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Effect of different fertilizer sources on the yield and fiber quality of *Musa textilis* 'Tangongón'

Efecto de diferentes fuentes fertilizantes en la producción y calidad de fibra de *Musa textilis* 'Tangongón'

Efeito de diferentes fontes de fertilizantes na produção e qualidade da fibra de *Musa textilis* 'Tangongón'

Leonardo Rafael Jácome Gómez[1]*
Janeth Rocío Jácome Gómez[2]
María Cristina Martínez Sotelo[3]
Marco De La Cruz Chicaiza[2]
Holger Froilán Chica Solórzano[3]

[1]Universidad de las Fuerzas Armadas ESPE. Vía Santo Domingo – Quevedo km 24, Santo Domingo, Ecuador.
[2]Universidad Laica Eloy Alfaro de Manabí. Av. 3 de julio PG9P+MF8, El Carmen, Ecuador.
[3]Instituto Superior Tecnológico Tsáchila. Av. Galo Luzuriaga y Franklin Pallo. Santo Domingo, Ecuador.

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Abstract

The fertilization of abacá through the application of organic and chemical fertilizers influences fiber production, but its combined effect still requires evaluation. This research evaluated the effect of different fertilizer sources on the fiber production of the 'Tangongón' abacá in Santo Domingo de los Tsáchilas, Ecuador, to determine the most efficient alternative for improving abacá fiber yield and quality. A randomized complete block design with a 2×3 factorial arrangement and four replications was used. Two soil fertilizers and three foliar fertilizer conditions were evaluated, and growth, yield, and fiber quality variables were analyzed. Fertibanano without foliar supplementation stood out for achieving the highest fiber yield (1.25 $t.ha^{-1}.year^{-1}$) and for producing the highest proportion of higher-quality fiber (2^{nd} quality = 0.307 $kg.pseudostem^{-1}$). Furthermore, it generated the highest averages of $suckers.plant^{-1}$ (2.13) and $shoots.plant^{-1}$ (7.25). Although the combination of Ecoabonaza with Bayfolan promoted the greatest plant height (1.58 $cm.month^{-1}$), and Fertibanano with humic acids showed the highest values in the number of $leaves.plant^{-1}$ (0.85) and pseudostem circumference (2.59 cm), these treatments exhibited lower fiber yield and a lower proportion of second-quality fiber. It was concluded that nutritional management based on Fertibanano constitutes a nutritional strategy to optimize the yield and quality of abacá fiber.

*Corresponding author:lrjacome4@espe.edu.ec

Resumen

La fertilización del abacá, mediante la aplicación de fertilizantes orgánicos y químicos, influye en la producción de fibra, pero su efecto combinado aún requiere evaluación. En esta investigación se evaluó el efecto de diferentes fuentes de fertilizantes en la producción de fibra de abacá 'Tangongón', en Santo Domingo de los Tsáchilas, Ecuador; con el fin de determinar la alternativa más eficiente para mejorar el rendimiento y calidad de la fibra de abacá. Se utilizó un diseño de bloques completos al azar con un arreglo factorial 2×3, con cuatro repeticiones. Evaluándose dos fertilizantes edáficos y tres condiciones de fertilizantes foliares y se analizaron variables de crecimiento, rendimiento y calidad de fibra. Fertibanano sin complementación foliar destacó por lograr el mayor rendimiento de fibra (1,25 $t.ha^{-1}.año^{-1}$), y por producir la mayor proporción de fibra de mejor calidad (2^a = 0,307 $kg.pseudotallo^{-1}$). Además, generó los mayores promedios de $hijuelos.planta^{-1}$ (2,13) y $brotes.planta^{-1}$ (7,25). Aunque la combinación de Ecoabonaza con Bayfolan promovió la mayor altura de planta (1,58 $cm.mes^{-1}$), y Fertibanano con ácidos húmicos presentó los mayores valores en número de $hojas.planta^{-1}$ (0,85) y perímetro del pseudotallo (2,59 cm), estos tratamientos mostraron un menor rendimiento de fibra y una menor proporción de fibra de 2^a calidad. Concluyéndose que el manejo nutricional basado en Fertibanano constituye una estrategia nutricional para optimizar el rendimiento y calidad de la fibra de abacá.

Palabras clave: foliar, fibra, hijuelo, pseudotallo, rendimiento.

