

Influence of Nitrogen-Potassium Fertilizers on the Growth and the Productivity Parameters of Plantain Banana PITA 3, FHIA 21 and CORNE 1

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Abstract

This study was undertaken to measure the impact of fertilizers (nitrogen-potassium) on the growth and the development of plantain banana. Different doses of fertilizers (T2, T3, T4, T5 and T6) were applied to two hybrid varieties (PITA 3 and FHIA 21) and a traditional variety (CORNE 1) on an experimental split plot plan with a planting density of 2500 plants per hectare. Results showed that fertilizers improve parameters of plantain than control (T1). T6 with high potassium content (240 kg·ha⁻¹ N and 987 kg·ha⁻¹ K) improved the growth (35.72 ± 0.95 cm·month⁻¹) and the widening (9.56 ± 0.17 cm·month⁻¹) of PITA 3, and performed FHIA 21 agronomic parameters by reducing the length of the production cycle and increased the length of fruits. T2 treatment improved FHIA 21 agronomic and yield parameters. Also, the weight of CORNE 1 regimens (9.00 ± 0.67 kg) and fruits (296.59 ± 4.50 g), the length (33.37 ± 0.31 cm) and the circumference (14.73 ± 0.31 cm) increased with T2. T4 induced shorter production cycle of PITA 3 (390.40 ± 0.67 cm·month⁻¹), improved PITA3 regimens weight (10.33 ± 0.44 kg) and the number of hands by regimen (6.00 ± 0.00) of FHIA 21. T3 with weak nitrogen content (120 kg·ha⁻¹ N and 658 kg·ha⁻¹ K) improved the characteristics of PITA 3 fruits notably, the weight (176.09 ± 2.96 g) and the circumference (13.87 ± 0.89 cm). T5 (240 kg·ha⁻¹ N and 329 kg·ha⁻¹ K) performed CORNE 1 trees number of sheets (3.85 ± 0.16). CORNE 1 cycle production with T6 treatment was 137.80 days longer than those of T2 treatment (483 ± 3.50 days). In conclusion, with T2 and T6, growth parameters were globally improved in FHIA 21 by the regimen largest and the higher number of fingers, and productivity parameters were improved in CORNE 1 by the heaviest, the longest and the thickest of the fruits.

Keywords

Nitrogen, Potassium, Growth, Yield, Plantain Variety

1. Introduction

Among cultivated banana, plantain constitutes a homogeneous group with cultivars whose genome is triploid and bispecific (ABB). Plantain fruits are staple food and important cash crop for many developing countries. It is important for food security [1]. In contrast to dessert bananas, plantain fruits must be cooked before eating and are energy food able to provide body 120 kcal or 497 kJ per 100 g.

With a production of 1.6 million tons, the plantain crop ranks third in annual food production after yam and cassava in Côte d'Ivoire [2]. It is a means of diversifying and increasing income, due to the external markets that are developing [1]. Unfortunately, the low crop density (1667 plants·ha⁻¹ to 2500 plants·ha⁻¹) has long led to low yields [3]. A decade ago, [4] showed that increasing planting density in pure culture improves yields. Thus, since 2016, the crop density has increased to 2500 plants·ha⁻¹ for traditional varieties CORNE 1 and Orishele and hybrids PITA 3 and FHIA 21 [5].

Moreover, population growth is leading to an ever-increasing demand, which far exceeds supply [6]. As a result, the strong pressure on agricultural land reduces its availability and causes a significant drop in soil fertility and crop yields [7] [8]. To compensate for this state of affairs, chemical fertilizers are used to correct the soil's deficiency in mineral elements and improve crop productivity [9]. To this end, [10] showed that plants need essentially and significant quantities of nitrogen (N), phosphorus (P) and potassium (K) to complete their growth cycle.

Among minerals, nitrogen and potassium are especially recommended for plantain cultivation [11] as opposed to phosphorus requirements [12]. [5] showed in a recent study that for an intensive crop (2500 plants·ha⁻¹) of plantain (CORNE 1, FHIA 21 and PITA 3), the doses of 240 kg·ha⁻¹ (N) and 658 kg·ha⁻¹ (K) are recommended which were opposed to those previously proposed by [3] with 100 kg·ha⁻¹ (N) and 240 kg·ha⁻¹ (K). According to [13], beyond the quantities of minerals, it is indispensable to consider nitrogen-potassium interaction for better appreciation of plants response. Indeed, nitrogen contributes to the vegetative development of all aerial parts of the plant [14] while potassium has a great influence on fruit quality attributes and plant yield [15]. However, the physiological functions of nitrogen and potassium in plant production are closely related [16]. Thus, potassium intake may increase the efficiency of nitrogen use or exert a limiting effect. Similarly, higher potassium uptake results in a parallel increase in nitrogen uptake [13] [16]. This indicates that the nitro-

gen-potassium interaction is the most important interaction with potassium [13].

The objective of this contribution to the improvement of plantain productivity in Côte d'Ivoire is to determine the impact of different doses of nitrogen and potassium on the development and the yield parameters of plantain PITA 3, FHIA 21 and CORNE 1 produced in Côte d'Ivoire.

2. Material

2.1. Vegetal Material

The plant material is made up of vivo plants of 3 varieties of plantain including 2 tetraploid hybrids, PITA 3 (AAAB) and FHIA 21 (AAAB), high yield and tolerant to Black Berry Disease (BBD) and a local variety CORNE 1 (AAB). These vivo-plants were produced at the research station of the National Centre for Agronomic Research (CNRA) in Bimbresso.

2.2. Study Area

Experimental field was conducted in Bimbresso research station (Anguédédou) at 25 km west of Abidjan with the following geographical coordinates: 5°25' North latitude, 4°08' West longitude and 25 m altitude (Figure 1). The soils in this area, clayey-sandy by nature are ferrallitic. Before mineral input, total nitrogen content was 0.11 g·kg⁻¹. The cationic exchange capacity and potassium content were respectively 5.34 méq/100g and 0.35 méq/100g. The acid soils (pH

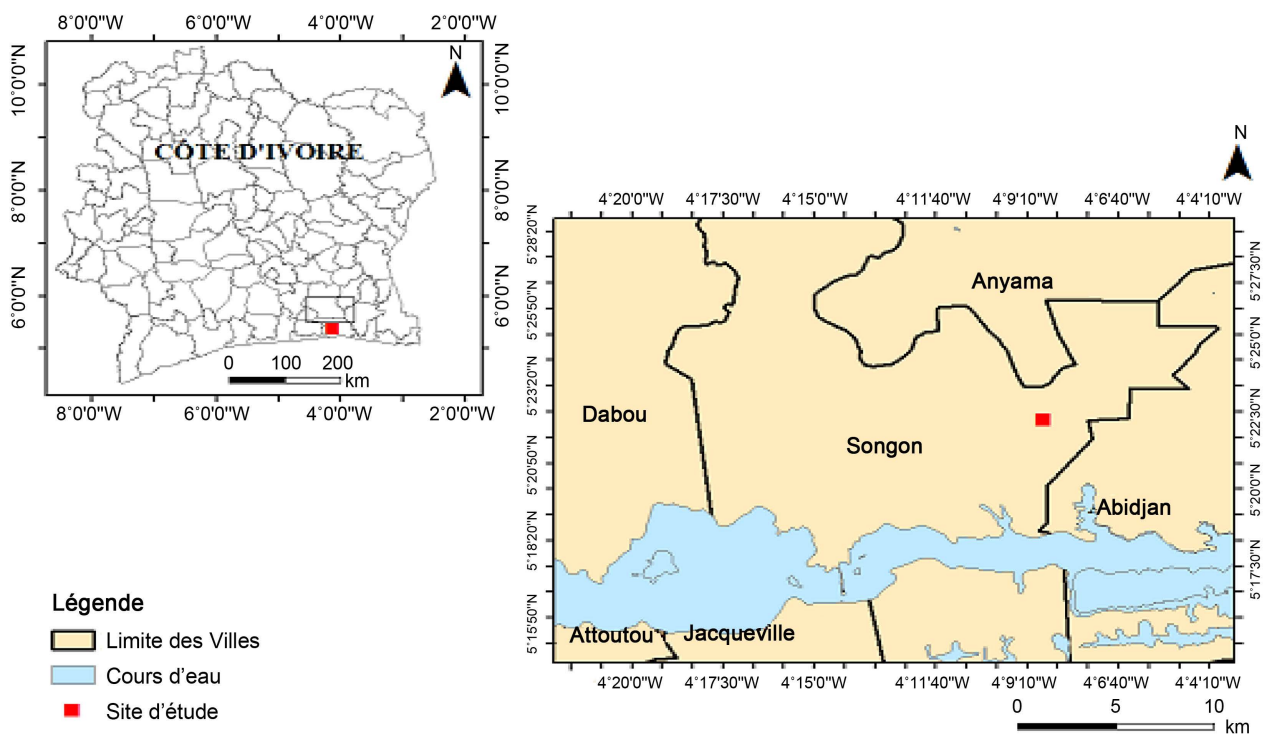


Figure 1. Geographic location of the study site.

