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Growth and Production Study of Six Plantain (*Musa spp*) Cultivars under the Ecological Conditions of Kindu, Maniema Province, DR Congo

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ABSTRACT

To contribute to a better knowledge of six plantain (*Musa spp*.) cultivars, the most widely grown and collected in five territories of Maniema province, a growth and production study was carried out at the experimental site of Kindu University. Growth and production parameters were evaluated using two well-decomposed organic fertilizers (sawdust and rice husks) compared to the control (no fertilizer). The experiment was conducted in a split plot set up at Lwama 1, in the concession of the University of Kindu. The type of fertiliser was the primary factor with three levels and the cultivar was the secondary factor with six levels, making eighteen treatments each repeated ten times. The observations made during this investigation focused on crown diameter (cm), pseudo-trunk height (m) and leaf area (cm^2) as growth parameters on the one hand, and on the other hand, finger length, number of hands per diet, number of fingers per hand, finger circumference and diet weight as production parameters. The results obtained showed that the growth parameters varied with fertiliser and cultivar. The set of cultivars ranked in descending order as follows: C_6 (Otangala); C_1 (Kyankola); C_5 (Kambelekete); C_4 (Mbonjilo); C_2 (Mbudi 1) and C_3 (Mbudi 2). The analyses of variance carried out on the growth parameters showed that there were very highly significant differences between fertilisers but no significant differences between cultivars. As for the production parameters, they varied between fertilisers and cultivars; sawdust was the best fertiliser for all production parameters studied compared to rice husks and the control. Analyses of variance revealed that there were no significant differences between fertilisers, while there were very highly significant differences between cultivars. Because of their simplicity and low cost, both substrates can be recommended to farmers.

Key words: growth and production study, cultivars, plantain, ecology, Maniema, DR Congo

INTRODUCTION

Bananas play an important role in global food security. It is the fourth most important fruit crop in the world (Lassoudière, 2007). It originates from South Asia and is grown in more than 120 countries around the world (Jones, 2000). World banana production is estimated at 102.687 million tons with 40 million tons for plantain in 2003. It is also an important source of income, employment and export earnings (Foure & Tezenas, 2000).

Worldwide, the banana (dessert and plantain) is the most important fresh fruit, traded internationally. Its socio-economic and nutritional importance is considerable (Dhed'a *et al.*, 2010). From the fruit to the pseudo-stem and the leaves, the banana tree plays a role in food and even in phytotherapy (Rabbani *et al.*, 2001).

In DR Congo, plantain is one of the main self-consumption crops of the population, mainly in Maniema province, where it contributes to improving food security like cassava, rice or maize and palm oil (Mobambo *et al*., 2011).

Most of the research on banana concerns pathologies, varietal improvement and plant description. The growth of the reproductive system has been studied in detail for many years. In the field of modelling, some studies have developed a few models. However, models for the growth of this plant are still rare (Lassoudière, 1978; Anno, 1981).

In a study based on the morphological diversity of plantains in Maniema Province (Kasongo, Kailo, Kibombo and Pangi Territories), Tambwe *et al.* (2019) listed 19 banana cultivars distributed as follows: 4 French type plantains, 3 false horns, 2 true horns, 6 dessert type bananas and 4 cooking plantains Among the plantains, there are six cultivars that are the most appreciated and cultivated by the farmers, these include: Kambelekete (Amakake), Mbudi 1 (Red Ikpolo), Bonjilo (Bosakarakaka 1); Kyankola (Magoma 1); Mbudi 2 (Red Ikpolo); Otangala (Egbe-O-Mabese 1).

Based on this situation, there is a need to deepen the knowledge on these six cultivars by doing an agronomic study by following some growth and production parameters in the ecological conditions of Kindu. This work would, among other things, shed light on the growth and production of these six cultivars and even classify them. This study is based on the fact that since each cultivar has its own genetic heritage that differs from the others, the growth and production parameters are not the same regardless of the cultivation method (fertilised or unfertilised).

MATERIALS AND METHODS

Study Environment

The experiments took place in the concession area of the University of Kindu, more precisely on the experimental site of the Department of Phytotechnics located at Lwama 1, with geographical coordinates (S 02°56' 525°; E 025°53'118 and an altitude of 469 m) in the city of Kindu, Maniema province in the Democratic Republic of Congo.

The concession of Kindu University has a characteristic relief of the central Congolese basin, with a clayey-sandy and sandy-clay soil that allows the practice of all kinds of crops, whether market gardening, food crops or industrial. Located in the equatorial zone, our study area benefits from an equatorial climate: average monthly temperature varies between 22.5 and 29.3°C, with an annual average close to 25°C. As is the case throughout the central forest basin, annual rainfall varies between 1500 - 2000 mm, with an average of 1750 mm (Vandenput, 1981).

