis of variance of the variables: weight in g of 100 seeds of parchment coffee, and conversion of cherry coffee to gold coffee, no significant differences were found, neither between factors, nor at the level of simple analysis. Therefore, the analysis of these variables was not extended, arguing that, at the level of these variables, all treatments are equal.

In the variable weight 100 g dry parchment coffee, it was demonstrated that there is a highly significant difference both in treatments and in the interaction between factors by means of the 5% Tukey significance test (Figure 5), which indicates and leaves as the best treatment Worm humus at dose 1, followed by the treatments gypsum D1, gypsum D2, mycorrhizae at dose 1 and humus D3, leaving the control at the end.

Figure 3. *Yield to coffee gold kg/ha*

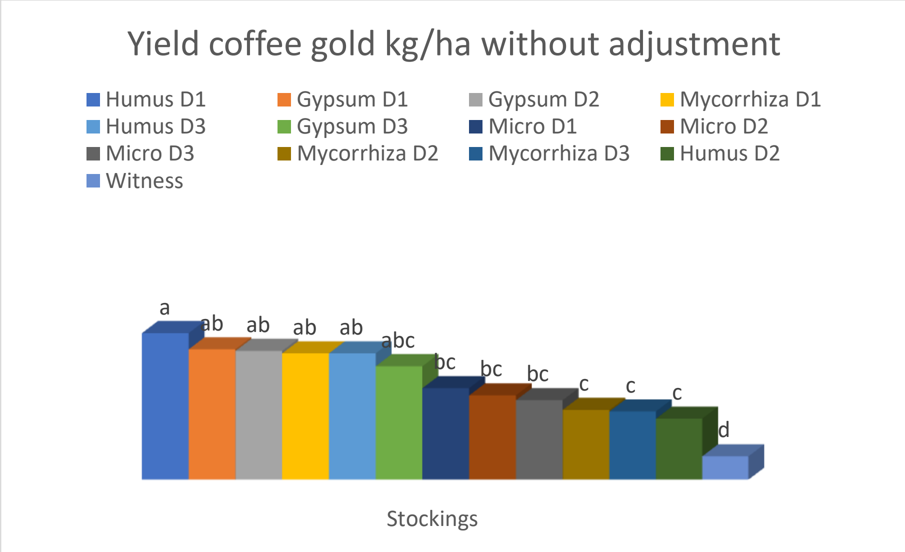


Table 5 shows the results of the Pearson analysis, where correlation was detected between the productive variables: there is a perfect correlation (1) between the variables yield gold coffee kg/ha and qq/ha and the variable weight 100 g parchment coffee; other correlations between productive variables are appreciated, however, the correlation between morphological variables of the plant and productive variables is remarkable, a high average correlation is appreciated (0.6 - 0.8), between the variables gold coffee in kg and qq, with the variables number of knots per branches and plant height.

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Table 5. *Pearson correlation: coefficients/probabilities*

Variables	blade diameter	Blade length cm	Size of the leaf apex....	N° of knots per branch	plant height	stem diameter	crown diameter	branch numbers	Weight g. 100 ripe fruits.	Production weight g/pl.	Weight g 100 of pergam.	Coffee cherry coffee conversion.	Yield to gold coffee kg/..	Yield to gold coffee qq/..
sheet diameter	1													
Blade length cm	0,57	1												
Size of the leaf apex...	0,62	0,51	1											
N° of knots per branch	0,58	0,55	0,37	1										
plant height	0,59	0,63	0,35	0,69	1									
stem diameter	0,5	0,51	0,22	0,6	**0,85**	1								
crown diameter	0,36	0,45	0,22	0,46	0,59	0,59	1							
branch numbers	0,4	0,44	0,22	0,6	**0,77**	**0,87**	0,6	1						
Weight g. 100 ripe fruits...	0,3	0,31	0,12	0,37	0,35	0,38	0,23	0,26	1					
Production weight g/pl.	0,5	0,51	0,47	0,66	0,61	0,53	0,47	0,57	0,48	1				
Weight g 100 of pergam.	0,3	0,35	0,12	0,35	0,34	0,31	0,23	0,2	**0,97**	0,49	1			
Coffee cherry coffee conversion.	0,03	0,05	-0,03	0,12	0,12	0,21	0,06	0,09	**0,84**	0,29	0,74	1		
Yield to gold coffee kg/..	0,5	0,51	0,47	0,66	0,61	0,53	0,47	0,57	0,48	1	0,49	0,29	1	
Yield to gold coffee qq/..	0,5	0,51	0,47	0,66	0,61	0,53	0,47	0,57	0,48	1	0,5	0,29	1	1

This article seeks to determine the adequate nutritional management of coffee plantations in the productivity stage and to provide a basis for making the right decision. With respect to morphological characters, Milla-Pino et al (2019) point out that factors such as variety and shade species are important for morphological development. Castillo Ronquillo and Pilaguano Tigasi (2022) identify that the use of fertilizers determines the success of the crop, but also the use of inputs is a problem of contamination, soil degradation and, most importantly, affects the producer's economy.