5.31) of the experimental area had 32 mg·kg⁻¹ available phosphorus content and 220.75 mg·kg⁻¹ total phosphorus.

3. Methods

3.1. Setting Up of the Experimental Field

Experimental device was in split plot plan with plantain varieties as the main factor and doses of fertilizers as secondary factor. Planting density was 2500 plants per hectare with plants equidistant of 2 m. Each experimental unit or elementary plot of 60 m² had 15 useful plants. Plantain variety was composed of three modalities: PITA 3, FHIA 21 and CORNE 1. Fertilization was defined by the doses of nitrogen and potassium to be applied to the plants as a treatment (T). According to [5], for a density of 2500 plants·ha⁻¹, 240 kg·ha⁻¹ of nitrogen and 658 kg·ha⁻¹ of potassium (T2) are recommended. Based on this recommendation, 5 doses (T2-T6) were considered and compared to control without fertilizer (T1):

- T1. Without fertilizer (Control),
- T2. 240 kg·ha⁻¹ N and 658 kg·ha⁻¹ K (Conventional or recommended dose),
- T3. 120 kg·ha⁻¹ N and 658 kg·ha⁻¹ K,
- T4. 360 kg·ha⁻¹ N and 658 kg·ha⁻¹ K,
- T5. 240 kg·ha⁻¹ N and 329 kg·ha⁻¹ K,
- T6. 240 kg·ha⁻¹ N and 987 kg·ha⁻¹ K.

The number of treatments was defined according to factorial plan which was plantain variety (3) × fertilizer doses (6), *i.e.* 18 treatments. The 18 experimental plots were repeated on 3 blocks on an area of 5184 m².

3.2. Fertilizer Application during Cultivation

Fertilizers were brought to plants in form of urea containing 46% nitrogen and potassium chloride containing 60% potassium. The quantity of urea applied per plant was calculated by mathematic formula:

$$U = (N \times 100) / (46 \times 2500)$$

U = Amount of urea per plant (g),

N = Amount of nitrogen (g),

46 = Percentage of nitrogen in urea,

2500 = Number of plants per hectare.

The amount of KCl applied per plant was calculated by mathematic formula:

$$C = (K \times 100) / (60 \times 2500)$$

C = Amount of potassium chloride per plant (g),

K = Amount of potassium (g),

46 = Percentage of potassium in potassium chloride,

2500 = Number of plants per hectare.

For treatments, amounts of urea and potassium chloride were shared into 8 periods where doses 1 to 3 were applied on separate occasions with 3 weeks inter-

vals and doses 4 to 8 were applied on separate occasions with 4 weeks intervals (**Table 1**).

3.3. Plant Maintenance and Stabilization Treatment

Others plant growth essential minerals were brought to plantain plants in single dose. A week after planting, plants received 100 g of dolomite $\text{CaMg}(\text{CO}_3)_2$ containing calcium and magnesium and 80 g of tricalcium phosphate ($\text{Ca}_3(\text{PO}_4)_2$) to provide plants needs in phosphorus. “Nematicide” treatment was carried out at the flowering of the plantain plants, with a dose of 30 g per plant to destroy all dangerous parasitic worms. Insecticide treatment was carried out quarterly. Weeding was manual and monthly up to 6 months after planting and then bi-monthly up to 12 months after planting.

3.4. Evaluation of Growth and Development Parameters of Plantain Trees

Growth parameters (height and circumference of pseudo trunk) and development parameters (number of leaves released, Plantation-Flowering Interval (PFI) and Plantation-Harvest Interval (PHI)) were measured per month from 3rd to 10th months after planting, and then at flowering and harvesting. The measurements concerned all the useful plants of the plot ([17] [18]). Height was carried out from the collar to V formed by the last two emitted leaves and circumference

Table 1. Splitting of fertilizers application per plant.

Periods	Date	Activity	Treatments (g)					
	04/16/2018	Plantation	T1	T2	T3	T4	T5	T6
		Fertilization						
1	07/17/2018	Urea	0	30	15	45	30	30
		KCl	0	60	60	60	30	90
2	08/06/2018	Urea	0	30	15	45	30	30
		KCl	0	60	60	60	30	90
3	08/27/2018	Urea	0	30	15	45	30	30
		KCl	0	60	60	60	30	90
4	09/17/2018	Urea	0	24	12	36	24	24
		KCl	0	60	60	60	30	90
5	10/15/2018	Urea	0	24	12	36	24	24
		KCl	0	72	72	72	36	108
6	11/14/2018	Urea	0	24	12	36	24	24
		KCl	0	72	72	72	36	108
7	12/12/2018	Urea	0	24	12	36	24	24
		KCl	0	72	72	72	36	108
8	01/09/2019	Urea	0	24	12	36	24	24
		KCl	0	72	72	72	36	108

at 10 cm above the ground. Emitted leaves were determined by direct counting. PFI was the average of the duration in days between planting and flowering of 50% of the plants when PHI was the average of the duration in days between planting and optimal maturity of fruits.

3.5. Evaluation of Yield Parameters of Plantain Trees

Bunches of 3 plantain trees per treatment were randomly selected at optimal maturity. The weight (kg) was determined using a hand scale. The number of hands and fingers was counted directly on the bunch. Fruits characteristics were determined using the three median fruits of the second hand of each bunch. Fruit weight was taken on an electronic scale and the length and circumference were measured with a tape measure from pedicel to apex.

3.6. Statistical Analysis of the Results

Triplicated data were presented as mean \pm standard deviation. Statistical analysis was performed using SPSS version 16.0 software where data were subjected to analysis of variance and then compared with Newmann-Keuls test at the 5% threshold. PCA was used to discriminate treatments according to growth, development and yield characteristics of plantain.

4. Results

4.1. Effect of Fertilizers on Plantain Growth Parameters

4.1.1. Height of Pseudo Trunk

The effect of fertilization on the height and the circumference of plantain trees is presented in **Table 2**. Compared to the control T1, plantain trees treated with T2-T6 showed high height with a growth ranging from 3.36 cm·month⁻¹ for PITA 3 (T5) to 12.89 cm·month⁻¹ for FHIA 21 (T2). With a height growth of 35.72 \pm 0.95 cm·month⁻¹, the fertilizer T6 induced significantly ($p \leq 0.05$) a gain of 9.34 cm·month⁻¹ of height in PITA 3 compared to T1 (26.38 \pm 1.28 cm·month⁻¹) and T5 (29.74 \pm 0.50 cm·month⁻¹) which induced the lowest height in the same variety. In FHIA 21, the highest height (24.18 \pm 0.64 cm·month⁻¹) was obtained with recommended treatment T2 and the lowest with T4 (19.23 \pm 1.11 cm·month⁻¹). For CORNE 1, with a height of 22.75 \pm 1.22 cm·month⁻¹ (T4) and 22.39 \pm 1.17 cm·month⁻¹ (T6), T4 and T6 induced the most significant increases of height ($p \leq 0.05$). Compared to T2 treatment (recommended dose) and according to variety, PITA 3 treated with fertilizer T6 (35.72 \pm 0.95 cm·month⁻¹) and CORNE 1 treated with T4 (22.75 \pm 1.22 cm·month⁻¹), and T6 (22.39 cm·month⁻¹) had significant height increases ($p \leq 0.05$) of 3.69 cm·month⁻¹, 3.19 cm·month⁻¹ and 2.83 cm·month⁻¹ respectively. Among varieties, FHIA 21 treated with T2 had the largest increase in size (114.17%) compared to control T1 and CORNE 1 had the largest increase in size (16.31%) compared to recommended treatment T2.

Table 2. Growth parameters of plantain trees subjected to fertilizers.