Plant Material

The plant material used in this study consists of offshoots of the six most popular plantain cultivars grown and collected in the Kindu region, whose characteristics are presented in Figure 1 below. These include the cutivars: Kyankola (Magoma 1); Mbudi 1 (Red Ikpolo); Mbudi 2 (Red Ikpolo); Otangala (Egbemabese); Kambelekete (Amakake) and Bonjilo (Bosakarakaka 1).

The characteristics and photographic illustrations are as follows:

Figure 1: Different plantain cultivars under study

Methods

Experimental set-up and treatments

The experimental design adopted was the split plot design with replications arranged in elongated plots. Fertiliser type was the primary factor and cultivars the secondary factor. Each cultivar in each fertiliser was repeated ten times. In total eighteen treatments were tested. For each cultivar; 10 plants were planted in each treatment (without fertiliser, under sawdust and under decomposed rice husks) (Figure 2).

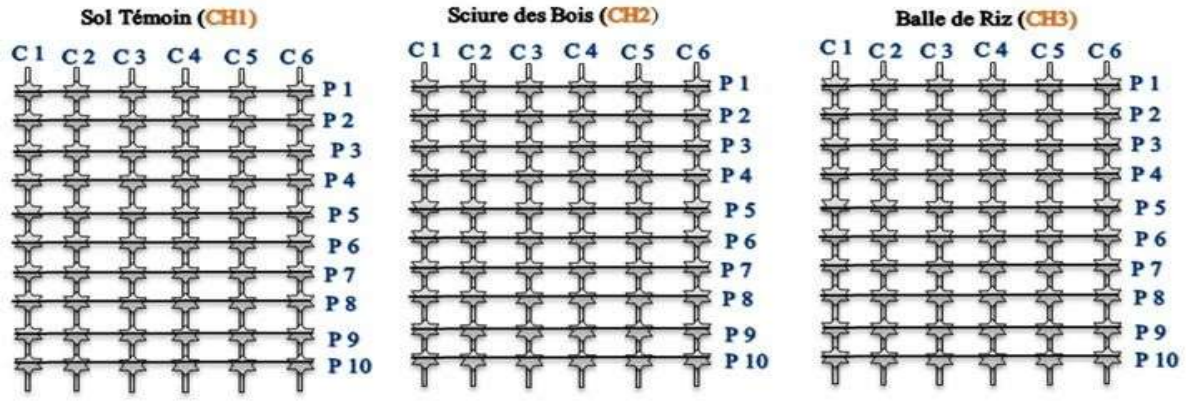

Figure 2. Experimental set-up

Legend: from C_1 to C_6: Cultivar 1 to Cultivar 6; from P_1 to P_{10}: Plant 1 to Plant 10 and from CH_1 to CH_3: Field 1 to Field 3.

Conduct of the test

A collection field of 40 x 60 m was set up within the experimental site of the Department of Plant Science of the University of Kindu, located in the Lwama 1 district. In all, six cultivars most appreciated and cultivated by farmers and consumers were collected. Each cultivar was replicated ten times under each type of fertiliser corresponding to a field, thus making a study of the production growth of six cultivars of plantain (*Musa spp*) under the ecological conditions of Kindu. The spacing adopted was 3 x 3 m. Maintenance consisted of weeding, leaf removal, mulching and staking.

Growth assessment

Observations were made mainly on the following parameters: pseudo-stem length, collar diameter, number of leaves and leaf area (the product of leaf length and width with a correction factor: 0.47). These parameters were taken at harvest. Neck diameter and pseudostem length were measured with a tape measure and caliper respectively. For leaf length and leaf width, we used the second last leaf from the sheath to the top and the largest width with a tape measure.

Production parameters

Harvesting took place at maturity before the fruits started to change colour (turn yellow), when they were full. Production parameters included: finger length, number of hands per bunch, number of fingers per hand, finger circumference and bunch weight. The vegetative cycle was evaluated in terms of the number of days from planting to harvest. The numbers of hands per bunch and fingers per hand were determined by counting. The length of the fingers and the circumference of the fingers were evaluated with a tape measure. Bunch weight was obtained by weighing the bunches immediately after harvest.

Statistical analysis

Means and variances, coefficient of variation and analysis of variance were submitted using R software version 6.4.0 (Cornillon *et al.*, 2008).

PRESENTATION OF THE RESULTS

Growth Parameters

Height of pseudo-trunk

The average pseudo stem height values of the different cultivars under different treatments are presented in Table 1, while the results of the multifactor statistical analyses are within each factor and are reported in Tables 4 and 5.

