

Original Research Article

**Fertility management for cassava production in the
Center Region of Cameroon**

ABSTRACT

Cassava is a major food crop in Cameroon that has the capacity to grow under poor soils or drought conditions. But, little is known about the impact of fertilizer application on cassava production on poor ferrallitic soils of Cameroon. The aim of this work was to examine the effect of NPK (Nitrogen, Phosphorus and Potassium) fertilizer and poultry manure treatments on root yield of cassava (*Manihot esculenta* Crantz). The lone variety that was used (96/0326) was grown during the 2016/2017 cropping season in the IRAD (Institute for Agricultural Research for Development) experimental farm at Nkolbisson, characterized by a rhodic ferralsol with very low pH and nutrient availability. Four treatments were applied: No input-Control (T0), 20-10-10 NPK fertilizer use (T1), 12-11-18 NPK fertilizer use (T2), poultry manure application (T3) in completely randomized block design. The data obtained were subjected to analyses of variance (ANOVA) using the IBM SPSS Statistics 20 Software. Level of significance was determined at 5% probability level. Pearson's correlation test was performed at 0.1%, 1% and 5% level of probability. The results showed a significantly ($P < .001$) higher vegetative growth with T3, T2 and T1 treatments compared to the control. In addition, the root yields were significantly higher ($P < .001$) in the fertilizer applied plots than the control. Thus, T3 was 149% > control, T2 65% > control and T1 33% > control. The dry matter contents were similar in control, T1 and T3, while a 10% decrease was observed with T2. Since organic and inorganic fertilizer use enhanced cassava root yield, it appears paramount to apply both inorganic and organic fertilizer to obtain a stable increase in cassava yield under very poor ferrallitic soils.

Keywords: *dry matter, ferralsol, Manihot esculenta, organic and inorganic fertilizer, poultry manure, root yield*

11 1. INTRODUCTION

12 Cassava (*Manihot esculenta* Crantz) is one of the most important food crop in Cameroon. It is grown
 13 in all the five agro-ecological zones of Cameroon [1, 2]. Cassava is reputed to be a soil-nutrient
 14 depleting crop [3]. Furthermore, soils in sub-Saharan African countries have a low level of inherent
 15 fertility [4]. Thus, a minimal amount of nutrient input is required for an acceptable cassava yield [5, 6]
 16 although the crop is known to grow and produce on poor soils. Some authors advocate the correction
 17 of soil nutrient deficiencies through the use of some fertilizer formulations [7, 8]. However, the majority
 18 of cassava farmers neither know of these formulations nor use any other nutrient enhancement
 19 technology for cassava production. Additionally, the use of fertilizer formulations requires proper soil
 20 analysis that only adds to the costs of production of the farmers. A better approach could be to test
 21 the effect of available fertilizers on the local market in order to select the most appropriate for cassava
 22 cultivation. Several works have already been carried out on the fertilization of cassava in Africa [8-12].
 23 However, there is a wide heterogeneity across countries in soil physical and chemical properties, crop
 24 history and farm management. The objective of this work was to evaluate the effect of available
 25 fertilizer types (20-10-10, 12-11-18 and poultry manure) on cassava growth and yield in Center
 26 Region of Cameroon.

27 2. METHODOLOGY

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29 2.1 Experimental site

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31 The experiment was conducted at Nkolbisson, in the Center Region (Mfoundi Division) belonging to
 32 the humid forest agro-ecological zone of Cameroon (N3°51'57"-3°52', E11°27'31"-11°27'36") in April
 33 2016. An average rainfall of 1 700 mm was recorded during the experimental period. The average
 34 daily temperature is estimated at 23-24°C (Source: climatic data service IRAD, 2016). The area is
 35 characterized by a bimodal rainfall pattern, with four seasons: Long rainy season from September to
 36 November, long dry season from December to February, short rainy season from March to June and
 37 short dry season from July to August. The study site was a plain covered with an old fallow,
 38 dominated by *Panicum maximum* and *Chromolaena odorata*. Soil analysis was carried out in the
 39 Analysis Laboratory of Soils, Plants, Fertilizers and Waters of the Institute of Agricultural Research for
 40 Development (IRAD) of Nkolbisson (Cameroon).

41 Composite sample of the top soil (0-15 cm depth) was collected from the experimental site with an
 42 auger before bed preparation following the transect method [13]. About 200 g of the samples were
 43 analyzed for physical and chemical properties in the laboratory. Soil sample was air-dried and ground
 44 to pass through a 2 mm sieve. For carbon (C) and nitrogen (N) analysis, soil was further fine ground
 45 to pass through a 0.5 mm sieve. Soil pH in water, was determined in a 1:2.5 (w/v) soil: water
 46 suspension. Organic C was determined by chromic acid digestion and spectrophotometric analysis
 47 [14]. Total N determined from a wet acid digest and analyzed by colorimetric analysis [15]. P was
 48 extracted using Bray extractant and the resulting extract analyzed using the molybdate blue
 49 procedure [16]. Exchangeable cations (Ca, Mg, K and Na) were extracted using the ammonium
 50 acetate (NH₄OAC, pH: 7) and determined by flame atomic absorption spectrophotometry. Cation
 51 exchange capacity (CEC) was determined using ammonium acetate.