	PITA 3	FHIA 21	CORNE 1
Height of pseudo trunk (cm·month ⁻¹)			
T1	26.38 ± 1.28 ^{d,α}	11.29 ± 0.31 ^{d,β}	15.11 ± 0.95 ^{c,β}
T2	32.03 ± 1.03 ^{b,α} (+5.69*)	24.18 ± 0.64 ^{a,β} (+12.89*)	19.56 ± 1.76 ^{b,β} (+4.45*)
T3	31.67 ± 0.33 ^{b,α} (+5.29*, -0.36**)	22.11 ± 0.83 ^{b,β} (+10.82*, -2.07**)	20.20 ± 0.65 ^{b,β} (+5.09*, +0.64**)
T4	32.09 ± 0.45 ^{b,α} (+5.71*, +0.06**)	19.23 ± 1.11 ^{c,β} (+7.94*, -4.95**)	22.75 ± 1.22 ^{a,β} (+7.64*, +3.19**)
T5	29.74 ± 0.50 ^{c,α} (+3.36*, -2.29**)	22.96 ± 0.82 ^{b,β} (+11.67*, -1.22**)	20.31 ± 0.86 ^{b,β} (+5.20*, +0.75**)
T6	35.72 ± 0.95 ^{a,α} (+9.34*, +3.69**)	23.31 ± 0.47 ^{b,β} (+12.02*, -0.87**)	22.39 ± 1.17 ^{a,β} (+7.28*, +2.83**)
Circumference of pseudo trunk (cm·month ⁻¹)			
T1	6.26 ± 0.22 ^{d,α}	3.65 ± 0.20 ^{c,β}	4.81 ± 0.31 ^{c,β}
T2	9.12 ± 0.17 ^{b,α} (+2.86*)	8.43 ± 0.31 ^{a,β} (+4.78*)	6.64 ± 0.42 ^{b,β} (+1.83*)
T3	8.61 ± 0.20 ^{c,α} (+2.35*, -0.51**)	7.50 ± 0.48 ^{b,β} (+3.85*, -0.93**)	6.61 ± 0.19 ^{b,β} (+1.80*, -0.03**)
T4	9.04 ± 0.26 ^{b,α} (+2.78*, -0.08**)	7.28 ± 0.36 ^{b,β} (+3.63*, -1.15**)	6.36 ± 0.76 ^{b,β} (+1.55*, -0.28**)
T5	8.43 ± 0.22 ^{c,α} (+2.17*, -0.69**)	7.61 ± 0.56 ^{b,β} (+3.96*, -0.82**)	6.86 ± 0.42 ^{b,β} (+2.05*, +0.22**)
T6	9.56 ± 0.17 ^{a,α} (+3.30*, +0.44**)	7.86 ± 0.31 ^{b,β} (4.21*, -0.57**)	7.08 ± 0.33 ^{a,β} (2.27*, +0.44**)

T1. Without fertilizer, T2. 240 kg·ha⁻¹ N and 658 kg·ha⁻¹ K, T3. 120 kg·ha⁻¹ N and 658 kg·ha⁻¹ K, T4. 360 kg·ha⁻¹ N and 658 kg·ha⁻¹ K, T5. 240 kg·ha⁻¹ N and 329 kg·ha⁻¹ K, T6. 240 kg·ha⁻¹ N and 987 kg·ha⁻¹ K. Per parameter, values in column with the same arabic alphabetic letter are not significantly different according to the Student Newmann-Keuls test at $\alpha = 0.05$. Per parameter, values in line with the same greek alphabetic letter are not significantly different according to the Student Newmann-Keuls test at $\alpha = 0.05$. * Tn-T1, ** Tn-T2 with n dose number.

4.1.2. Circumference of Pseudo Trunk

Plantain subjected to treatments T2 to T6 recorded significantly higher circumferences ($p \leq 0.05$) than control T1 (Table 2). The increase was from 1.55 cm·month⁻¹ for CORNE 1 to 4.78 cm·month⁻¹ for FHIA 21. With circumferences of 9.56 ± 0.17 cm·month⁻¹ (PITA 3), 6.86 ± 0.42 cm·month⁻¹ (CORNE 1) and 7.08 ± 0.33 cm·month⁻¹ (CORNE 1), T6 and T5 induced significantly higher circumferences ($p \leq 0.05$) compared to those treated with T2. T6 provoked an increase up to 0.44 cm·month⁻¹ in PITA 3 and CORNE 1 varieties compared to those of T2. Compared to T1 (3.65 ± 0.20 cm·month⁻¹), significant increase of circumference was observed in FHIA 21 with T2 (+4.78 cm·month⁻¹). The growth of PITA 3 circumference without fertilizer was 1.30 to 1.72 times larger than those of CORNE 1 and FHIA 21 respectively. Similarly, the increase of circumference of PITA 3 subjected to T6 was 1.13 and 2.48 times significantly ($p \leq$

0.05) larger than those observed in FHIA 21 and CORNE 1 respectively.

4.2. Effect of Fertilization on Plantain Development Parameters

4.2.1. Number of Sheets

Table 3 shows fertilizers impact on plantain development parameters. Data showed

Table 3. Development parameters of plantain subjected to fertilizers.

	PITA 3	FHIA 21	CORNE 1
Number of sheets			
T1	3.12 ± 0.07 ^{b,b}	3.78 ± 0.09 ^{c,a}	3.48 ± 0.13 ^{b,β}
T2	3.60 ± 0.14 ^{a,β} (+0.48*)	4.38 ± 0.18 ^{a,a} (+0.60*)	3.63 ± 0.14 ^{a,β} (+0.15*)
T3	3.44 ± 0.26 ^{a,b} (+0.32*, -0.16**)	4.19 ± 0.18 ^{b,a} (+0.41*, -0.19**)	3.76 ± 0.16 ^{a,β} (+0.28*, +0.13**)
T4	3.58 ± 0.10 ^{a,β} (+0.46*, -0.02**)	3.90 ± 0.19 ^{c,a} (+0.12*, -0.48**)	3.62 ± 0.01 ^{a,β} (+0.14*, -0.01**)
T5	3.45 ± 0.16 ^{a,b} (+0.33*, -0.15**)	4.16 ± 0.13 ^{b,a} (+0.38*, -0.22**)	3.85 ± 0.16 ^{a,β} (+0.37*, +0.22**)
T6	3.54 ± 0.15 ^{a,β} (+0.42*, -0.06**)	4.10 ± 0.19 ^{b,a} (+0.32*, -0.28**)	3.76 ± 0.13 ^{a,β} (+0.28*, +0.13**)
Plantation-flowering interval (day)			
T1	379.60 ± 8.72 ^{ca}	450.01 ± 7.84 ^{dβ}	610.54 ± 6.30 ^{eb}
T2	311.00 ± 7.20 ^{ba} (-68.60*)	374.00 ± 6.80 ^β (-76.01*)	413.00 ± 4.80 ^{ab} (-197.54*)
T3	318.00 ± 5.20 ^{ba} (-61.60*, +7.00**)	387.40 ± 1.92 ^{bβ} (-62.61*, +13.40**)	442.20 ± 6.24 ^{cb} (-168.34*, +29.20**)
T4	302.40 ± 1.12 ^{aa} (-77.20*, -8.60**)	408.40 ± 4.72 ^{cb} (-147.61*, +34.40**)	424.20 ± 7.84 ^{bb} (-186.34*, +11.20**)
T5	314.00 ± 2.40 ^{ba} (-65.60*, +3.00**)	392.10 ± 6.92 ^{bβ} (-57.91*, +18.10**)	410.40 ± 5.28 ^{ab} (-200.14*, -2.60**)
T6	314.83 ± 6.30 ^{ba} (-64.60*, +3.00**)	371.60 ± 6.32 ^β (-78.41*, -2.40**)	546.80 ± 6.16 ^{da} (-63.74*, +133.80**)
Plantation-Harvest Interval (day)			
T1	482.60 ± 0.67 ^{da}	565.25 ± 0.89 ^{cb}	716.67 ± 4.89 ^{eb}
T2	403.00 ± 0.67 ^{ba} (-79.60*)	470.67 ± 1.56 ^β (-94.58*)	483.00 ± 3.50 ^{ab} (-233.67*)
T3	415.33 ± 1.33 ^{ca} (-67.27*, +12.33**)	475.73 ± 0.97 ^β (-89.52*, +5.06**)	514.87 ± 2.89 ^{cb} (-201.80*, 31.87**)
T4	390.40 ± 0.67 ^{aa} (-92.20*, -12.60**)	504.40 ± 0.67 ^{bβ} (-60.85*, +33.73**)	507.53 ± 0.89 ^{cb} (-209.14*, 24.53**)
T5	402.43 ± 0.44 ^{ba} (-80.17*, -0.57**)	492.43 ± 0.44 ^{bβ} (-72.82*, +21.76**)	495.07 ± 0.44 ^{bb} (-221.60*, 12.07**)
T6	403.16 ± 0.44 ^{ba} (-79.44*, +0.16**)	468.60 ± 0.67 ^β (-96.65*, -2.07**)	620.80 ± 4.00 ^{db} (-95.87*, 137.80**)