Table 1. Mean values of pseudo-trunk height (m) under various fertilizers

Cultivars	Witness	Rice husks	Sawdust	Amounts	Averages	Spreads	CV (%)
C_1	3,24	3,16	3,43	9,83	3,24	0,71	21,89
C_2	2,86	2,95	3,12	8,93	2,86	0,81	28,49
C_3	2,79	3,04	3,20	9,03	2,79	0,82	29,56
C_4	2,91	3,16	3,23	9,3	2,91	0,75	25,81
C_5	3,20	3,34	3,64	10,18	3,20	0,61	19,07
C_6	3,34	3,28	3,63	10,25	3,34	0,55	16,36
Amounts	**18,34**	**18,93**	**20,25**				
Averages	**3,06**	**3,15**	**3,37**				
Spreads	**0,73**	**0,69**	**0,74**				
CV (%)	**23,82**	**21,90**	**21,93**				

From Table 1 it can be seen that the height of the pseudo-trunk varied between the different types of fertiliser. Sawdust produced the most vigorous banana plants for all cultivars. Considering the overall averages of pseudo stem height (m) under different fertilisers, it can be seen that these evolve in an increasing manner, respectively 3.06 ± 0.73 m for the control, followed by 3.15 ± 0.69 m under rice husks and 3.37 ± 0.74 m under sawdust.

As for the overall averages in relation to the cultivars for all fertilisers, we note respectively 3.34 ± 0.55 m for C_6; followed by 3.24 ± 0.71 m for C_1; 3.20 ± 0.61 m for C_5; 2.91 ± 0.75 m for C_4; 2.86 ± 0.81 m for C_2 and 2.79 ± 0.82 m for C_3. Comparing the different cultivars, it can be seen that the cultivar C_6 (Otangala) has the longest plants, followed respectively by C_1 (Kyankola); C_5 (Kambelekete); C_4 (Mbonjilo); C_2 (Mbudi 1) and finally C_3

(Mbudi 2). Considering the coefficient of variation as a whole (within fertilisers and cultivars), it can be seen that the data are homogeneous, as the coefficients of variation are all below 30%.

Diameter at the collar

The mean values of crown diameter under different cultivars and fertilisers are shown in Table 2, while the results of the multi-factor statistical analyses are reported in Tables 4 and 5.

Table 2. Diameter at crown (cm) of different cultivars under different fertilisers

Cultivars	Witness	Rice husks	Sawdust	Amounts	Averages	Spreads	CV (%)
C_1	32,90	33,20	44,40	110,50	36,83	17,56	47,67
C_2	36,15	34,55	48,90	119,60	39,87	15,88	39,84
C_3	35,80	35,70	47,20	118,70	39,57	18,00	45,48
C_4	36,70	30,70	41,30	108,70	36,23	15,11	41,69
C_5	35,00	29,00	52,90	116,90	38,97	20,16	51,74
C_6	36,30	34,60	47,10	118,00	39,33	20,07	51,02
Amounts	**212,85**	**197,75**	**281,80**				
Averages	**35,48**	**32,96**	**46,97**				
Spreads	**11,22**	**12,74**	**23,43**				
CV (%)	**31,63**	**38,67**	**49,88**				

From this table it can be seen that the diameter at the crown varied from one type of fertiliser to another. Sawdust gave the most vigorous banana plants for all cultivars. Considering the overall mean neck diameter (cm) under different fertilizers, it can be seen that the latter evolve in a sawtooth pattern, respectively 35.48 ± 11.22 cm for the control, followed by 32.96 ± 12.74 cm under rice husks and 46.97 ± 23.43 cm under sawdust.

As for the general averages for the cultivars for all fertilisers, we note respectively 39.87 ± 15.88 cm for C_2, followed by 39.57 ± 18.00 cm for C_3, 39.33 ± 20.07 cm for C_6, 38.97 ± 20.16 cm for C_5, 36.83 ± 17.56 cm for C_1 and 36.23 ± 15.11 cm for C_4. Comparing the different cultivars, it can be seen that the cultivar C_2 (Mbuli 1) has the most vigorous plants, followed respectively by C_3 (Mbudi 2); C_6 (Otangala); C_5 (Kambelekete); C_1 (Kankola) and finally C_4 (Mbonjilo). Considering the CV as a whole (within fertilisers and cultivars), it can be seen that the data are heterogeneous, as the coefficients of variation are all above 30%.

Leaf area

The average leaf area values under different cultivars and fertilisers are compiled in Table 3, while the results of the multifactorial statistical analyses are reported in Tables 4 and 5.

Table 3. Leaf area (cm^2) of different cultivars under different fertilizers

Cultivars	Witness	Rice husks	Sawdust	Amounts	Averages	Spreads	CV (%)
C_1	55,80	66,07	68,41	190,28	63,43	21,64	34,12
C_2	56,67	58,70	59,14	174,52	58,17	17,21	29,59
C_3	68,10	66,38	72,65	207,14	69,05	17,87	25,88
C_4	64,79	70,40	73,49	208,68	69,56	19,42	27,92
C_5	59,43	63,84	72,63	195,89	65,30	16,26	24,89
C_6	59,05	66,00	73,47	198,52	66,17	24,80	37,48
Amounts	**363,84**	**391,39**	**419,80**				
Averages	**60,64**	**65,23**	**69,97**				
Spreads	**18,68**	**18,38**	**21,54**				
CV (%)	**30,80**	**28,18**	**30,78**				

From this table it can be seen that the leaf area varied according to the type of fertiliser used. Sawdust resulted in banana plants with the most open leaves for all cultivars. Considering the overall leaf area averages (cm^2) under various fertilisers, it can be seen that these evolve in an increasing manner, respectively 60.64 ± 18.68 cm^2 for the control, followed by 65.23 ± 18.38 cm^2 under rice husks and 69.97 ± 21.54 cm^2 under sawdust.

