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Research Article

Validating Nutrient Deficiencies in Abaca (*Musa textilis* Née var. Inosa) via Morpho-Physiological and Biochemical Analysis Under Field Conditions

James Francienne J. Rosit[1]*, Romel B. Armecin[2]

[1]Philippine Fiber Industry Development Authority, Cebu City 6000, Philippines
[2]National Abaca Research Center, Visayas State University, Baybay City, Leyte 6521-A, Philippines

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**Corresponding author:*
E-mail:
jamesfranciennej.rosit@gmail.com

ABSTRACT

This study was conducted in order to validate and compare the nutrient composition, morpho-physiological and biochemical properties of asymptomatic and symptomatic abaca in the field. This approach may provide insights on the possible association between disease infestation and nutrient deficiency symptoms observed in abaca. Three sampling sites were selected for sample collection; The National Abaca Research Center (NARC), Visayas State University, Baybay City, Leyte, Brgy. Basak, Maasin City and Brgy. Lonoy, Maasin City, Southern Leyte. Five sample plants for both asymptomatic and symptomatic plants were collected for data gathering. Field validation showed that asymptomatic showed better leaf morphology than symptomatic abaca plants. Furthermore, asymptomatic abaca plants have higher chlorophyll a and b content than symptomatic plants. Nitrogen, phosphorus, and potassium content in asymptomatic abaca plants were higher than symptomatic plants. Nitrogen content was higher in soils from asymptomatic abaca plants while phosphorus and potassium were very high on soils from symptomatic abaca plants. Despite the very high phosphorus and potassium content in symptomatic soils, abaca plants exhibited clear signs of nutrient deficiency, suggesting that excessive P and K may interfere with the availability or uptake of other essential nutrients, such as magnesium, calcium, or micronutrients like zinc and iron resulting to the occurrence of nutrient deficiency symptoms in the abaca plants.

***Keywords**: Abaca, Macronutrient, Asymptomatic, Symptomatic, Nutrient analysis, Field condition*

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Introduction

Commonly referred to as Manila hemp, abaca is harvested for its exceptionally strong fibers. However, it is important to note that abaca is not true hemp; it belongs to the Musaceae family (Cook, 2001) and is classified as a non-woody plant (Armecin et al., 2014; Hakeem et al., 2014). Abaca fiber typically measures between 1 to 3 meters in length, with a diameter ranging from 3 to 30 μm (Armecin et al., 2014; Hakeem et al., 2014). Due to its strength and resilience, abaca fiber is extensively utilized in the maritime industry for applications such as ropes and fishing lines. The Philippines leads global production, contributing approximately 63.51% of the world's abaca raw fiber (Munar, 2024).

However, the Philippine Fiber Industry Development Authority (PhilFIDA, 2023) Regional Office 8 Annual Report indicates a concerning decline in abaca production over recent years, with a significant drop of about 64.4% in 2020 compared to previous years (Parac et al., 2021). This decrease can be attributed to several factors, including repeated strong typhoons, the rapid harvesting of abaca suckers for expansion and rehabilitation efforts, a shortage of local traders, nutrient management, and the detrimental impact of the predominant challenge facing the industry: the abaca bunchy top virus. The symptoms of the abaca bunchy top virus (ABTV) resemble those associated with nutrient deficiencies of selected macronutrients. Thus, validation is needed whether nutrition has a significant role in the decline of abaca fiber production in the field.

Materials and Methods

Site Selection

Three sample sites were visited and, in each site, 5 sample plants were assessed and collected. These sampling sites are as follows: National Abaca Research Center - Abaca Nursery, Baybay City, Leyte; Brgy. Lonoy, Maasin City, Southern Leryte and Brgy. Basak, Maasin City, Southern Leyte. These areas have been known to have existing abaca for years and have been observed to have the disease-like appearance/nutrient deficiency symptoms of abaca.