52 **2.2 Plant material**

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54 The plant material used in this study consisted of an improved cassava variety, namely 92/0326. It is
 55 renowned for its resistance to African cassava mosaic disease and bacterial blight; its tolerance to
 56 mealy bugs and bacterial blight. Its average yield is between 30-45 t.ha⁻¹ of fresh cassava root with a
 57 dry matter content of 35-38%.

58 **2.3 Experimental design**

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60 The experimental design spread over an area of 544 m² (of which 448 m² for the test and 96 m² of
 61 border) consisted of two completely randomized blocks, each with 16 experimental units of 14 m². The
 62 treatments consisted of a no-input control and three fertilizer types replicated in four times as follows:

- 63 - Control or without fertilizer (T₀);
- 64 - 20-10-10 NPK fertilizer (T₁);
- 65 - 12-11-18 NPK fertilizer (T₂);
- 66 - Poultry manure (T₃).

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71 2.4 Sowing and amendment

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73 Cassava was planted at the rate of one cutting of 25-30 cm in length per hole following a 1 m x 1 m
74 pattern. The cuttings were planted in such a way that 2/3 of the cutting was below ground and 1/3
75 above ground level with a 45 ° inclination. The poultry manure was applied at 20 tons.ha⁻¹ [7, 12, 17]
76 on experimental plots before the cuttings were planted. The mineral fertilizers [N:P:K] [20:10:10] and
77 [N:P:K] [12:11:18] were applied at 400 kg.ha⁻¹ (40 g/plant) [8, 18] on experimental plots two months
78 after sowing. Manual weeding was done as required. Harvesting was done 12 months after planting.

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80 2.5 Agronomic parameters

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82 The petiole length and the number of leaves were recorded at a month interval, beginning at three
83 months up to six months after planting. The plant height and height to first branching was recorded at
84 a month interval, beginning at three and seven months respectively up to twelve months after
85 planting.

86 At harvest, the cassava yield (t.ha⁻¹) was obtained by evaluating the weight of the tuberous
87 roots on a sampling plot of 10 m² repeated three times per treatment and by relating the average of
88 this weight to a hectare.

89 The dry matter (DM) content was calculated according to the following formula:

$$90 \text{ DM (\%)} = (\text{DMW}/\text{FMW}) * 100$$

91 Where FMW: Fresh Matter Weight; DMW: Dry Matter Weight.

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93 2.6 Data analysis

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95 The data obtained were tested for normality by the Kolmogorov-Smirnov and Shapiro-Wilk tests and
96 the homogeneity of variances by the Levene test. They were treated by analysis of variance (ANOVA)
97 with the IBM SPSS Statistics 20 software using univariate general linear model. Comparison and
98 classification of means was done using Student-Newman-Keuls test at the threshold of 5%. Non-
99 compliant data to the ANOVA assumptions (normality and homogeneity of variance) were analyzed by

the Kruskal-Wallis test and averages were compared by the Mann-Whitney U test at the threshold of 5%. Relationships between the parameters were highlighted by the Pearson correlation test.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Soil analysis

The results of analysis showed that the soil at the experimental sit was acidic, low in organic carbon content, total nitrogen, and poor in exchangeable base (Table 1). The soil type was rhodic compact ferralsol with red color derived from basic rocks with an average organic matter content and available P. The soil was sandy clay. The calcium (1.3 cmol.kg^{-1} of soil) content associated with very low magnesium ($0.26 \text{ cmol.kg}^{-1}$ of soil) and potassium ($0.12 \text{ cmol.kg}^{-1}$ of soil) contents indicated a very poor soil fertility with very low nutrient mobility.

Table 1. Soil characteristics as measured before the beginning of an open field experiment

Sand	Loam	Clay	pH KCl	pH H ₂ O	OM	OrgC	N	P	Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺	CEC
%			-		g.kg ⁻¹			mg.kg ⁻¹	cmol.kg ⁻¹				
39	15	46	4.41	5.75	46.98	27.25	1.71	7.41	1.30	0.26	0.12	0.10	6.07

The values were obtained from ten soil samples randomly taken from the experimental field

3.1.2 Phenology and development

The number of leaves per plant and petiole length under different fertilizers applied showed exponential growth and significant differences ($P < .001$) between treatments (Table 2). Compared to the control, the number of leaves per plant was significantly higher at T3, followed by T2 and T1. The length of the petioles at T3 was significantly greater compared to T2, that of T2 was significantly greater compared to T1, and that of T1 was significantly greater than the control (Table 2).