As for the general averages in relation to the cultivars for all the fertilisers, we note respectively 69.56 ± 19.42 cm^2 for C_4, followed by 69.05 ± 17.87 cm^2 for C_3; 66.17 ± 24.80 cm^2 for C_6; 65.30 ± 16.26 cm^2 for C_5; 63.43 ± 21.64 cm^2 for C_1 and 58.17 ± 17.21 cm^2 for C_2. Comparing the different cultivars, it can be seen that the cultivar C_4 (Mbonjilo) has the largest leaf area, followed respectively by C_3 (Mbudi2); C_6 (Otangala); C_5 (Kambelekete); C_1 (Kankola) and finally C_2 (Mbudi 1).

Considering the coefficient of variation as a whole (within fertilisers and cultivars), it can be seen that the data are heterogeneous for the fertilisers for the controls and sawdust on the one hand and C_1 and C_6 for the cultivars on the other, as the coefficients of variation are all higher than 30%, while the data are homogeneous for the rice husk fertiliser and the cultivars (C_2, C_3, C_4 and C_5), as the coefficients of variation are all lower than 30%.

Statistical analysis

The comparison within factors (primary and secondary) for vegetative parameters is shown in Tables 4 and 5.

Table 4. Comparison of the average values of statistical summary of crown diameter, pseudo-trunk height and leaf area within main factor (fertilizer)

Fertilizers	Neck diameter	Pseudo-trunk height	Leaf area
Control (no fertiliser)	35,50^a	3,06^a	60,64^a
Rice husks	33,00^a	3,15^a	65,23^b
Sawdust	47,00^b	3,37^b	69,97^b
p-values	0,00001***	0,048*	0.03549*

From this summary table of the analysis of variance it can be seen that there are very highly significant differences between fertilisers with regard to crown diameter. For pseudo stem height and leaf area the difference is significant.

Table 5. Comparison of average values of crown diameter, pseudo-trunk height and leaf area within secondary factor (cultivars)

Cultivars	Neck diameter	Pseudo-trunk height	Leaf area
C_1	36,83^a	3,24^a	63,43^a
C_2	39,87^a	2,86^a	58,17^a
C_3	39,57^a	2,79^a	69,05^a
C_4	36,23^a	2,91^a	69,56^a
C_5	38,97^a	3,20^a	65,30^a
C_6	39,33^a	3,34^a	66,17^a
p-values	0,9529^{NS}	0,059^{NS}	0.2487^{NS}

The analysis of variance table shows that there are no significant differences between the cultivars with regard to crown diameter, pseudo-trunk height and leaf area.

Production Parameters

The results relating to the production parameters of the different cultivars tested in the experimental site are given in the points below.

Finger length (cm)

The average finger length values under different cultivars and fertilisers are presented in Table 6, while the results of the multi-factor statistical analyses are reported in Tables 11 and 12.

Table 6. Finger length (cm) of different cultivars under different fertilizers

Cultivars	Witness	Rice husks	Sawdust	Amounts	Averages	Spreads	CV (%)
C_1	6,80	6,80	14,30	27,90	9,30	3,90	41,99
C_2	9,10	7,30	9,40	25,80	8,60	1,20	14,52
C_3	7,30	7,20	9,50	24,00	8,00	1,40	17,06
C_4	15,10	15,00	15,10	45,20	15,07	0,60	3,87
C_5	7,70	8,00	8,00	23,70	7,90	0,80	10,69
C_6	9,20	10,10	9,90	29,20	9,73	1,30	12,92
Amounts	**55,20**	**54,40**	**66,20**				
Average	**9,20**	**9,07**	**11,03**				
Deviation	**2,94**	**3,02**	**2,94**				
CV (%)	**32,01**	**33,36**	**26,65**				

From this table it can be seen that finger length varied between the different types of fertiliser. Sawdust gave the longest fingers for all cultivars. Considering the overall averages of finger length (cm) under various fertilisers, it can be seen that these evolve in an increasing manner, respectively 9.20 cm ± 2.94 cm for the control followed by 9.07 cm ± 3.02 cm under rice husks and 11.03 cm ± 2.94 cm under sawdust.