Resumo

A fertilização do abacá, através da aplicação de fertilizantes orgânicos e químicos, influencia a produção de fibra, mas o efeito combinado de ambos ainda tem de ser avaliado. Esta investigação avaliou o efeito de diferentes fontes de fertilizantes na produção de fibra da abacá 'Tangongón' em Santo Domingo de los Tsáchilas, Equador, de forma a determinar a alternativa mais eficiente para melhorar o rendimento e a qualidade da fibra. Foi utilizado um delineamento experimental em blocos casualizados completos com um arranjo fatorial 2×3 e quatro repetições. Foram avaliadas duas condições de fertilização do solo e três condições de fertilização foliar, e foram analisadas as variáveis de crescimento, rendimento e qualidade da fibra. O Fertibanano sem suplementação foliar destacou-se por conseguir o maior rendimento em fibra (1,25 $t.ha^{-1}.ano^{-1}$) e por produzir a maior proporção de fibra de elevada qualidade (2^a qualidade = 0,307 $kg.pseudocaule^{-1}$). Gerou também as médias mais elevadas de $rebentos.planta^{-1}$ (2,13) e de $rebentos.planta^{-1}$ (7,25). Embora a combinação de Ecoabonaza com Bayfolan tenha promovido a maior altura da planta (1,58 $cm/mês^{-1}$), e o Fertibanano com ácidos húmicos tenha apresentado os valores mais elevados para o número de $folhas.planta^{-1}$ (0,85) e circunferência do pseudocaule (2,59 cm), estes tratamentos exibiram um menor rendimento em fibra e uma menor proporção de fibra de 2^a qualidade. Concluiu-se que o maneio nutricional baseado em Fertibanano constitui uma estratégia nutricional para otimizar o rendimento e a qualidade da fibra de abacá.

Palavras-chave: foliar, fibra, rebento, pseudocaule, rendimento.

Introduction

Abacá *(Musa textilis Née)* is a herbaceous plant widely cultivated in tropical regions and appreciated for the physical, chemical and mechanical properties of the fiber obtained from the leaf sheaths that form the pseudostem, which is mainly composed of cellulose (63 - 68 %), hemicellulose (19 - 20 %), lignin (5 - 6 %) and lower proportions of pectin, fats, waxes, and water-soluble compounds (Araya-Gutiérrez *et al*., 2023).

The chemical composition of abacá fiber gives it a high tensile strength, superior to that of synthetic fibers such as nylon, a remarkable flexural strength equivalent to glass fiber, and an exceptional ability to withstand adverse conditions, including exposure to salt water. These qualities position abacá as an ideal raw material for industrial and commercial applications, where its adaptability represents a renewable alternative to contribute to a more sustainable and efficient future (Barbosa *et al*., 2023).

The main use of abacá fiber is the manufacture of technical papers and ropes of great strength and durability, especially those intended for maritime uses. In the paper industry, due to its natural whiteness, which reduces the need for chemical bleaching, it is used for the production of paper money, tea filters, food wrappers, cigarette paper, and other technical papers (FAO, 2010). Currently, abacá fiber is also used in the textile industry to produce fabrics, as well as in the automotive sector as an alternative to fiberglass to create lightweight parts (Ullah *et al*., 2025; Unal *et al*., 2020).

Ecuador is the second largest producer of abacá, with an annual production of approximately 35,000 t and a market share of 14.59 % (Yap *et al.*, 2024). A large part of the volume produced is destined for export, with the Philippines and the United Kingdom being the main destinations. In 2023, the value of these exports generated 5,534 million USD, consolidating abacá fiber as an important source of income for the country (Central Bank of Ecuador, 2023).

In this context, abacá production, as in other crops, depends largely on appropriate agronomic practices; among which nutrition occupies a decisive place, since the plant requires a balanced supply of nutrients (nitrogen, phosphorus, and potassium) to optimize vegetative growth, plant health, and fiber yield (Bureau of Agriculture and Fisheries Standards [BAFS], 2019). Despite this, nutritional deficiencies are common in production systems, which is why fertilizers adapted to the specific needs of the crop are applied.

According to previous reports, chemical fertilization can improve fiber yield by up to 41 % (Bande *et al*., 2013), promoting both root development and aerial plant growth (Ramos *et al*., 2022), as well as higher dry matter yield (Castro & Chávez *et al*., 2022). On the other hand, organic fertilization favors the formation of taller pseudostems with a larger diameter (Macay-Anchundia *et al*., 2025; Bongoloan & Dinopol, 2016), increases the number and size of functional leaves, and improves the survival rate of plants (Mangmang & Cozo, 2021). In addition, it has been observed that organic fertilization is related to a higher number of suckers per plant (Jácome Gómez *et al*., 2025).