Table 2. Relationship between number of leaves per plant or petiole length (Y) and time (x in months) up to six months after sowing of cassava on control (without fertilizer), by 20-10-10 NPK fertilizer (T1), 12-11-18 NPK fertilizer (T2), poultry manure (T3)

Parameters	Treatment	Time (months)	Regression equation for plant height (cm)	R^2
Number of leaves	Control	$3 \leq x \leq 6$	$y = 22.29e^{0.37x}$ (***)	0.99
	T1	$3 \leq x \leq 6$	$y = 27.24e^{0.35x}$ (***)	0.95
	T2	$3 \leq x \leq 6$	$y = 27.11e^{0.41x}$ (***)	0.93
	T3	$3 \leq x \leq 6$	$y = 35.85e^{0.50x}$ (***)	0.99
Petiole length (cm)	Control	$3 \leq x \leq 6$	$y = 18.69e^{0.04x}$ (***)	0.93
	T1	$3 \leq x \leq 6$	$y = 20.70e^{0.09x}$ (***)	0.98
	T2	$3 \leq x \leq 6$	$y = 22.33e^{0.05x}$ (***)	0.86
	T3	$3 \leq x \leq 6$	$y = 31.51e^{0.05x}$ (***)	0.97

* $P < .05$, ** $P < .01$, *** $P < .001$. Values used are means from ten plants per experimental plot

The plant height and height to first branching under different fertilizers applied showed exponential growth and significant differences ($P < .001$) between treatments (Table 3). Plant height at T3 was significantly greater with respect to T2, the T2 was significantly greater compared with T1, and the T1 was significantly greater than the control. Compared to the control, height to first branching was significantly higher at T3, followed by T2 and T1 (Table 3).

Table 3. Relationship between plant height or height to first branching (Y) and time (x in months) up to twelve months after sowing of cassava, without fertilizers (control), with 20-10-10 NPK fertilizer (T1), 12-11-18 NPK fertilizer (T2), poultry manure (T3)

Parameters	Treatment	Time (months)	Regression equation for plant height (cm)	R^2
Plant height (m)	Control	$3 \leq x \leq 12$	$y = 39.08x^{0.98}$ (***)	0.98
	T1	$3 \leq x \leq 12$	$y = 52.38x^{0.60}$ (***)	0.99
	T2	$3 \leq x \leq 12$	$y = 57.80x^{0.59}$ (***)	0.99
	T3	$3 \leq x \leq 12$	$y = 96.58x^{0.96}$ (***)	0.97
Height to first branching (m)	Control	$7 \leq x \leq 12$	$y = 36.72x^{0.18}$ (***)	0.91
	T1	$7 \leq x \leq 12$	$y = 41.40x^{0.23}$ (***)	0.95
	T2	$7 \leq x \leq 12$	$y = 39.74x^{0.33}$ (***)	0.95
	T3	$7 \leq x \leq 12$	$y = 110.72x^{0.14}$ (***)	0.95

* $P < .05$, ** $P < .01$, *** $P < .001$. Values used are means from ten plants per experimental plot

3.1.3 Yield and dry matter content

Significant responses to fertilizers were observed for the root dry matter ($P = .01$) and yield ($P < 0.001$) (Table 4). The dry matter contents were similar in control, T1 and T3. However, lowly significant cassava contents ($P = .01$) in dry matter were observed on T2 treatment (with 10% decrease) compared with those grown without fertilization (Table 4). T3 showed the best yield (53.5 t.ha⁻¹) with a rate of increase of 148.8% compared to the control. It is followed by T2 (35.5 t.ha⁻¹) and T1 (28.5 t.ha⁻¹) with rate of increase of 65.1 and 32.6%, respectively.

Table 4. Production of cassava cultivated on ferrallitic soil, without fertilizers (control), with 20-10-10 NPK fertilizer (T1), 12-11-18 NPK fertilizer (T2), poultry manure (T3)

Treatment	Yield (t.ha ⁻¹)	RI Yield	Dry matter (DM) (%)
Control	21.5 ± 11.7 a	0	36.1±0.2 b
T1	28.5 ± 8.5 ab	32.6	37.7±0.6 b
T2	35.5 ± 16.1 b	65.1	32.4±1.6 a
T3	53.5 ± 23.5 c	148.8	35.7±1.0 b
Fertilizers	***	-	**

* $P < .05$, ** $P < .01$, *** $P < .001$. Values with the same small letter for each measured parameter are not significantly different at the .05 probability level. Mean yield ± Standard deviation of means of 10 repetitions. Mean Dry matter ± Standard deviation of mean of four repetitions. RI: Rate of increase

Apart from the dry matter content which was not correlated with any other variable, the other variables studied were strongly correlated with each other (Table 5). Thus, tuber yield was positively and significantly correlated to plant height ($r: 0.6^{***}$), height to first branching ($r: 0.61^{***}$), number of leaves per plant ($r: 0.4^{**}$) and length of petioles ($r: 0.52^{***}$). Plant height was positively and significantly correlated to height to first branching ($r: 0.91^{***}$), number of leaves per plant ($r: 0.69^{***}$), petiole length ($r: 0.85^{***}$) and yield ($r: 0.6^{***}$).