T1. Without fertilizer, T2. 240 kg·ha⁻¹ N and 658 kg·ha⁻¹ K, T3. 120 kg·ha⁻¹ N and 658 kg·ha⁻¹ K, T4. 360 kg·ha⁻¹ N and 658 kg·ha⁻¹ K, T5. 240 kg·ha⁻¹ N and 329 kg·ha⁻¹ K, T6. 240 kg·ha⁻¹ N and 987 kg·ha⁻¹ K. Per parameter, values in column with the same arabic alphabetic letter are not significantly different according to the Student Newmann-Keuls test at $\alpha = 0.05$. Per parameter, values in line with the same greek alphabetic letter are not significantly different according to the Student Newmann-Keuls test at $\alpha = 0.05$. * Tn-T1, ** Tn-T2 with n dose number.

that plantain subjected to T2-T6 treatments produced significantly ($p \leq 0.05$) higher quantities of leaves than those of control T1. No significant difference ($p \leq 0.05$) was observed between PITA 3 leaves (3.44 ± 0.26 leaves·month⁻¹ with T3 to 3.60 ± 0.14 leaves·month⁻¹ with T2) and CORNE 1 leaves (3.62 ± 0.01 leaves·month⁻¹ with T4 to 3.85 ± 0.16 leaves·month⁻¹ with T5). The leaves production in FHIA 21 was the best with an average around 4 leaves·month⁻¹. In the same variety, leaves production with T2 treatment (4.38 ± 0.18 leaves·month⁻¹) was significantly the highest ($p \leq 0.05$) and those of T4 treatment (3.90 ± 0.19 leaves·month⁻¹) was the lowest. CORNE 1 was the best in leaves production with 0.13 leaf·month⁻¹ (T3 and T6) and 0.22 leaf·month⁻¹ (T5) compared to the recommended one T2.

4.2.2. Plantation-Flowering Interval (PFI)

Plantain time flowering in T1 Control was significantly longer ($p \leq 0.05$) than those of the others treatment (T2-T5) with delays of 379.6 ± 8.72 days for PITA 3, 450.01 ± 7.84 days for FHIA 21 and 610.54 ± 6.30 days for CORNE 1 (**Table 3**). With 302.40 ± 1.12 days (PITA 3), 371.60 days ± 6.32 (FHIA 21) and 410.40 ± 5.28 days (CORNE 1), T4, T6 and T5 treatments induced significantly ($p \leq 0.05$) shorter flowering times of 8.60 days, 2.40 days and 2.60 days respectively compared to those of T2. CORNE 1 showed a greater PFI reduction compared to control T1 and PITA 3 the greatest PFI reduction compared to T2 fertilizer. Also, PITA 3 with T4 treatment showed the shortest flowering time of 69.2 days and 108 days compared to FHIA 21 and CORNE 1 treated with T6 and T5 respectively.

4.2.3. Plantation-Harvest Interval (PHI)

Cycle production was significantly ($p \leq 0.05$) longer for plantains with T1 than those of treatments (**Table 3**). PITA 3 PHI lasted between 390.40 ± 0.67 days (T4) and 482.60 ± 0.67 days (T1) when FHIA 21 PHI ranged from 468.60 ± 0.67 days (T6) to 565.25 ± 0.89 days (T1). CORNE 1 cycle production was very long with T1 (716.67 ± 4.89 days) and shorter with T2 (483.00 ± 3.50 days). According to T2 treatment, hybrid plantain (PITA 3 and FHIA 21) had better responses than traditional variety (CORNE 1) by reducing the PHI. With T4 (390.40 ± 0.67 days) and T5 (402.43 ± 0.44 days), PITA 3 recorded reduction of 12.60 days and 0.57 days respectively. T6 reduced 2.07 days of PHI in FHIA 21. The reduction of PHI was more pronounced in CORNE 1 and PITA 3 compared to those of T1 and T2 respectively. The production cycle of PITA 3 was 80.27 days and 92.60 days significantly ($p \leq 0.05$) shorter than those of FHIA 21 (T6) and CORNE 1 (T2) respectively.

4.3. Effect of Fertilization on Plantain Yield Parameters

4.3.1. Regimens Characteristics

1) Regimens weight

The effect of fertilizers on plantain regimen is presented in **Table 4**. Treatments

Table 4. Characteristics of plantain bunches after fertilization.

	PITA 3	FHIA 21	CORNE 1
Weight of regimens (kg)			
T1	7.00 ± 0.67 ^{cβ}	10.00 ± 2.00 ^{ba}	7.00 ± 0.67 ^{bβ}
T2	9.67 ± 0.49 ^{bβ} (+2.67*)	13.50 ± 1.67 ^{aa} (+3.50*)	9.00 ± 0.67 ^{aβ} (+2.00*)
T3	10.00 ± 0.01 ^{abβ} (+3.00*, +0.33**)	12.67 ± 2.22 ^{aa} (+2.67*, -0.83**)	7.00 ± 0.67 ^{bβ} (+0.00*, -2.00**)
T4	10.33 ± 0.44 ^{aβ} (+3.33*, +0.66**)	13.33 ± 0.44 ^{aa} (+3.33*, -0.17**)	7.67 ± 0.44 ^{bβ} (+0.67*, -1.33**)
T5	9.33 ± 0.39 ^{bβ} (+3.00*, -0.34**)	12.17 ± 0.22 ^{aa} (+2.17*, -1.33**)	7.83 ± 0.22 ^{bβ} (+0.83*, -1.17**)
T6	10.00 ± 0.67 ^{abβ} (+2.33*, +0.33**)	12.83 ± 0.22 ^{aa} (+2.83*, -0.67**)	8.67 ± 0.89 ^{aβ} (+1.67*, -0.33**)
Number of hands by regimen			
T1	4.25 ± 0.55 ^{bβ}	5.67 ± 0.44 ^{ba}	5.50 ± 0.17 ^{ba}
T2	4.42 ± 0.49 ^{aβ} (+0.17*)	6.00 ± 0.00 ^{aa} (+0.33*)	6.33 ± 0.44 ^{aa} (+0.83*)
T3	4.67 ± 0.44 ^{aβ} (+0.42*, +0.25**)	5.33 ± 0.44 ^{ba} (-0.34*, -0.67**)	5.67 ± 0.59 ^{ba} (+0.17*, -0.66**)
T4	4.42 ± 0.49 ^{aβ} (+0.17*, +0.00**)	6.00 ± 0.00 ^{aa} (+0.33*, +0.00**)	6.00 ± 0.27 ^{aa} (+0.50*, -0.33**)
T5	4.17 ± 0.56 ^{bβ} (-0.08*, -0.25**)	6.00 ± 0.00 ^{aβ} (+0.33*, +0.00**)	6.67 ± 0.44 ^{aa} (+1.17*, +0.34**)
T6	4.83 ± 0.42 ^{aβ} (+0.58*, +0.41**)	5.33 ± 0.44 ^{bβ} (-0.34*, -0.67**)	6.33 ± 0.44 ^{aa} (+0.83*, -0.66**)
Number of fingers by regimen			
T1	42.67 ± 1.56 ^{cβ}	53.33 ± 1.00 ^{ca}	23.00 ± 0.67 ^{bβ}
T2	50.25 ± 4.46 ^{bβ} (+7.58*)	66.67 ± 1.78 ^{aa} (+13.34*)	22.33 ± 0.44 ^{abβ} (-0.67*)
T3	54.00 ± 6.17 ^{aa} (+11.33*, +3.93**)	53.00 ± 2.00 ^{ba} (+12.34*, -1.00**)	19.33 ± 2.44 ^{bβ} (-3.00*, -2.33**)
T4	54.18 ± 6.32 ^{aβ} (+11.51*, +3.93**)	65.67 ± 1.11 ^{aa} (+12.34*, -1.00**)	20.00 ± 2.00 ^{bβ} (-3.00*, -2.33**)
T5	47.17 ± 7.64 ^{bβ} (+4.50*, -3.08**)	66.67 ± 1.44 ^{aa} (+13.34*, +0.00**)	25.33 ± 1.11 ^{aβ} (+2.33*, +3.00**)
T6	56.75 ± 5.17 ^{aa} (+14.08*, +6.50**)	62.00 ± 4.67 ^{aa} (+8.67*, -4.67**)	23.33 ± 2.44 ^{abβ} (+0.33*, +1.00**)