Consequently, it has been suggested that the combination of organic and inorganic fertilizers could cause abacá to grow healthy and produce superior quality fiber (BAFS, 2019). However, the synergistic effects of the combination of fertilizers and the simultaneous application of the methods in abacá production are still limited, making it difficult to understand how these strategies could influence fiber yield, quality, and efficiency.

Therefore, the objective of this work was to evaluate the production of abacá fiber (*Musa textilis*) 'Tangongón', using different types of fertilizers (soil and foliar), in Santo Domingo de los Tsáchilas, Ecuador, to determine the most efficient alternative to improve the yield and quality of the crop fiber.

Materials and methods

Study area

The experiment was carried out between April and July 2024 at the Mishili Experimental Farm, located in La Aurora sector, Santo Domingo Canton, Province of Santo Domingo de los Tsáchilas, Ecuador. The geographical coordinates of the site are 00°30'08'' S and 79°20'56'' W, at an altitude of 488 meters above sea level. The study area is located in a tropical rainy zone, with annual average temperatures of 24.6 ºC, average relative humidity of 88 %, and precipitation of 2,945 mm.year^{-1}. During the period of the experiment, an accumulated precipitation of 1,433 mm was recorded, with a monthly average of 358.51 mm, corresponding to the rainy season (INAMHI, 2024).

The soil analysis of the crop area was carried out in the Agrolab laboratory, and the results are presented in Table 1.

Experimental design

A randomized complete block experimental design was used, with a factorial arrangement of 2 x 3 (two sources of soil fertilizers × three foliar fertilization conditions), with four replications, forming a total of 24 experimental units, each of 35 m^2. The soil fertilizers corresponded to a chemical product (Fertibanano 16-3-30-3) and an organic product (Ecoabonaza 3-2-4-1), while the foliar fertilizers included a chemical product (Bayfolan 9-9-7) and an organic product (Humina with humic acids).

Experiment management

The trial was carried out in an established crop of abacá (*Musa textilis*), Tangongón variety, in the production stage (45 months old), with a planting density of 1,111 plants.ha^{-1} (3 × 3 m) and was conducted under rainfed conditions. Prior to the application of the treatments, crop maintenance tasks were carried out, including weed control, crown management, and defoliation. Subsequently, fertilizers were applied in accordance with the recommendations of the soil chemical analysis (Table 1) and based on the nutritional requirements of the crop in production, as presented in Table 2.

Table 2. Nutritional requirements of the abacá crop in production

Age	kg.ha^{-1}					
	N	P	K	Ca	Mg	S
> 500 days	28.35	6.92	90.5	21.08	5.09	3.56
	g.ha^{-1}					
	Fe	Cu	Zn	Mn	B	
	1740	16	86	430	86	

Note: Arias *et al*. (2024). *Technical Manual for the Sustainable Production of abacá (Musa textilis Née) in Costa Rica*. PROCOMER

The chemical soil fertilizer (Fertibanano) was applied in doses of 0.23 kg.plant^{-1}, while the organic soil fertilizer (Ecoabonaza) was applied in doses of 2.25 kg.plant^{-1}. Both were applied broadcast (or uniformly spread) on the crown of the most developed sucker of the banana tree. On the other hand, chemical (Bayfolan) and organic (Humina with humic acids) foliar fertilizers were applied by spraying to the foliage using a motor pump (Nuvola brand), on four occasions. The first application was made at the beginning of the trial, and the subsequent applications were made every 15 days using doses of 1 L.ha^{-1} and 2 L.ha^{-1}, respectively.

Phytosanitary control was carried out by applying Benfuracarb (40 %) to control nematodes. During the experimental period, no visible diseases were recorded in the crop.

Study variables

Sixteen (16) abacá plants were evaluated per treatment. The development variables were measured at 60 and 120 days after fertilizer application, and included:

Plant height: it was measured from the base of the pseudostem, at ground level, to the insertion point of the highest leaf corresponding to the last unfolded leaf, using a flexometer. In each plot, three measurements were made, expressing the results in centimeters.

Number of leaves: it was determined by counting the fully unfolded leaves of the most developed sucker of each plant.