Sample Collection

Samples were randomly selected from the field that showed symptoms such as yellowing of leaves (chlorosis), plant cell death (necrosis) stunted growth accompanied by curling and narrowing of leaves, and other abnormalities that might be associated with nutrient deficiencies or disease infestation. Samples for physiological and biochemical analysis were collected early in the morning and secured in a zip-lock plastic bag. These were placed inside an ice bucket to maintain their freshness and were transported to the Visayas State University, Baybay City, Leyte for analysis.

Morphological Characteristics of Abaca

Data was collected by measuring the following parameters; plant height, pseudostem length, pseudostem girth, leaf length, leaf width, and total leaf area.

Chlorophyll Content and FRSA

The Hiscox and Israelstam, (1979) method were used to measure the amount of total chlorophyll. Samples were thinly sliced, bleached and were incubated using a water bath that contains 80% ethanol for 24 hours. Then, the absorbance of the solution was determined using a spectrophotometer (Epoch microplate spectrophotometer, Biotek™, Epoch™) set at 645 and 663 nm, and the rate was recorded and calculated using the equation of Aron, (1949).

Free radical scavenging of abaca was determined using the DPPH (1,1-diphenyl-1-1 picrylhydrazyl) assay following the procedure of Salas et al., (2015). The absorbance of the resulting solutions was read using a Shimadzu UV-Vis spectrophotometer at 517 nm using ethanol as the main reference.

Quantification of Macronutrients (Tissue and Soil)

Quantification of nutrients (N, P, & K) was done at the National Abaca Research Center (NARC) - Soil Analytical Laboratory using Kjeldahl digestion for N, while Phosphorous was quantified using the molybdenum blue Method by colorimetry and spectrophotometry at 470 nm (Wieczorek et al., 2022) and K was analyzed using the X-ray fluorescence (XRF) spectroscopy.

Results and Discussion

Leaf Geometric Properties of Aymptomatic and Symptomatic Abaca Plants

As indicated in Table 1, asymptomatic abaca plants from the National Abaca Research Center exhibit longer leaves compared to their symptomatic counterparts. Additionally, the asymptomatic plants demonstrate both wider and taller leaf dimensions, as well as a greater total leaf area than the symptomatic plants. This observation suggests that symptomatic abaca plants possess smaller and narrower leaves. The alteration in leaf morphology significantly impacts the overall growth and development of the abaca plants. This decrease in leaf size can be further elucidated by examining the leaf tissue contents presented in Table 2.

Table 1. Leaf geometric properties of asymptomatic and symptomatic abaca plants the NARC nursery (N), Visayas State University, Baybay City, Leyte; Brgy. Basak (BB), and Brgy. Lonoy (BL), Maasin City, Southern Leyte.

Source	Leaf Geometric Properties								
	Leaf Length (cm)			Leaf Width (cm)			Total Leaf Area (in^2)		
	N	BB	BL	N	BB	BL	N	BB	BL
Asymp	57.6^a	63.4	54	22.4^a	23.7^a	19^a	766.7^a	906^a	636.1^a
Symp	47.4^b	49	44.6	11.4^b	11^b	12.7^b	332.1^b	319.6^b	335.1^b
Total	**105**	**112.4**	**98.6**	**33.8**	**34.7**	**32.3**	**1098**	**1225**	**971.2**
Mean	**52.5**	**56.2**	**49.3**	**16.9**	**17.3**	**16.1**	**549.4**	**612.8**	**485.6**

Groups sharing a letter are not significantly different (Tukey HSD, p<0.05

Table 2. Leaf tissue analysis for NPK content of asymptomatic and symptomatic abaca plants from NARC nursery (N), Visayas State University, Baybay City, Leyte; Brgy. Basak (BB), and Brgy. Lonoy (BL), Maasin City, Southern Leyte