T1. Without fertilizer, T2. 240 kg·ha⁻¹ N and 658 kg·ha⁻¹ K, T3. 120 kg·ha⁻¹ N and 658 kg·ha⁻¹ K, T4. 360 kg·ha⁻¹ N and 658 kg·ha⁻¹ K, T5. 240 kg·ha⁻¹ N and 329 kg·ha⁻¹ K, T6. 240 kg·ha⁻¹ N and 987 kg·ha⁻¹ K. Per parameter, values in column with the same arabic alphabetic letter are not significantly different according to the Student Newmann-Keuls test at $\alpha = 0.05$. Per parameter, values in line with the same greek alphabetic letter are not significantly different according to the Student Newmann-Keuls test at $\alpha = 0.05$. * Tn-T1, ** Tn-T2 with n dose number.

(T2-T6) induced greater regimen than T1. Only PITA 3 showed significantly ($p \leq 0.05$) an improvement of the regimen weight compared to T2. Gains of weight of 0.33 kg were observed with T3 and T6 treatments, and 0.66 kg for T4. Fertilizer T2 induced the heaviest bunch of FHIA 21 (13.50 ± 1.67 kg) and CORNE 1 (9.00 ± 0.67 kg). The increase of regimen weight was significant ($p \leq 0.05$) in FHIA 21 and PITA 3 compared to T1 (10.00 ± 2.00 kg) and T2 (9.67 ± 0.49 kg) respectively. Among varieties and according to treatments, only FHIA 21 produced largest regimens. The slightest regimen of FHIA 21 from T1 got 10 kg where the heaviest regimen of PITA 3 and CORNE 1 had 10.33 kg (T4) and 9.00 kg (T2) respectively.

2) Hands number

The hands numbers of PITA 3 and FHIA 21 were significantly lower ($p \leq 0.05$) than those of control without fertilizer T1 (Table 4). FHIA 21 treated with T3 and T6 (5.33 ± 0.44 hands) provoked less than 0.34 hand compared to T1 treatment (5.67 ± 0.44 hands). The hands number of PITA 3 treated with T3 (4.67 ± 0.44 hands) and T6 (4.83 ± 0.42 hands), and CORNE 1 treated with T5 (6.67 ± 0.44 hands) were significantly higher ($p \leq 0.05$) than those of the recommended dose T2. However, the increase of PITA 3 hands number was greater than CORNE 1. The increase for CORNE 1 was the most significant ($p \leq 0.05$) compared to Control T1. PITA 3 regimens had 4.17 hands (T5) to 4.83 hands (T6). FHIA 21 and CORNE 1 hands were 1.24 times and 1.38 times higher than those of PITA 3.

3) Fingers number

PITA 3 treated with fertilizers produced significantly ($p \leq 0.05$) most fingers than those without fertilizer T1 (42.67 ± 1.56 fingers). However, FHIA 21 treated with T3 (53.00 ± 2.00 fingers), and CORNE 1 treated with T2 (22.33 ± 0.44 fingers), T3 (19.33 ± 2.44 fingers) and T4 (20.00 ± 2.00 fingers) produced significantly ($p \leq 0.05$) less than 0.33 fingers, 0.67 fingers, 3.67 fingers and 3.00 fingers respectively compared to control T1 (23.00 ± 0.67). PITA 3 treated with T5 (47.17 ± 7.61 fingers) had 3.08 fingers lower than recommended T2 (50.25 ± 4.46 fingers). The others treatments (T3-T6) induced reduction of FHIA 21 regimens fingers compared to T2 when CORNE 1 treated with T3 (19.33 ± 2.44 fingers) and T4 (20.00 ± 2.00 fingers) reduced significantly ($p \leq 0.05$) 3.00 and 1.00 fingers respectively. PITA 3 subjected to fertilizer T6 had the best performance compared to T1 and T2 with 14.08 and 6.50 gains of fingers respectively. FHIA 21 produced the more fingers and CORNE 1 the fewest fingers per regime. The numbers of fingers of PITA 3 and FHIA 21 were 2.43 to 2.86 times greater than those of CORNE 1.

4.3.2. Characteristics of Fruits Plantain

1) Fruits weight

Table 5 shows the effect of fertilizers on plantain fruits characteristics. Except FHIA 21 treated with T4 (163.30 ± 4.12 g) and T5 (169.54 ± 0.70 g), fertilizers

Table 5. Characteristics of plantain fruits.

	PITA 3	FHIA 21	CORNE 1
Weight of fruits (g)			
T1	143.71 ± 3.46 ^{cb}	170.57 ± 2.53 ^{bc^β}	229.78 ± 3.64 ^{ca}
T2	167.51 ± 2.09 ^{bb} (+23.80*)	191.75 ± 4.65 ^{ab} (+21.18*)	296.59 ± 4.50 ^{aa} (+66.81*)
T3	176.09 ± 2.96 ^{ab} (+32.38*, +8.58**)	183.12 ± 5.05 ^{ab^β} (+12.55*, -8.63**)	269.91 ± 4.28 ^{ba} (+40.13*, -26.68**)
T4	172.83 ± 4.77 ^{ab} (+29.12*, +5.32**)	163.30 ± 4.12 ^{cb} (-7.27*, -28.45**)	279.35 ± 6.23 ^{ba} (+49.57*, -17.24**)
T5	146.38 ± 4.46 ^{cb} (+2.67*, -21.13**)	169.54 ± 0.70 ^{bc^β} (-1.03*, -22.21**)	233.55 ± 2.80 ^{ca} (+3.77*, -63.04**)
T6	169.80 ± 2.32 ^{bb} (+26.09*, +2.29**)	173.85 ± 2.83 ^{bc^β} (+3.28*, -17.90**)	240.53 ± 3.19 ^{ca} (+10.75*, -56.06**)
Length of fruits (cm)			
T1	21.33 ± 0.56 ^{ab}	23.40 ± 0.40 ^{c^β}	30.01 ± 0.67 ^{ba}
T2	21.33 ± 0.78 ^{ab} (+0.00*)	26.07 ± 0.62 ^{ab^β} (+2.67*)	33.37 ± 0.31 ^{aa} (+3.36*)
T3	23.07 ± 0.89 ^{ab} (+1.74*, +1.74**)	22.87 ± 0.49 ^{c^β} (-0.53*, -3.20**)	31.17 ± 0.22 ^{ba} (+1.16*, -2.20**)
T4	22.80 ± 1.47 ^{ab} (+1.47*, +1.47**)	25.00 ± 0.01 ^{b^β} (+1.60*, -1.07**)	34.67 ± 1.11 ^{aa} (+4.66*, +1.30**)
T5	21.17 ± 1.44 ^{ab} (-0.16*, -0.16**)	27.30 ± 0.60 ^{ab} (+3.90*, +1.23**)	29.67 ± 0.89 ^{ba} (-0.34*, -3.70**)
T6	23.23 ± 0.56 ^{ab} (+1.90*, +1.90**)	26.47 ± 0.51 ^{ab^β} (+3.07*, +0.40**)	34.87 ± 0.57 ^{aa} (+4.86*, +1.50**)
Circumference of fruits (cm)			
T1	13.33 ± 0.51 ^{aa}	12.77 ± 0.44 ^{ab}	13.86 ± 0.45 ^{aa}
T2	13.53 ± 0.44 ^{ab} (+0.20*)	13.17 ± 0.22 ^{ab} (+0.40*)	14.73 ± 0.31 ^{aa} (+0.87*)
T3	13.87 ± 0.89 ^{aa} (+0.54*, +0.34**)	13.30 ± 0.20 ^{ac} (+0.53*, +0.13**)	14.33 ± 0.56 ^{aa} (+0.47*, -0.40**)
T4	13.53 ± 0.04 ^{ab} (+0.20*, +0.00**)	13.00 ± 0.31 ^{ab} (+0.23*, -0.17**)	14.37 ± 0.04 ^{aa} (+0.53*, -0.36**)
T5	13.23 ± 0.04 ^{ab} (-0.10*, -0.30**)	12.87 ± 0.29 ^{ab} (+0.10*, -0.30**)	13.83 ± 0.22 ^{aa} (-0.03*, -0.90**)
T6	13.53 ± 0.29 ^{ab} (+0.20*, +0.00**)	13.03 ± 0.24 ^{ab} (+0.26*, -0.14**)	14.40 ± 0.21 ^{aa} (+0.53*, -0.33**)