Number of suckers: it was obtained by counting vegetative shoots taller than 20 cm and weighing more than 400 g, taking three samples per plot.

Number of shoots: corresponding to the initial vegetative shoots, less than 20 cm and weighing less than 400 g, which were differentiated from the suckers.

Table 1. Soil characteristics of the research area

Parameter	Value	Description	Parameter	Value	Description
pH	5.78	Acid Med.		Meq.100 g^{-1}	
Electric conductivity	0.06 dS.m^{-1}	Non-saline	K	0.10	Low
Org. matter	4.91%	Medium	CA	3.00	Low
	ppm		Mg	0.66	Low
N	23.21	Low	Ca/Mg	4.55	Optimal
P	5.13	Low	Mg/K	6.60	Optimal
S	2.23	Low	(Ca+Mg)/K	36.60	Optimal
Cu	4.30	High	Texture	%	Sandy Loam
B	0.25	Medium	Sand	62	
Fe	97.20	High	Silt	23	
Zn	2.70	Low	Clay	15	
Mn	2.20	Low			

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Perimeter of the pseudostem: it was measured with a tape measure at two points: 10 cm from the ground and at the top where the leaves emerge; the values obtained were expressed in centimeters.

The production variables were recorded at the end of the experiment, at 120 days, in a crop with 49 months of age, corresponding to the abacá production stage. This time coincided with the usual harvest cycle, which takes place three to four times a year. Included:

Pseudostem weight: it was determined by the fresh weighing of the harvested pseudostems, using a digital scale with a capacity of 100 kg. The values were expressed in kilograms per plant (kg.plant^{-1}). For this measurement, the pseudostems were cut at the base with a banana digging spade (HANSA brand).

Fresh fiber: it was obtained using a shredding machine (AGRALE brand), which operates with a belt motor and a sharp blade responsible for detaching the fibers of material removed from the pseudostem sheaths.

The fiber obtained was visually classified according to color and level of cleanliness, following the criteria proposed by Frank (2005): the second category corresponded to the fiber of highest quality (white with a high-gloss yellow hue); the third, to medium quality (white with bright yellow hue); the fourth, to white fibers with a yellow or tanned hue of subtle shine; and the fifth, to those of lowest quality (white with yellow or tanned tones and undefined shine).

Subsequently, the fiber was dehydrated in the environment for approximately 24 hours, until it reached a moisture content close to 15 %, suitable for storage and subsequent industrial processing. Finally, the weight of dry fiber per pseudostem (expressed in kg) was determined, and the dry fiber yield was calculated from the average number of pseudostems harvested per plant and its fiber weight, expressing the result in tons per hectare per year (t.ha^{-1}.year^{-1}).

Statistical analysis

An analysis of variance was performed using the Generalized Linear Model (GLM) from the free version of InfoStat software (National University of Córdoba, version 2020). When the study factors showed significant effects, Tukey's test was used with a significance level of 5 % for the comparison of means.

Results and discussion

Development variables

The results obtained on the monthly increase in the development variables show that the combination of soil and foliar fertilizers differentially influences each variable evaluated (Table 3). Regarding plant height, the most effective interaction was the application of Ecoabonaza with Bayfolan (E_2F_1), reaching an increase of 1.58 cm.month^{-1}, significantly higher than the other treatments (p= 0.0009). On the contrary, the lowest growth was observed in Ecoabonaza without foliar fertilization (E_2F_0).

The variables: number of leaves.plant^{-1}, suckers.plant^{-1}, shoots. plant^{-}1, and pseudostem diameter did not present significant differences (p>0.05). However, it was observed that the application of Fertibanano with Humina (E_1F_2) presented the highest values in the number of leaves.plant^{-1} (0.85) and the diameter of the pseudostem (2.59 cm). On the other hand, the application of Fertibanano without foliar fertilization (E_1F_0) reached the best averages in the emission of suckers.plant^{-1} (2.13) and shoots.plant^{-1} (7.25) of abacá.

The results obtained in height exceed those reported by Castro and Chávez (2022), who recorded a significant increase of 1.22 cm.month^{-1} with the application of foliar fertilizers combined with organic and inorganic components, compared to the treatment without fertilization, which did not exceed 0.84 cm.month^{-1}.