As for the general averages in relation to the cultivars for all the fertilisers, we note respectively 15.07 cm ± 0.60 cm for C_4, followed by 9.73 cm ± 1.30 cm for C_6, 9.30 cm ± 3.90 cm for C_1; 8.60 cm ± 1.20 cm for C_2, 8.00 cm ± 1.40 cm for C_3 and 7.90 cm ±0.80 cm for C_5. Comparing the different cultivars, it can be seen that the cultivar C_4 (Mbongilo) has the longest fingers, followed respectively by C_6 (Otangala); C_1 (Kyankola); C_3 (Mbudi 2) C_2 (Mbudi 1) and finally C_5 (Kambelekete).

Considering the coefficient of variation as a whole (within fertilisers and cultivars), we notice that the data are heterogeneous for the fertilisers concerning the control and rice husks on the one hand and for the cultivar C_1 on the other hand, because the coefficients of variation are all higher than 30%, while the data are homogeneous for the sawdust fertiliser on the one hand and for the cultivars (C_2, C_3, C_4, C_5 and C_6) on the other, because the coefficients of variation are all lower than 30%.

Number of hands per scheme

The average values of number of hands per diet under different cultivars and fertilisers are shown in Table 7, while the results of the multifactor statistical analyses are reported in Tables 11 and 12.

From Table 7 it can be seen that the number of hands per diet varied from one type of fertilizer to another. Sawdust gave the highest number of hands per diet for all cultivars. When considering the overall average number of hands per diet (count) under the various fertilisers, it can be seen that these evolve in an increasing manner, respectively 6.67 ± 5.16 for the control, followed by 6.67 ± 4.84 under rice husks and 7.00 ± 4.86 under sawdust.

Table 7. Number of hands per regime of the different cultivars and under different fertilizers

Cultivars	Witness	Rice husks	Sawdust	Amounts	Averages	Spreads	CV (%)
C_1	6,00	6,00	8,00	20,00	6,67	1,15	17,24
C_2	1,00	1,00	1,00	3,00	1,00	0,00	0,00
C_3	3,00	3,00	3,00	9,00	3,00	0,00	0,00
C_4	16,00	15,00	15,00	46,00	15,33	0,58	3,78
C_5	7,00	7,00	7,00	21,00	7,00	0,00	0,00
C_6	7,00	8,00	8,00	23,00	7,67	0,58	7,56
Amounts	**40,00**	**40,00**	**42,00**				
Averages	**6,67**	**6,67**	**7,00**				
Spreads	**5,16**	**4,84**	**4,86**				
CV (%)	**77,36**	**72,56**	**69,42**				

As for the general averages in relation to the cultivars for all the fertilisers, we note respectively 15.33 ± 0.58 for C_4, followed by 7.67 ± 0.58 for C_6, 700 ± 0.00 for C_5; 6.63 ± 1.15 for C_1, 3.00 ± 0.00 for C_3 and 1.00 ± 0.00 for C_2. Comparing the different cultivars, it can be seen that the cultivar C_4 (Mbonjilo) has the highest number of hands, followed respectively by C_6 (Otangala); C_5 (Kambelekete); C_1 (Kyankola); C_3 (Mbudi 1) and finally C_2 (Mbudi 2). Considering the coefficient of variation as a whole (within fertilisers and cultivars), it can be seen that the data are heterogeneous for the fertilisers, as the coefficients of variation are all higher than 30%**,** while the data for the given cultivars are homogeneous, as the coefficients of variation are all below 30%.

Number of fingers per hand

The average values of the number of fingers per hand under different cultivars and fertilisers are reported in Table 8, while the results of the multi-factor statistical analyses are reported in Tables 11 and 12.

Table 8. Number of fingers per hand of the different cultivars and under different fertilisers

Cultivars	Witness	Rice husks	Sawdust	Amounts	Averages	Spreads	CV (%)
C_1	7,00	7,00	14,00	28,00	9,33	4,04	43,30
C_2	9,00	7,00	9,00	25,00	8,33	1,15	13,80
C_3	7,00	7,00	10,00	24,00	8,00	1,73	21,62
C_4	15,00	15,00	15,00	45,00	15,00	0,00	0,00
C_5	8,00	8,00	8,00	24,00	8,00	0,00	0,00
C_6	9,00	10,00	10,00	29,00	9,67	0,58	5,99
Amounts	55,00	54,00	66,00				
Averages	9,17	9,00	11,00				
Spreads	2,99	3,16	2,83				
CV (%)	32,60	35,11	25,72				

From this table it can be seen that the number of fingers per hand varied between the different types of fertiliser. Sawdust gave the highest number of fingers per hand for all cultivars. Considering the general averages of the number of fingers per hand (count) under

various fertilizers, we note that these evolve in a sawtooth pattern, respectively 9.17 ± 2.99 for the control, followed by 9.00 ± 3.16 under rice husks and 11.00 ± 2.83 under sawdust.