T1. Without fertilizer, T2. 240 kg·ha⁻¹ N and 658 kg·ha⁻¹ K, T3. 120 kg·ha⁻¹ N and 658 kg·ha⁻¹ K, T4. 360 kg·ha⁻¹ N and 658 kg·ha⁻¹ K, T5. 240 kg·ha⁻¹ N and 329 kg·ha⁻¹ K, T6. 240 kg·ha⁻¹ N and 987 kg·ha⁻¹ K. Per parameter, values in column with the same arabic alphabetic letter are not significantly different according to the Student Newmann-Keuls test at $\alpha = 0.05$. Per parameter, values in line with the same greek alphabetic letter are not significantly different according to the Student Newmann-Keuls test at $\alpha = 0.05$. * Tn-T1, ** Tn-T2 with n dose number.

increased fruit weight compared to T1. Only PITA 3 showed an increase of fruits weight compared to T2 (167.51 ± 2.09 g). The weight gains of 8.58 g, 5.32 g and 2.29 g, were observed with T3, T4 and T6 treatments respectively compared to recommend T2. Compared to T1, CORNE 1 recorded the most significant ($p \leq 0.05$) increase in fruits weight. T2 gave significantly highest fruit weight ($p \leq 0.05$) with CORNE 1 (296.59 ± 4.50 g) and FHIA 21 (191.75 ± 4.65 g). PITA 3 reached the highest significant fruits weight with T3 (176.09 ± 2.96 g). The fruits weight of CORNE 1 was significantly ($p \leq 0.05$) higher than those of PITA 3 and FHIA 21 hybrids by 120.50 g and 104.84 g respectively.

2) Fruits length

Reductions in fruits length with T2-T6 treatments compared to T1 control were noted (**Table 5**). With T5 treatment of PITA 3 (21.17 ± 1.44 cm) and CORNE 1 (29.67 ± 0.89 cm), and T3 treatment of FHIA 21 (22.87 ± 0.49 cm) a loss of 0.16 cm, 0.34 cm and 0.53 cm respectively were observed. Compared to T2 (21.33 ± 0.78 cm), PITA 3 subjected to T3 (23.07 ± 0.89 cm), T4 (22.80 ± 1.47 cm) and T6 (23.23 ± 0.56 cm) had significantly ($p \leq 0.05$) superior fruits length with the increase of 1.74 cm, 1.47 cm and 1.90 cm, respectively. Only FHIA 21 treated with T6 (26.57 ± 0.51 cm) and T5 (27.30 ± 0.60) showed a length increase of 0.40 cm and 1.23 cm respectively. CORNE 1 treated T4 (34.67 ± 1.11 cm) and T6 (34.87 ± 0.57 cm) induced an increase of fruits length compared to T2 (33.37 ± 0.31 cm). The greatest increase of fruits length was observed in CORNE 1 and PITA 3 compared to T1 and T2, respectively. CORNE 1 fruits length was significantly ($p \leq 0.05$) greater than those of PITA 3 and FHIA 21. The highest CORNE 1 fruit length obtained with T6 treatment was 8.8 cm and 11.64 cm higher compared to those of FHIA 21 and PITA 3 respectively.

3) Fruits circumference

Except PITA 3 with T5 treatment (13.33 ± 0.51 cm - 13.23 ± 0.04 cm), fruits circumference increased by using fertilizers (**Table 5**). Only fruits of hybrid (PITA 3 and FHIA 21) treated with T3 had greater circumference than those of T2. CORNE 1 subjected to T2 had the best fruits circumference increase compared to T1 (13.86 ± 0.45 cm) where PITA 3 got the highest increase compared to T2. Plantain fruits circumference were closed with high values of 13.87 ± 0.89 cm (T3), 13.30 ± 0.20 cm (T3) and 14.73 ± 0.31 cm (T2) for PITA 3, FHIA 21 and CORNE 1 respectively.

4.4. Classification of Treatments According Plantain Agronomic Parameters

PCA allowed the characterization of treatments on the basis of plantain agronomic parameters (**Figures 2-4**). For PITA 3 (**Figure 2**), F1 and F2 axes contributed to 92.45% of total variation observed. Height and circumference of pseudo-trunk, number of sheets, regimen weight, hands number, fingers number, and fruits weight, length and circumference were negatively correlated to F1 axis with T3, T4 and T6 treatments. PFI and PHI were associated to T1. T3, T4 and

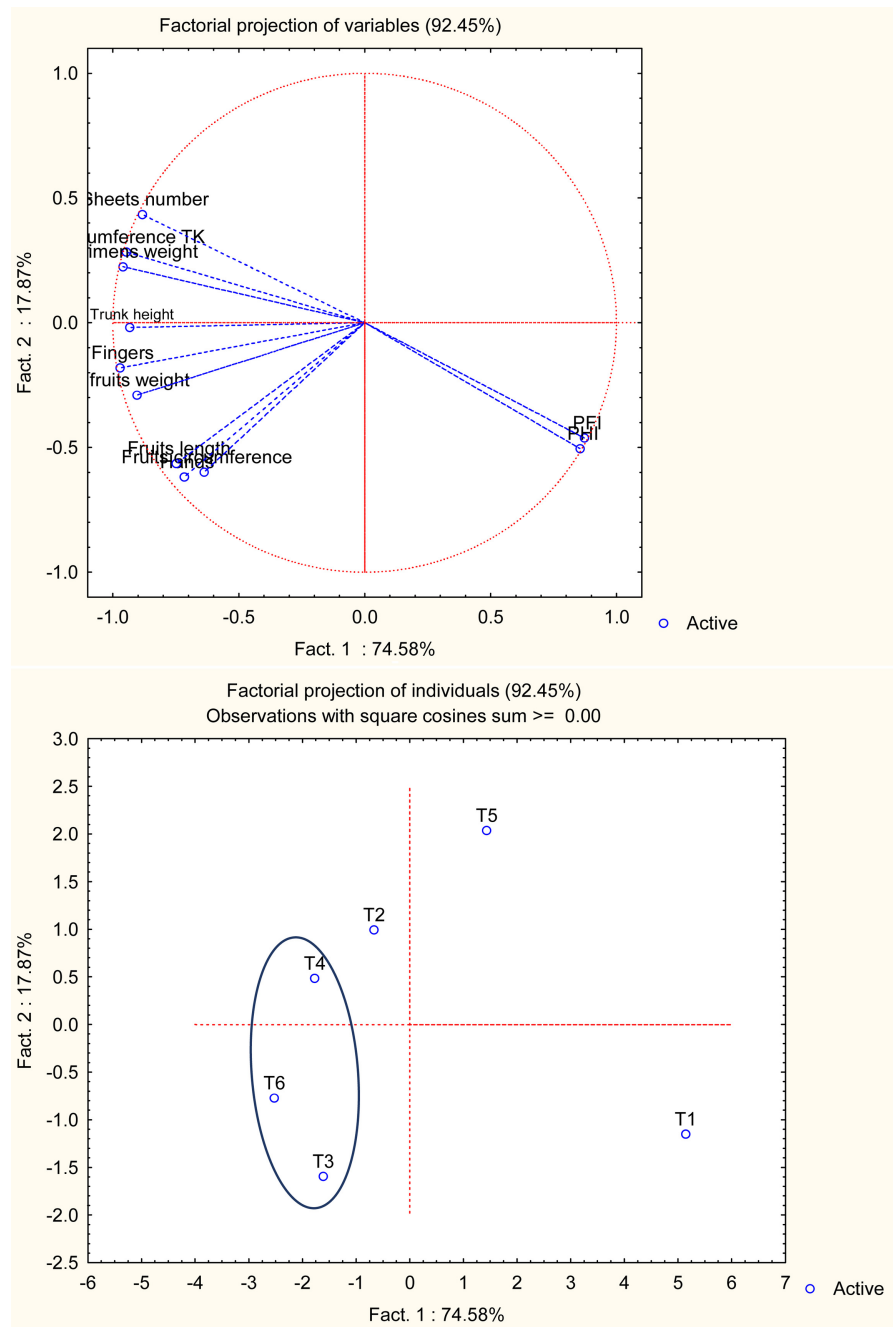


Figure 2. Distribution of treatments and parameters of growth and yield of plants of variety PITA 3 in plan 1 and 2 of the principal component analysis.