The highest growth in height observed in the present study could be attributed to the synergistic effect between Ecoabonaza + Bayfolan (E_2F_1), which optimizes the absorption and use of nutrients at both root and leaf levels. Ecoabonaza supplies nutrients gradually, improving soil fertility and the sustained nutrient availability in the rhizosphere (Wei *et al*., 2024). The foliar application with Bayfolan complements this action by providing nitrogen and potassium in easily assimilated forms, in addition to chelated micronutrients (B, Fe, Mn, Mo) that stimulate cell elongation, protein synthesis, and the production of phytohormones responsible for the elongation of meristematic tissues (Pandey, 2018).

Regarding leaf development and pseudostem thickening, the highest values observed in the treatment of Fertibanano + Humina (E_1F_2) contrast with those reported by Bravo *et al*. (2023), who recorded a number of leaves per plant of 0.28 with chicken manure, and 0.14 with pig manure, as well as pseudostem diameters of 2.15 cm and 1.76 cm, respectively. Similarly, Macay-Anchundia *et al*. (2025) obtained an average diameter of 0.04 cm when Fertibanano was applied as an independent treatment. The differences suggest that the combination of Fertibanano with humic acids (E_1F_2) was more efficient in stimulating vegetative development, compared to conventional fertilizers of animal origin or with the exclusive use of Fertibanano.

This behavior could be attributed to the biostimulant action of humic acids, which enhance the absorption of soil nutrients, particularly potassium, that favors cell turgor and strengthens cell walls, which physiologically translates into greater thickening of the pseudostem (Karpinets & Greenwood, 2024).

Table 3. Results of the monthly increase in development variables.

	Treatments		Plant height (cm)	N° leaves/plant	N° suckers/plant	N° shoots/plant	Pseudostem Diameter (cm)
T1	Fertibanano	Without foliar fert.	0.68 bc	0.34	2.13	7.25	2.00
T2	Fertibanano	Bayfolan	1.02 ab	0.43	0.90	4.52	1.86
T3	Fertibanano	Humina	0.94 b	0.85	1.07	1.28	2.59
T4	Ecoabonaza	Without foliar fert.	0.34 c	0.38	0.60	1.08	1.80
T5	Ecoabonaza	Bayfolan	1.58 a	0.34	0.81	1.37	1.54
T6	Ecoabonaza	Humina	1.24 a	0.34	0.60	3.50	2.41
	C.V. %		18.49	16.86	19.14	15.64	16.49
	Fertilizers x Foliar fert.		0.0009 **	0.6151 ns	0.0786 ns	0.2700 ns	0.7615 ns

Note: Means within each column with different letters show statistical differences according to Tukey's test at 5 %. NS= Not significant at 5 % error probability level; *= Significant at 5 %; **= Significant at 1 %.

In addition, humic acids increase the permeability of cell membranes and enhance enzymatic activity, which stimulates cell expansion and structural vigor of the plant (Ampong *et al*., 2023; Nardi *et al*., 2021). However, in vegetative propagation, Fertibanano presented a more favorable behavior, regardless of foliar application. In this case, the high potassium content (30 %) seems to be the determining factor, since it participates in the absorption and transport of nutrients, as well as in the enzymatic activation that stimulates the formation of new shoots or suckers (Sardans & Peñuelas, 2021). The absence of foliar treatment suggests that, when biostimulants such as humic acids are applied, the plant redirects its resources towards structural growth (leaves and stems) rather than vegetative reproduction. Jácome-Gómez *et al*. (2025) also observed in abac**á** (*Musa textilis* Bungalanón) that the highest number of shoots per plant (2.56) was obtained with the application of chemical soil fertilizers without the application of complementary fertilization; although the number of suckers was lower, probably due to factors such as fertility, agronomic management, and environmental conditions, these results confirm that Fertibanano soil fertilization favors vegetative propagation.

Production variables of abacá "Tangongón" fiber.

The results of the production variables of abacá fiber (Table 4) show that the treatments evaluated did not generate significant differences between them, both at the level of interaction and individual factors ($p>0.05$). However, the application with Fertibanano without foliar fertilizer (E_1F_0) showed a tendency to increase all production variables, reaching average fiber yields of 1.25 $t.ha^{-1}.year^{-1}$. In contrast, Ecoabonaza without fertilization (E_2F_0) presented the lowest fiber yield (0.60 $t.ha^{-1}.year^{-1}$).