As for the general averages in relation to the cultivars for all fertilisers, we note respectively 15.00 ± 0.00 for C_4, followed by 9.67 ± 0.58 for C_6, 9.33 ± 4.04 for C_1; 8.33 ± 1.15 for C_2, 8.00 ± 1.17 for C_3 and 8.00 ± 0.00 for C_5. Comparing the different cultivars, it can be seen that the cultivar C_4 (Mbonjilo) has the highest number of fingers, followed respectively by C_6 (Otangala); C_1 (Kyankola); C_3 (Mbudi 1) and finally C_2 (Mbudi 2). Considering the coefficient of variation as a whole (within fertilisers and cultivars), it can be seen that the data are heterogeneous for two fertilisers and one cultivar (control and rice husks and the cultivar C_1), as the coefficients of variation are all higher than 30%, while the data are homogeneous for sawdust and the five remaining cultivars, as the coefficients of variation are all lower than 30%.

Finger circumference

The average finger circumference values under different cultivars and fertilisers are presented in Table 9, while the results of the multifactorial statistical analyses are reported in Tables 11 and 12.

Table 9. Finger circumference per hand (cm) of different cultivars and under different fertilizers

Cultivars	Witness	Rice husks	Sawdust	Amounts	Averages	Spreads	CV (%)
C_1	16,30	16,80	17,20	50,30	16,77	0,45	2,68
C_2	16,70	16,80	18,20	51,70	17,23	0,84	4,87
C_3	16,80	17,20	18,80	52,80	17,60	1,06	6,02
C_4	16,00	16,10	16,80	48,90	16,30	0,44	2,69
C_5	12,40	12,40	12,40	37,20	12,40	0,00	0,00
C_6	12,30	13,70	12,80	38,80	12,93	0,71	5,49
Amounts	**90,50**	**93,00**	**96,20**				
Averages	**15,08**	**15,50**	**16,03**				
Spreads	**2,14**	**1,97**	**2,76**				
CV (%)	**14,19**	**12,70**	**17,21**				

From this table it can be seen that the number of finger circumferences varied between the different types of fertiliser. Sawdust gave the highest finger circumference per hand for all cultivars. Considering the overall averages of finger circumference per hand (count) under various fertilisers, it can be seen that these evolve in an increasing manner, respectively 15.08 cm ± 2.14 cm for the control, followed by 15.50 cm ± 1.97 cm under rice husks and 16.03 cm ± 2.76 cm under sawdust.

As for the overall averages in relation to the cultivars for all the fertilisers, we note respectively 17.60 cm ± 1.06 cm for C_3, followed by 17.23 cm ± 0.84 cm for C_2, 16.77 cm ± 0.45 cm for C_1; 16.30 cm ± 0.44 cm for C_4; 12.93 cm ± 0.71 cm for C_6 and 12.40 cm ± 0.00 cm for C_5. Comparing the different cultivars, it can be seen that the cultivar C_3 (Mbudi 2) has the highest finger circumference, followed respectively by C_2 (Mbudi 1); C_1 (Kyankola); C_4 (Mbonjilo); C_6 (Otangala) and finally C_5 (Kambelekete). Considering the coefficient of variation as a whole (within fertilizers and cultivars). It can be seen that the data are homogeneous, as the coefficients of variation are all above 30%.

Diet weight and average yield in tons per hectare

The average values of diet weight and average yield in tons per hectare under different cultivars and fertilisers are shown in Table 10, while the results of the multifactorial statistical analyses are reported in Tables 11 and 12.

Table 10. Diet weight (Kg) of different cultivars under different fertilizers

Cultivars	Witness	Rice husks	Sawdust	Amounts	Averages	Spreads	CV (%)
C_1	13,50	14,20	18,10	45,80	15,27	2,48	16,24
C_2	4,90	5,30	5,91	16,11	5,37	0,51	9,49
C_3	9,20	9,80	7,08	26,08	8,69	1,43	16,45
C_4	41,90	42,10	42,00	126,00	42,00	0,10	0,24
C_5	12,10	12,20	12,10	36,40	12,13	0,06	0,49
C_6	14,70	20,80	17,10	52,60	17,53	3,07	17,51
Amounts	**96,30**	**104,40**	**102,29**				
Averages	**16,05**	**17,40**	**17,05**				
Spreads	**13,14**	**13,14**	**13,20**				
CV (%)	**81,86**	**75,51**	**77,41**				

From this table it can be seen that the diet weight varied between the different types of fertiliser. The rice husks gave the highest diet weight than the control and sawdust for all cultivars. Considering the overall average diet weights (weighing) under the various fertilisers, it can be seen that these evolve in a sawtooth pattern, respectively 16.05 ± 13.14 for the control, followed by 17.40 ± 13.14 under rice husk and 17.05 ± 13.20 under sawdust.

As for the general averages in relation to the cultivars for all the fertilisers, we note respectively 42.00 ± 0.10 for C_4; followed by 17.53 ± 3.07 for C_6; 15.27 ± 2.48 for C_1; 12.13 ± 0.06 for C_5; 8.69 ± 1.43 for C_3 and 5.37 ± 0.51 for C_2. Comparing the different cultivars, it can be seen that the cultivar C_4 (Mbonjilo) has the highest weights, followed respectively by C_6 (Otangala); C_1 (Kyankola); C_5 (Kambelekete); C_3 (Mbudi 2) and finally C_2 (Mbudi 1). Considering the coefficient of variation as a whole (within fertilisers and cultivars). It can be seen that the data are heterogeneous for fertilisers, as the coefficients of variation are all above 30%, while the data are homogeneous for cultivars, as the coefficients of variation are all below 30%.