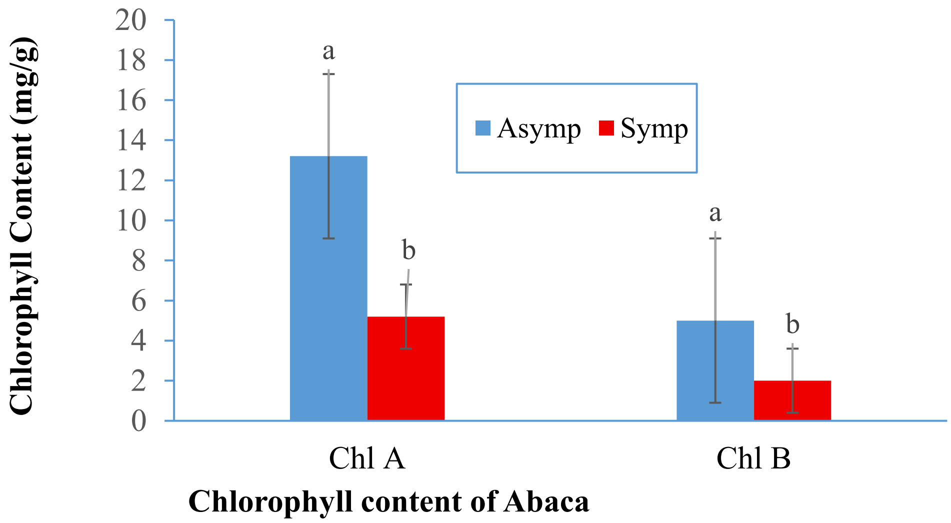
Source	Nutrient Content								
	Nitrogen (%)			Phosphorus (ppm)			Potassium (%)		
	N	BB	BL	N	BB	BL	N	BB	BL
Asymp	3.4	3.8	3.7	65	142.5	176.6	10.6	15.7	15.9
Symp	2.9	3.3	2.1	83.6	114.6	148.7	9.9	11.1	10.3
Total	**6.3**	**7.1**	**5.8**	**148.6**	**257.1**	**325.3**	**20.5**	**26.8**	**26.2**
Mean	**3.15**	**3.55**	**2.9**	**74.3**	**128.5**	**162.6**	**10.2**	**13.4**	**13.1**

Groups sharing a letter are not significantly different (Tukey HSD, p<0.05

Nitrogen is a crucial component of proteins and nucleic acids, playing a significant role in leaf expansion. Phosphorus is vital for plant cell division, as it is an essential component of nucleoproteins involved in the processes of cell division (Gul et al., 2015). Potassium is key to various metabolic functions in plants, including stomatal movement, enzyme activation, protein synthesis, energy transfer, photosynthesis, osmoregulation, phloem transport, and maintaining cation-anion balance, as well as contributing to stress resistance. Therefore, a balanced intake of macronutrients such as nitrogen, phosphorus, and potassium is essential for achieving an optimal leaf area index in plants, which ultimately promotes efficient photosynthesis and healthy plant growth.

Chlorophyll Content of Asymptomatic and Symptomatic Abaca Plants

As illustrated in Figure 1, chlorophyll a and b levels were higher in asymptomatic plants compared to symptomatic ones. This indicates that symptomatic plants are unable to optimize their photosynthetic activity due to lower chlorophyll content, resulting in a reduction in leaf morphology. This observation aligns with the finding that symptomatic abaca plants exhibit lower NPK content compared to their asymptomatic counterparts (see Table 2). The diminished chlorophyll levels in symptomatic abaca plants contribute to smaller leaf sizes, as chlorophyll plays a crucial role in photosynthesis, the process by which the plant generates the nutrients necessary for healthy growth and development. Moreover, the decline in chlorophyll content in abaca under nutrient-deficient conditions may stem from a reduction in the plant's photosynthetic apparatus, which is primarily composed of nitrogen (Bassi et al., 2018). Adequate nitrogen intake during the later stages of growth is essential for delaying or mitigating the degradation of chlorophyll and protein compounds and extends the duration of plant photosynthesis thereby increasing the level of defenses of the leaves and preventing or delaying leaf senescence.



Groups sharing a letter are not significantly different (Tukey HSD, p<0.05

Figure 1. Average chlorophyll a and chlorophyll b content of asymptomatic and symptomatic abaca (Musa textilis Née var. Inosa) plants from the NARC Nursery, Visayas State University, Baybay City, Leyte, Brgy. Basak and Brgy. Lonoy, Maasin City, Southern Leyte.