It is necessary that the coffee crop has access to the nutrients it needs so that in its production stage its yield is of quality for this reason the Inter-American Institute for Cooperation on Agriculture "IICA", (2015) , indicates that a fertilization plan should be designed that corresponds to the yield projections, the results of the soil analysis and the stage in which the crop is found where fertilization can be organic, chemical or a combination of both.

Fernández (2020) indicates that "organic fertilizers are a set of biodegradable materials rich in nitrifying bacteria and active microorganisms that allow a greater availability of micro and macro nutrients such as: N, P, K, Ca, Mg, Mn, in protein form (electrolytes), which prevents their leaching and guarantees permanent soil fertility for crops". Aguilar et al. (2016), mentions that the application of organic matter to agricultural soils increases the activity of phosphatases, stimulating microbial biomass and root secretion, an aspect that is corroborated by (19, 20) who found that the application of organic fertilizers influences the agronomic and productive behavior of coffee plantations.

In the analysis of the variables established, it was determined that in the second year, dose 1 of mycorrhizae (0.5% +25 g of urea) led almost all the production variables, being considered as the best by the 0.5% Tukey test, and this is how Lumbi and Zoledon (2015), state that the use of mycorrhizae in low doses increases production at a lower cost, because it helps to keep the plant nourished, making the most of what the soil has and improving the soil structure, in addition to reducing the use of inorganic fertilizers.

It should be emphasized that dose 3 of worm humus (1.5 kg + 0.25 gr) is positioned as the second best option for adequate fertilization according to the production variables supported by Sotelo Reyes & Tellez Páramo (2007), who indicate that worm humus is recommended for its nutritional balance and richness of microorganisms, in addition to providing physical and chemical properties that allow for good production of organic coffee.

The research exposed by Marcedo (2014), determines significant statistical differences between the average values registered by the treatments, based on treatment Guano de Isla (300 g/plta) reached the best grain yield with 34.36 qq, showing statistical equality with treatments Guano de la Isla (400 g/plta), Guano de la Isla (200 g/plta) and Humus (400 g/plta), which reached grain yields equivalent to 30.24, 29.48 and 27.32 qq respectively; however it showed statistical superiority over the rest of the treatments, whose values ranged between 25.92 and 13.93 qq, these values corresponding to the treatments Ekotron 70 (300 g/plta) and the Control, the latter with the

e-ISSN:2706-6800

lowest yields. Román et al. (2013) justifies this fact, and reports that the greater the amount of organic matter, the greater the microbial quantity, since when organic fertilizers are applied, there is a greater possibility of nutrient release and when they are applied to the soil, the decomposition process continues.

Cabrera (2019) evaluated the effect of the application of improved organic fertilizers on the harvest characteristics of Coffea arabica L. variety Costa Rica 95 when improved organic fertilizers were applied. The treatments were: 0 kg N.ha -1 , island guano 200 kg N.ha -1 , formula 2 (200 and 400 kg N.ha-1), formula 4 (200 and 400 kg N. ha-1). Contrary to the results of Marcedo and those obtained in the research, no statistical differences were found in the variables weight of 100 ripe fruits, weight of cherry coffee, weight of dry parchment coffee, ratio of cherry coffee/dry parchment coffee and yield in quintals.

León (2022), in his research with fertilizers combined with urea, indicated that the best responses were obtained at the level of weight of 100 ripe fruits in g, weight of production/plant, yield to gold coffee kg/ha, and yield to gold coffee qq/ha, expressing differences in favor of the treatments worm humus at a dose of 50 g/plant plus 25 g urea and agricultural gypsum at a dose of 50 g/plant plus 25 g of urea. These results coincide with those reported by Álvarez-Lino et al. (2023), who combined mycorrhizae and humus with fertilizers, and increased by 71% on average compared to the control, and indicated that an adequate nutrition strategy in the productive stage of coffee could stimulate physiological processes, and have an impact on productive parameters and yield.

Considering that the control has been one of the least productive treatments, there is a similarity with the research work of Capa (2015), who has used mineral and organic fertilization in 3 dosage levels, obtaining as a result that the control treatment has also generated a negative cost-benefit ratio. The organic fertilization, despite obtaining very considerable yields and high prices for the sale of the product (parchment coffee) in the market, was not able to obtain economic benefits due to the high doses of fertilizer required.

The results express the incidence of organic fertilizers combined with urea, over the treatments where only chemical fertilizers and urea were applied, which ratifies what was stated by Ormeño and Ovalle, (2007); Restrepo et al. (2014), who mentioned that organic substances contain biostimulants, which provide higher yields in coffee cultivation.

Conclusions

Of the fertilizers or biostimulants that proved most beneficial over time were mycorrhizae and earthworm humus, both combined with 25 g of urea/plant; agricultural gypsum was the one with the best response in the morphological growth stage.

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