T6 fertilizers performed agronomic parameters of PITA 3 plantain.

F1 and F2 axes contributed to 85.67% of total variation observed in FHIA 21. Height and pseudo-trunk circumference, number of sheets, PFI, PHI, regimen weight, fruit weight and circumference were negatively correlated to F1 axis with the T2 and T6 treatments. Regimen hands number, fingers number and fruit length were negatively correlated to F2 axis with T4 and T5. Treatment T1 showed preponderance for PFI and PHI variables. T2 and T6 treatments resulted in a better

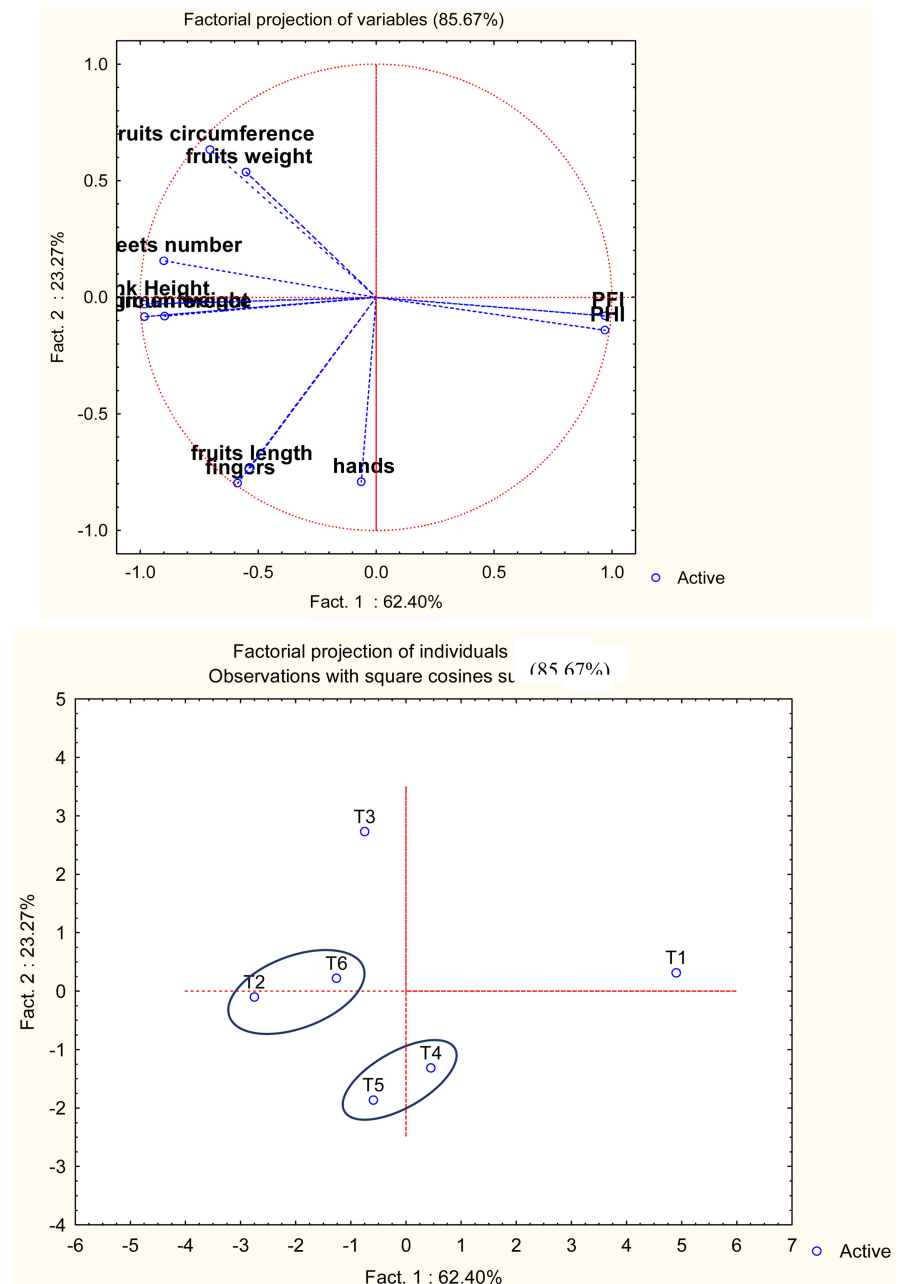


Figure 3. Distribution of treatments and parameters of growth and yield of plants of variety FHIA 21 in plan 1 and 2 of the principal component analysis.

agronomic performance for FHIA 21 (**Figure 3**).

The contribution of F1 and F2 axes was 73.83% of variations observed with CORNE 1 (**Figure 4**). Four groups of variables were observed: pseudotrunk height and circumference, regimen weight, hands number, fruits length and circumference were negatively correlated to F1 axis with T2 and T6 (group 1); sheets and fingers number were positively correlated to F2 axis with T5 (group 2), PFI and PHI were positively correlated to F1 axis with T1 treatment (group 3) and T3 and T4 treatments showed a preponderance for fruit weight (group 4). T2,