Nutrient Content of Soils Grown with Asymptomatic and Symptomatic Abaca Plants

As shown in Table 3, the nitrogen content in asymptomatic plants from Brgy. Basak, Maasin City, and Southern Leyte was greater than that in symptomatic plants. In contrast, phosphorus (P) and potassium (K) soil concentrations were elevated in symptomatic abaca plants from both Brgy. Basak and Brgy. Lonoy in Maasin City, Southern Leyte. The higher nitrogen concentration in the soil of asymptomatic abaca plants from Brgy. Basak indicates that these plants have an adequate supply of nitrogen for absorption. Nitrogen is crucial for plants, playing a significant role in various physiological processes. It contributes to the dark green color of foliage and promotes the growth of leaves, stems, and other essential vegetative parts. Sufficient nitrogen levels facilitate rapid plant growth and enhance the uptake and utilization of other vital nutrients, such as potassium and phosphorus, thereby supporting overall plant development (Bloom, 2015; Hemerly, 2016). Conversely, nitrogen deficiency can result in stunted growth, chlorosis (where leaves change from green to yellow), and the appearance of purple and red spots on the leaves, while also inhibiting lateral bud growth. Typically, the symptoms of deficiency will appear first in the affected areas on older leaves, as noted by Bianco et al., (2015), leaf senescence follows.

Table 3. Soil analysis on the NPK concentration of soils collected from asymptomatic and symptomatic abaca plants from NARC nursery (N), Visayas State University, Baybay City, Leyte; Brgy. Basak (BB), and Brgy. Lonoy (BL), Maasin City, Southern Leyte.

Source	Soil Analysis								
	Nitrogen (%)			Phosphorus (ppm)			Potassium (ppm)		
	N	BB	BL	N	BB	BL	N	BB	BL
Asymp	0.16	0.19[a]	0.62	3.93	13.05[b]	12.11[b]	67.33	136[b]	120.3[b]
Symp	0.16	0.13[b]	nd	3.36	30.49[a]	30.79[a]	63.00	262[a]	249[a]
Total	**0.32**	**0.32**	**0.62**	**7.29**	**43.54**	**42.9**	**130.0**	**398**	**369.3**
Mean	**0.16**	**0.16**	**0.62**	**3.64**	**21.77**	**21.45**	**65.16**	**199**	**184.6**

Groups sharing a letter are not significantly different (Tukey HSD, p<0.05

Conversely, the presence of higher phosphorus and potassium levels in the soil from symptomatic abaca plants in Brgy. Basak and Brgy. Lonoy indicates that the soil contains adequate amounts of P and K for plant uptake. However, it is possible that these nutrients are not being absorbed by the plants, leading to the visible signs of nutrient deficiency in abaca (Figure 2). Alva et al., (2006a) suggest that soils with high potassium concentrations can cause salt damage, which negatively impacts the plant's ability to absorb water and essential nutrients such as magnesium and calcium, ultimately resulting in significant defoliation. Additionally, Rausch & Bucher, (2002) reported that as potassium levels in the soil rise, phosphorus content also increases. This is due to enhanced nitrogen absorption by the plants, which inhibits phosphorus uptake under high potassium conditions. Furthermore, elevated levels of phosphorus (P) can lead to deficiencies in zinc or molybdenum in the soil (Agbenin, 1998), while high potassium (K) levels may hinder the absorption of calcium (Ca) and magnesium (Mg) by plants (Zhang et al., 2010). This could explain why these abaca plants display symptoms of nutrient deficiency despite the presence of high concentrations of P and K in the soil.

(A) **(B)**

Figure 2. Symptomatic abaca (Musa textilis Née) plants at Brgy. Basak (A) and Brgy. Lonoy (B), Maasin City, Southern Leyte.