Under the conditions evaluated, the treatment with the highest vegetative development did not correspond to the one with the highest fiber yield, which suggests that abacá productivity depends more on the internal dynamics of fibrous tissue formation than on external growth. In abacá, fiber is formed primarily from the deposition of cellulose and lignin in the vascular tissues of the pseudostem. When the plant receives balanced nutrition, carbohydrates and nutrients derived from photosynthesis can be used for fiber synthesis and strengthening (Araya-Gutiérrez *et al*., 2023). This explains why the application of Fertibanano without foliar fertilizer (E_1F_0) showed the highest yield without necessarily requiring a larger absolute plant size.

Similar results were reported by Jácome-Gómez *et al*. (2025), who observed high fiber yields (1.19 $t.ha^{-1}.year^{-1}$) under a nutritional scheme based on soil fertilization (Fertibanano), which reinforces the effectiveness of management in the optimization of photosynthetic metabolism and the formation of supporting tissues.

Consequently, the high yield observed in this study reflects that, in abacá, the density and quality of the pseudostem biomass may be more decisive for fiber production. It is possible that treatments with combined Fertibanano (T2 and T3) could have experienced an antagonistic physiological effect, diverting energy towards vegetative growth without improving fiber weight.

Fiber yield by quality grades

Table 5 shows variations in the effect of fertilizers on fiber yield by quality grade, although the differences were not significant ($p>0.05$). In all treatments, the greatest weight was concentrated in the 4th and 2nd class, with values between 0.24 and 0.36 $kg.pseudostem^{-1}$, while the fiber of 5th class had the lowest weights, close to 0.21 - 0.26 $kg.pseudostem^{-1}$. The values correspond to the fiber visually determined prior to its commercialization, with Fertibanano without foliar application (T1: E_1F_0) being the application that produced the highest proportion of fiber of better quality (2nd = 0.307 $kg.pseudostem^{-1}$).

Fiber yield by quality grades contrasts with the findings reported by Bravo *et al*. (2023), who in their research, the treatment that incorporated pig manure corresponding to the one with the best total yield showed a higher proportion of fiber in intermediate grades (3rd = 0.645 and 4th = 0.282) with a low proportion of 2nd quality fiber (0.230); which suggests that, unlike other managements, the balanced nutrition provided by Fertibanano allowed the plant to prioritize the formation of finer and whiter internal fibers, located in the leaves near the center of the pseudostem, responsible for the grade 2 characteristics according to the national classification (Frank, 2005). The difference indicates that, despite obtaining comparable total yields, the type of fertilization and the nutritional balance exert a greater effect on the distribution of fiber according to its position in the pseudostem and its fineness.

From an agricultural practice perspective, the findings in this study show that soil fertilization with Fertibanano can be a strategy to maximize the yield and quality of abacá Tangongón fiber.

Table 4. Results of abacá fiber production variables.

	Treatments		Pseudostem weight (kg)	Fresh fiber / Pseudostem (kg)	Dry fiber /Pseudostem (kg)	Fiber yield ($t.ha^{-1}.year^{-1}$)
T1	Fertibanano	Without foliar fertilization	62.84	1.74	1.22	1.25
T2	Fertibanano	Bayfolan	50.80	1.41	0.99	0.75
T3	Fertibanano	Humina	61.08	1.69	1.19	0.92
T4	Ecoabonaza	Without foliar ferti-lization	55.68	1.54	1.08	0.60
T5	Ecoabonaza	Bayfolan	57.50	1.59	1.12	0.80
T5	Ecoabonaza	Humina	57.16	1.58	1.11	0.90
C.V. %			19.49	19.47	19.39	26.60
Fertilizers vs Foliars			0.8894 ns	0.8853 ns	0.8841 ns	0.3222 ns

Note: NS = Not significant at 5% probability of error; * = Significant at 5%; ** = Significant at 1%.

Table 5. Fiber yield by quality grade.

Treatments			Fiber weight in kg.pesudostem-1				
			2nd	3rd	4th	5th	Total
T1	Fertibanano	Without foliar fertilization	0.307	0.298	0.358	0.257	**1.220**
T2	Fertibanano	Bayfolan	0.248	0.241	0.289	0.208	**0.986**
T3	Fertibanano	Humina	0.298	0.290	0.348	0.250	**1.186**
T4	Ecoabonaza	Without foliar fertilization	0.272	0.264	0.317	0.228	**1.081**
T5	Ecoabonaza	Bayfolan	0.281	0.273	0.328	0.235	**1.116**
T6	Ecoabonaza	Humina	0.279	0.271	0.326	0.234	**1.110**

From a theoretical perspective, the idea that efficiency in the allocation of resources within the plant is a priority for productivity and fiber quality, beyond absolute vegetative growth, is reinforced. However, the study presents methodological limitations that must be considered. First, the duration of the trial restricts the generalization of the results; In addition, soil and climatic variables or physiological parameters that could help to explain the observed effects more accurately were not evaluated, therefore, longitudinal and multisite studies are recommended to validate and expand the evidence obtained.