Statistical analysis

The comparison within factors (primary and secondary) for the production parameters is recorded in Tables 12 and 13.

Table 11. Comparison of average values of number of hands per diet, number of fingers per hand, finger circumference, finger length per hand and diet weight within main factor (fertiliser)

Fertilizers	Finger length	Number of hands per scheme	Number of fingers per hand	Finger circumference	Diet weight
Control (no fertiliser)	$31,30^a$	$6,50^a$	$9,20^a$	$15,10^a$	$16,10^a$
Rice husks	$31,70^a$	$6,50^a$	$9,07^b$	$15,50^a$	$17,40^a$
Sawdust	$33,20^a$	$6,80^a$	$11,03^c$	$16,00^a$	$17,05^a$
p-values	$0,7496^{NS}$	$0,9258^{NS}$	0,0003873***	$0,1016^{NS}$	$0,8221^{NS}$

The analysis of variance table reveals that there are no significant differences between the fertilisers with regard to finger length, number of hands per diet, finger circumference and diet weight, while for the number of fingers per hand, the analysis of variance shows a very highly significant difference.

Table 12. Comparison of average values of number of hands per diet, number of fingers per hand, finger circumference, finger length per hand and diet weight within secondary factor (cultivars)

Cultivars	Finger length	Number of hands per scheme	Number of fingers per hand	Finger circumference	Diet weight
C_1	33,60[a]	6,67	9,33	16,77	15,27
C_2	44,20[b]	1,00	8,33	17,23	5,37
C_3	42,70[c]	3,00	8,00	17,60	8,69
C_4	46,80[d]	15,33	15,00	16,30	42,00
C_5	12,10[e]	7,00	8,00	12,40	12,13
C_6	12,90[f]	7,67	9,67	12,93	17,53
p-values	< 0,000***	< 0,000***	< 0,000***	< 0,000***	< 0,000***

From this analysis of variance table, it can be seen that there are very highly significant differences between cultivars with regard to finger length, number of hands per diet, number of fingers per hand, finger circumference and diet weight.

DISCUSSION OF THE RESULTS

Evaluation of Growth Parameters

The results relating to the growth and production of plantain trees installed in the edaphoclimatic conditions of Kindu were as follows: pseudo-trunk length varied from 3.06 ± 0.73 m to 3.37 ± 0.74 m under sawdust. Neck diameter 32.96 ± 12.74 to 46.97 ± 23.43 cm under sawdust. Diameter at the neck at 10 cm from the ground: the measurements of the diameter at the neck at 10 cm from the ground for the plot with sawdust gave a value equal to 60.64 versus 69.97 cm. These results are much lower than those of Tenezas Du Montcel (1985); respectively plantain grown with fertiliser 78.5 cm while in unfertilised culture we recorded 35.48 ± 11.22 cm. These results are still within the range of those obtained by Lassoudiere (1978), Anno (1981), Dagba (1994), Turquin (1998) and Tixier (2004).

The overall analysis of the results of the diameter growth at the crown in relation to the pseudotrunk circumference shows a difference between the almond plots and the control plot. These differences are identical to those observed for leaf growth. This could explain why the differences between the cultivars are not significant.

For the height of the pseudostems, the height of plantain did not follow the same trends as the leaf area and ranged from 3.06 ± 0.73 m to 3.37 ± 0.74 m. This observation is general to most cultivars (Lassoudière, 1978). The maximum height of plantains obtained in Azaguié with fertiliser was 296 cm compared to 250 cm for the plots without fertiliser. This difference can again be explained by the effect of fertiliser. In the Yamoussoukro plots. The average height of the plantain trees was 326.5 cm in the plots with fertiliser and 318 cm in the plot without fertiliser. These results are much higher than those of Tenesas (1985). These differences with our results are due to the growing conditions and the types of cultivars tested.

The number of leaves evolved positively during the growth of plantain until flowering in all plots. In the plots with fertiliser, the observations showed that the nom amanded plots produced an average of 60.64 leaves compared to 69.97 cm^2 under sawdust and 69.97 ± 21.54 under rice husks. These results could be explained by the fact that the use of fertilizer stimulates the leaf meristem and allows the plantain to complete its crop cycle more quickly in the fertilized plots, unlike the one without fertilizer. Belfakih *et al*. (2013) obtained similar results by evaluating the effect of salinity on the growth of two banana varieties 'grande naine' and

'petite naine' and their mineral nutrition in Morocco. Pittison *et al*. (2006) also obtained similar results in Australia. In Yamoussoukro, the number of leaves observed in the plot without fertiliser was identical to that of the plantation with fertiliser. The rate of leaf emergence for both plots is about one leaf per week and resulted in 35 leaves at flowering. This leaf emission rate is identical to that obtained by Anno (1981) and Texier (2004). These authors found a number of 35 to 45 leaves emitted before flowering. Dagba (1994) obtained a slightly higher number of leaves than these different authors. These differences are due to differences in the environment and cultivars.