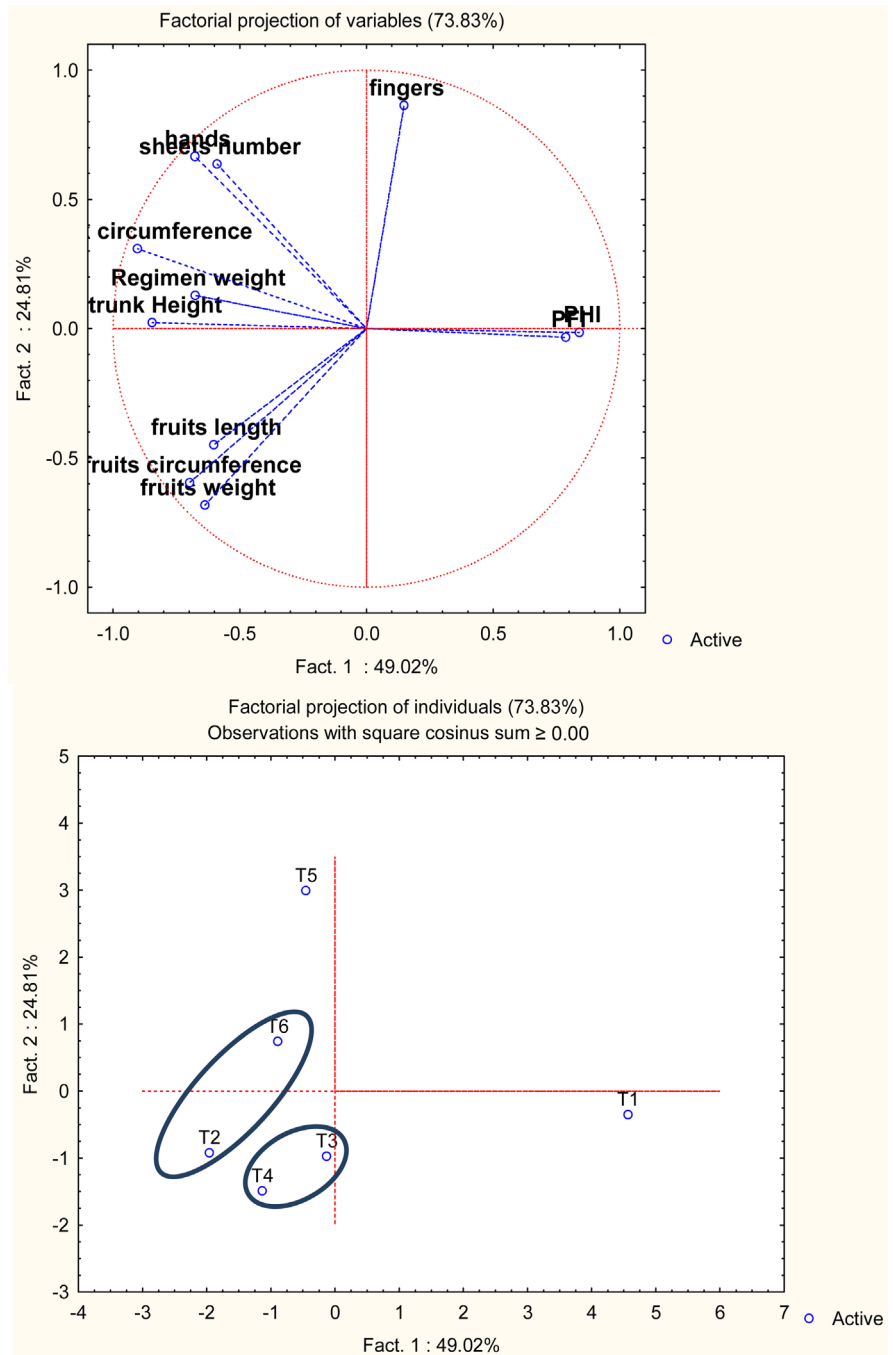


Figure 4. Distribution of treatments and parameters of growth and yield of plants of variety CORNE 1 in plan 1 and 2 of the principal component analysis.

T3, T4 and T6 treatments stood out for positive effect on CORNE 1 agronomic performance.

5. Discussion

Growth is a biological phenomenon of increasing size over time, involving the appearance of new tissues [19] [20]. In general, T1 treatment without fertilizer

induced significantly ($p \leq 0.05$) lower values of growth, development and yield parameters compared to treatments with fertilizer (T2-T6). This lack of improvement in performance indicates the positive effect of fertilizer on plantain growth as highlighted by [21]. When banana was subjected to fertilizers, data showed that PITA 3 performed in growth by an increase of height and circumference with T6 treatment, unlike T5 treatment. T5 and T6 differ by their potassium inputs. So, the growth of PITA 3 would be strongly influenced by the amount of potassium. Potassium has a positive effect on the growth of plantain as mentioned by [22]. However, an amount of nitrogen higher than $120 \text{ kg}\cdot\text{ha}^{-1}$ would be necessary because with T3 treatment (low dose of nitrogen), plantain reduced its enlargement. Nitrogen is involved in the main processes of plant development [14]. It contributes to the vegetative development of all aerial parts of the plant.

For FHIA 21, a strong increase of height, circumference and leaf production was observed with recommended T2 treatment. This impact on those parameters could be due to a positive correlation between growth, enlargement and leaf emission of FHIA 21 banana trees as reported by [23]. Data showed that growth drops when nitrogen input is higher than 240 kg/ha (T4). This could be explained by acidification of the root environment in the presence of high doses of nitrogen [24]. It leads to a reduction in the growth of plants sensitive to acid pH [25]. The FHIA 21 variety is adapted to low amounts of nitrogen and the T2 treatment with the doses of 240 kg/ha N and 658 kg/ha K is optimal for the cultivation of FHIA 21. Increased potassium inputs did not significantly improve plant growth. However, FHIA 21 tolerated the high potassium levels better than the high nitrogen levels. CORNE 1 had high growth for all treatments (T2, T5 and T6) providing $240 \text{ kg}\cdot\text{ha}^{-1}$.

Leaf release was uniform regardless of the rates applied to PITA 3 and FHIA 21. PFI was shorter with T4 (PITA 3), T2 and T6 (FHIA 21) and T2 and T5 (CORNE 1) treatments. Plantain trees are herbaceous plants. The pseudo-trunk is formed by the winding of sheaths into each other. It is at the top of each sheath that the petiole develops, which extends into the central vein supporting the leaf blade to give a leaf. The appearance of the leaves would be a logical continuation in the growth of the tree. Whatever the size of the sheaths, it would be able to produce leaves [26].

Flowering was accelerated by treatments with a nitrogen dose greater than or equal to the recommended nitrogen dose [5]. It would be the consequence of the effect of nitrogen on plant growth. Indeed, the inflorescence is formed at the level of the underground stem and travels throughout the false trunk before appearing in the center of the leaf cluster [27] [28] [29]. That hypothesis was confirmed by the half dose of nitrogen (T3) resulted in a longer PFI duration in CORNE 1.

PITA 3 had a maximum growth in height and circumference with T6 treatment. FHIA 21 reached its maximum with T2 treatment. CORNE 1 grew faster

with T4 and T6 treatments. These data corroborated that varieties differ in their ability to use potassium and the effect of nitrogen and potassium is a function of the plant material grown [13]. PITA 3 subjected to T3, T4 and T6 treatments resulted in larger bunches with higher numbers of hands and fingers. Also, T3 and T4 treatments produced heaviest fruits and shortest crop cycle. The T3 and T4 treatments were $120 \text{ kg}\cdot\text{ha}^{-1}$ (N) and $360 \text{ kg}\cdot\text{ha}^{-1}$ (N) respectively associated to $658 \text{ kg}\cdot\text{ha}^{-1}$ (K). The same effect of these two treatments (nitrogen dose was three times in T4) could be due to nitrogen absorption as a function of the amount of potassium as related by [16]. Thus, the quantity of potassium may increase the efficiency of nitrogen use or have a limiting effect. Higher potassium absorption results in a parallel increase in nitrogen absorption [13] [16]. However, the production cycle (PHI) was 25 days longer with the T3 treatment than those of T4 treatment. That demonstrated easily that nitrogen is involved in the main plant development processes for yield determination as mentioned in literature [14] [30].

Regimens had equivalent weight regardless of treatments applied to FHIA 21. However, the largest fruits were only obtained with T2 treatment followed by those of T3. In this study, T2 and T3 were treatments with a reduced dose of nitrogen. Regimen include the stem, fruit and spine [31] and the ability to induce these different parts depends on treatments [32]. The T2 treatment is the reference treatment and the T3 treatment is the reduced nitrogen dose treatment. These treatments with the T6 have resulted in a shorter production cycle. That shows that FHIA 21 variety grow in the presence of potassium compared to nitrogen, and the dose of $120 \text{ kg}\cdot\text{ha}^{-1}$ of nitrogen seems to be an important amount to stimulate the growth and development of this plant.

In CORNE 1, the heaviest bunches were obtained with T2 and T6 treatments. Only T2 gave heaviest fruits with a shorter production cycle. T6 (high dose of potassium) induced a longer production cycle of 137 days compared to T2. For potassium, by its quantity can have a limiting effect on the plant's use of nitrogen [16]. Especially since the T5 treatment offering half a dose of potassium resulted in a production cycle close to T2 and PHI was 31 days longer than those of T2 treatment. On the other hand, T3 resulted in minimum values for regimen weight, hands and fingers number, and fruit length. Nevertheless fruits under T3 treatment were of high weight. Nitrogen is involved in plant growth and potassium fertilization ensures fruit development in weight and size. Indeed, there is a positive correlation between potassium and fruit weight [15] [33].

The PITA 3 variety had the fastest growth with the shortest production time. In fact, it is a short-cycle hybrid variety [34]. The hybrid varieties PITA 3 and FHIA 21 have given the largest regimes and therefore a better yield. There are high-yielding varieties [35] [36]. The CORNE 1 variety was noted for the quality of its large fruits. It is indeed a product that is highly appreciated for the marketable quality of its fruit. This has led to its high demand by the population on the national, sub-regional and international markets [37] [38].

6. Conclusion

PITA 3 had an improved growth by the treatment with high dose of potassium ($987 \text{ kg}\cdot\text{ha}^{-1}$) with $240 \text{ kg}\cdot\text{ha}^{-1}$. FHIA 21 had optimal growth with the reference treatment T2 with $240 \text{ kg}\cdot\text{ha}^{-1}$ (N) and $658 \text{ kg}\cdot\text{ha}^{-1}$ (K). Increasing the nitrogen dose resulted in a drop in growth. For CORNE 1, growth was maximal in the presence of high doses of nitrogen and potassium. However, the repetition of these tests over 2 or 3 crop cycles in various areas would allow to better appreciate the relevance of this study findings.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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