Abaca Bunchy Top Virus (ABTV) Detection using LAMPARA Test Kit

The sample abaca plants, both asymptomatic and symptomatic, were subjected to Loop-mediated Isothermal Amplification (LAMPARA) to determine their status regarding the presence of the Abaca Bunchy Top Virus (ABTV). This testing was prompted by the observation that the symptoms displayed were similar to those typically associated with ABTV infection. The results indicated that all samples tested were negative for ABTV, as evidenced by the orange coloration of the test vials. These findings suggest that the samples used in the study were free of ABTV, and that the symptoms observed in the plants are likely related to nutrient deficiencies or other abiotic factors.

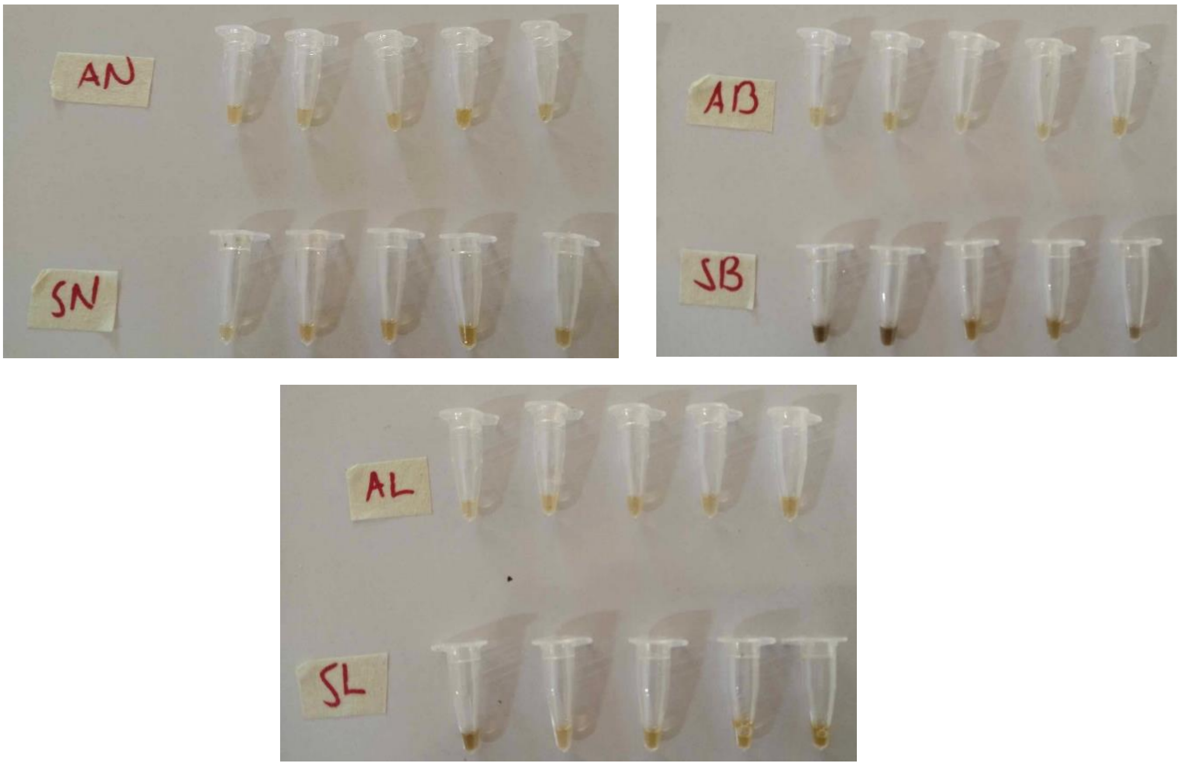


Figure 3. Loop-mediated isothermal amplification results on ABTV detection for asymptomatic and symptomatic abaca (Musa textilis Née) plants, orange (negative) green (positive).

Conclusion

Based on the results of the study, it is highly possible that ABTV is not the sole factor contributing to low fiber production; other abiotic factors such as nutrient deficiency may also play a role because symptomatic abaca plants had lower NPK content than asymptomatic abaca plants which showed similar symptoms to abaca bunchy top virus. Furthermore, the nutrient deficiencies in abaca under field conditions could accelerate the spread of diseases, as these plants are more vulnerable to disease under stress-induced environmental conditions.

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