Production Parameters

The results relating to the production parameters of the different cultivars tested in the experimental site are shown in the points below. It can be seen that the length of the fingers increases from 9.07 cm ± 3.02 cm under rice husks to 11.03 cm ± 2.94 cm under sawdust and 9.20 cm ± 2.94 cm for the control.

The average finger length values under different cultivars and fertilisers are presented in Table 6, while the results of the analyses are shown in Table 7. With regard to finger/hand length. The cultivar Mbonjilo is the most important cultivar compared to the other cultivars, followed by Mbudi 1, Otangala 1, Kambelekete, and lastly Kyankola. Respectively 9.07 cm ± 3.02 cm under rice husks versus 11.03 cm ± 2.94 cm under sawdust and 9.20 cm ± 2.94 cm for the control.

For the number of hands, the values vary from 1.00±0.00 to 8.50±1.27. The number of fingers/hands varies from 5.50±2.72 to 88.40±5.76. As for the circumference of fingers, it varies from 12.00±1.15 to 18.70±3.59 cm. The diet weight ranged from 7.40±1.17 to 18.60±3.63 kg. These results do not deviate from the mean data found by Ntazongwa *et al.* (2018).

The results related to finger circumference of plantain cultivars obtained in this study ranged from 12.00±1.15 to 18.70±3.59 cm after 164 days. These results are close to the data collected by Turquin (1998), Lassoudière (2007), Ntazongwa *et al.* (2018), where their work summarises that the girth under their study conditions is around 78.5cm at adulthood.

The number of hands per diet averaged 6.67 ± 5.16 for the control, 7.00 ± 4.86 for the sawdust and 6.67 ± 4.84 for the rice husks. According to Tezenas du Montcel (1985), the number of hands varies from 6 to more than 10; also according to Swennen and Vuylsteke, (2001) it is between 1-15 hands per diet. The averages of the number of hands obtained in this experiment fall within the two ranges stated by the authors. There is therefore a lower and an upper limit to the number of hands per diet in plantain.

The number of fingers per hand was 9.00 ± 3.16 under rice husks and 11.00 ± 2.83 under sawdust 9.17 ± 2.99 for the control. Compared to the results of Bangata *et al.* (2022), the average number of fingers per hand is 15, which is higher than the results of our research.

We note that the weight of the diet evolved in a sawtooth pattern, respectively 16.05 ± 13.14 kg for the control against 17.40 ± 13.14 kg under rice husks and 17.05 ± 13.20 kg under sawdust. According to Bangata *et al*. (2022), the average diet weight is 26 which is significantly higher in our experimental study. These differences are due on the one hand to the experimental conditions and on the other hand to the specific genetics of each cultivar tested. The average diet weight for each cultivar is respectively 42kg for C_4 (Mbonjilo); followed by C_6 (Otangala) 17.53kg; C_1 (Kyankola) 15.27kg; C_5 (Kambelekete) 12.13; C_3 (Mbudi 2) 8.69kg and finally, C_2 (Mbudi 1) 5.37kg.

CONCLUSION

To contribute to a better knowledge of six plantain (*Musa spp*.) cultivars, the most widely grown and collected in five territories of Maniema Province, a growth and production study

was carried out at the experimental site of Kindu University. Growth and production parameters were evaluated using two well-decomposed organic fertilizers (sawdust and rice husks) compared to the control (no fertilizer). The experiment was conducted in a split plot set up at Lwama I, in the concession of the University of Kindu, the trial included six cultivars each repeated ten times under each fertilizer. The observations made during this investigation focused on crown diameter (cm), pseudo-trunk height (m) and leaf area (cm^2) as growth parameters on the one hand, and on the other hand, finger length, number of hands per diet, number of fingers per hand, finger circumference and diet weight as production parameters. The results obtained on six cultivars are as follows:

(1) Regarding growth parameters: pseudostem height, crown diameter and leaf area varied between cultivars and according to the fertilisers used; sawdust was the best fertiliser compared to rice husks and the control and cultivar C_4 (Mbonjilo) was the tallest cultivar and the same trend was observed for leaf area. For crown diameter, the cultivar (Mbudi 1) was the highest.

(2) In terms of production parameters, there is variation between fertilisers and cultivars: sawdust was the best fertiliser for all production parameters studied compared to rice husks and the control; the average weight of the diet was greater in the cultivar C_4 (Mbonjilo) compared to the others. These two fertilizers can therefore be recommended to plantain farmers. In addition, they are inexpensive and simple to apply.

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