Conclusions

The evaluation of different sources of soil and foliar fertilizers on the production of abacá fiber, Tangongón variety, determined that the most efficient treatment was the application of Fertibanano as a soil fertilizer without foliar supplementation. This treatment stood out for achieving the highest fiber yield, with 1.25 $t.ha^{-1}.year^{-1}$, and for producing the highest proportion of fiber of better quality (2^{nd} = 0.307 $kg.pseudostem^{-1}$). In addition, this alternative favored the vegetative propagation of the crop, generating the highest averages of suckers (2.13 $suckers.plant^{-1}$) and shoots per plant (7.25 $shoots.plant^{-1}$). Although the combination of Ecoabonaza with Bayfolan promoted the highest plant height (1.58 $cm.month^{-1}$), and Fertibanano with humic acids (E_1F_2) presented the highest values in the number of $leaves.plant^{-1}$ (0.85) and the pseudostem diameter (2.59 cm), these treatments showed a lower fiber yield and a lower proportion of second-class fiber. Therefore, it is concluded that, among the alternatives evaluated, nutritional management based on Fertibanano constitutes a nutritional strategy to optimize crop yield and abacá fiber quality.

Literature cited

Ampong, K., Thilakaranthna, M. S., & Gorim, L. Y. (2022). Understanding the role of humic acids on crop performance and soil health. *Frontiers in Agronomy*, *4*, 848621. https://doi.org/10.3389/fagro.2022.848621

Araya-Gutiérrez, D., Monge, G. G., Jiménez-Quesada, K., Arias-Aguilar, D., & Cordero, R. Q. (2023). Abaca: a general review on its characteristics, productivity, and market in the world. *Revista Facultad Nacional de Agronomía Medellín*, *76*(1), 10263-10273. https://doi.org/10.15446/rfnam.v76n1.101710

Arias Aguilar, D., Araya Salas, M., Esquivel Segura, E. & Jiménez Montero, M. (2024). *Manual Técnico para la producción sostenible de abacá (Musa textilis Née) en Costa Rica*. PROCOMER

Banco Central del Ecuador. (2023). *Información Estadística Mensual: Nº 2054*. Dirección Nacional de Síntesis Macroeconómica. Recuperado de https://repositorio.bce.ec/handle/32000/2322

Bande, M. M., Grenz, J., Asio, V. B., & Sauerborn, J. (2013). Fiber yield and quality of abaca (*Musa textilis* var. Laylay) grown under different shade conditions, water, and nutrient management. *Industrial Crops and Products*, *42*, 70-77. https://doi.org/10.1016/j.indcrop.2012.05.009

Barbosa, C. F. C., Asunto, J. C., Koh, R. B. L., Santos, D. M. C., Zhang, D., Cao, E. P., & Galvez, L. C. (2023). Genome-wide SNP and indel discovery in Abaca (*Musa textilis* Née) and among other Musa spp. for Abaca genetic resources management. *Current Issues in Molecular Biology*, *45*(7), 5776-5797. https://doi.org/10.3390/cimb45070365

Bongoloan Jr, R., & Dinopol, E. (2016). Response of Abaca (*Musa textilis* N.) to Vermicast Application. *Journal on Agro-industrial Research and Development, 1*(1), 7-10. https://journal.asscat.edu.ph/index.php/jaird/article/view/5

Bravo, S., Pazmiño, J. y Jácome, L. (2023). Efecto de abonos orgánicos en el rendimiento en abacá (*Musa textilis*) variedad Tangongón en tres densidades de siembra. *Boletín Científico Ideas y Voces, 3*(3), 1361-1372. https://ciciap.org/ideasvoces/index.php/BCIV/article/view/105/123

Castro, R. C. T. y Chávez, J. P. A. (2022). Evaluación de la fertilización inyectada en el cultivo de abacá (*Musa textilis*). *Revista de Investigación Científica TSE DE*, *5*(3), 1-14. https://www.revista.tsachila.edu.ec/index.php/TSEDE/article/view/133

Franck, R. R. (Ed.). (2005). Bast and other plant fibres (Vol. 39). Crc Press.

Instituto Nacional de Meteorología e Hidrología (INAMHI). (2024). *Boletín N° 07, Informes meteorológicos anuales de temperatura y precipitación*. https://servicios.inamhi.gob.ec/clima1/

Jácome Gómez, L. R., Álava Rosado, A. M., y Arellano Cisneros, C. L. (2025). Efecto de la fertilización en la producción de abacá (*Musa textilis* Bungalanón). Boletín Científico Ideas Y Voces, 5(2), 159 – 170. https://doi.org/10.60100/bciv.v5i2.219

Karpinets, T. V., & Greenwood, D. J. (2024). Potassium dynamics. In *Handbook of Processes and Modeling in the Soil-Plant System* (pp. 525-559). CRC Press.

Macay-Anchundia, M. Ángel, Cobeña Loor, N. V., Balcázar Almeida, M. I., Ponce Hidalgo, E. J., & Mendoza Márquez, P. J. (2025). Efecto del fertilizante mineral en el rendimiento y calidad de la producción de Musa textilis. *Revista Científica Multidisciplinar G-nerando*, *6*(1) 936 – 946. https://doi.org/10.60100/rcmg.v6i1.445

Mangmang, M., & Cozo, K. (2021). Growth response of abaca (*Musa textilis* Nee) in abandoned mine soil amended with oil palm residues. *Southeastern Philippines Journal of Research and Development*, *26*(2), 23-46. https://doi.org/10.53899/spjrd.v26i2.158

Nardi, S., Schiavon, M., & Francioso, O. (2021). Chemical structure and biological activity of humic substances define their role as plant growth promoters. *Molecules*, *26*(8), 2256. https://doi.org/10.3390/molecules26082256

Organización de las Naciones Unidas para la Alimentación y la Agricultura (FAO). (2004). Perspectivas a plazo medio de los productos básicos agrícolas: Proyecciones al año 2010. Food & Agriculture Org. https://www.fao.org/4/y5143s/y5143s00.htm#Contents

Pandey, N. (2018). Role of plant nutrients in plant growth and physiology. In *Plant nutrients and abiotic stress tolerance* (pp. 51-93). Singapore: Springer Singapore.

Philippine Bureau of Agriculture and Fisheries Standards (BAFS). (2019). *Non-food crops – Abaca – Code of Good Agricultural Practices (GAP)*. Philippine National Standard PNS/BAFS 266:2019. https://philfida.da.gov.ph/images/Publications/PNS/PNS-Non-food-Abaca-GAP.pdf

Ramos, C. A., Saludo, K. E., & Corpuz, O. S. (2022). Growth Increment of Tissue Cultured Abaca Seedlings Applied with Conventional Fertilizer and Biostimulant. *Asian Journal of Agricultural and Horticultural Research*, *9*(4), 37-48. https://doi.org/10.9734/ajahr/2022/v9i430155

Sardans, J., & Peñuelas, J. (2021). Potassium control of plant functions: Ecological and agricultural implications. *Plants*, *10*(2), 419. https://doi.org/10.3390/plants10020419

Ullah, S., Akhter, Z., Palevicius, A., & Janusas, G. (2025). Review: Natural fiber-based biocomposites for potential advanced automotive applications. *Journal of Engineered Fibers and Fabrics*, *20,* 1-25. https://doi.org/10.1177/15589250241311468

Unal, F., Avinc, O., & Yavas, A. (2020). Sustainable textile designs made from renewable, biodegradable sustainable natural abaca fibers. In *Sustainability in the Textile and Apparel Industries: Sustainable Textiles, Clothing Design and Repurposing* (pp. 1-30). Cham: Springer International Publishing.

Wei, X., Xie, B., Wan, C., Song, R., Zhong, W., Xin, S., & Song, K. (2024). Enhancing soil health and plant growth through microbial fertilizers: Mechanisms, benefits, and sustainable agricultural practices. *Agronomy*, *14*(3), 609. https://doi.org/10.3390/agronomy14030609

Yap, K. L. P., Casinillo, L. F., Bales, M. C., & Baliña, F. T. (2024). Characterizing the profile and functions of abaca industry stakeholders: The case of the Philippines. *Journal of Management, Economics, & Industrial Organization (JOMEINO)*, *8*(2) 42-64. http://doi.org/10.31039/jomeino.2024.8.2.3