Table 5. Pearson correlation matrix of cassava measured variables

	Yield	Dry Matter	Height 12 MAP	HFB 12 MAP	Leaves number 6 MAP	Petiole lenght 6 MAP
Yield	1					
Dry Matter	-0.173 ^{ns}	1				
Height	0.598 ^{***}	-0.057 ^{ns}	1			
HFB	0.608 ^{***}	-0.034 ^{ns}	0.908 ^{***}	1		
Leaves number	0.351 ^{**}	-0.037 ^{ns}	0.685 ^{***}	0.685 ^{***}	1	
Petiole lenght	0.515 ^{***}	-0.057 ^{ns}	0.845 ^{***}	0.858 ^{***}	0.622 ^{***}	1

ns: not significant; * $P \leq .05$, ** $P \leq .01$, *** $P \leq .001$. HFB: height to first branching, MAP: Month after planting

3.2 Discussion

Fertilization (poultry manure, NPK) significantly improved growth (number of leaves, petiole length, plant height, height to first branching), root dry matter content and cassava root yield. The control plants recorded the lowest number of leaves and the shortest plants (plant height and height to first branching) with and least petiole length. This result is similar to those of several authors [7, 19]. The positive response of growth characters to the applied nutrients is attributable to their role in cell multiplication and photosynthesis which gave rise to increase in size and length of leaves and stems [10]. The positive response of root yield to increased levels of N, P and K could be attributed to high starch synthesis and translocation activities stimulated by application of N, P and K [10]. Cassava is known to respond to organic and inorganic fertilizers application. Several reports showed that the crop is responsive to fertilizer use [20, 21].

The best performance observed in fertilized cassava plants was due to a better plant growth through good photosynthesis and translocation of assimilates to the production and the harmonious development of tuberous roots. N, P and K have been shown to be necessary for cassava root initiation; increase in tuber size and number [5]. The correlation between growth variables and yield could also explain this result.

The best performance was observed in poultry manure (T3). The higher yield of tubers obtained with poultry manure could be attributed to favorable changes in the soil, which would have resulted in loose and friable soil conditions and consequently to better soil aeration and root development. In addition, the positive influence of poultry manure may be due to a slow and constant availability of nutrients throughout the growing period from poultry manure. The increase in cassava root yield could also be attributed to the increase in single root weight per stand [22]. This performance could have resulted in high biomass production due to increase in the N level in the poultry manure [12].

T2 (NPK: 12-11-18) was better compared to T1 (NPK: 20-10-10). T2 has been better compared to T1 because it contains more K and T1 contains more N. Indeed, a high N application stimulates the production of excessive foliage [19] and poor root development by the plants. Furthermore, a high N fertilizer application results in a reduction in root yield [8]. In addition to its role in photosynthesis, K promotes the circulation of the ascending sap in the xylem and descends into the phloem and allows the transfer of assimilates (Sugars, amino acids) to roots and reserve organs (grains, fruits, tubers). According to Adjanohoun [23], cassava plants consume more K than N and P. He noted that the

amount of K extracted by cassava plants is more than twice that of N. The level of P was almost the same for the two chemical fertilizers applied. Phosphorus promotes root development and increase the mass of roots, favoring nutrition and plant growth [24].

The dry matter contents were statistically similar in control (36.1^b), 20-10-10 NPK fertilizer (37.7^b) and poultry manure (35.7^b) treatments. The past work on organic manure and cassava productivity in Côte d'Ivoire showed dry matter contents ranging from 36.1-37.6% [9]. They noted that the dry matter content increased with the supply of fertilizers in certain varieties of cassava, while in other varieties this value was reduced or remained stable with the addition of manure.

During the experiment, we observed that the control plots were more infested by weeds than the fertilized plots. Indeed, significant vegetative growth in fertilized plants quickly led to the formation of a canopy that prevented or inhibited the growth of weeds. This result is similar to those of Fermont et al. [25] who found that with the use of fertilizers, the canopy closes in about three months after planting to suppress weeds. Closure of the canopy also helps reduce runoff, reducing soil erosion.

4. CONCLUSION

Under high soil nutrient status (poultry manure and the both NPK fertilizers applications), appreciable root yields were obtained and the productivity was high. The most appreciable yield was obtained with poultry manure producing 53.5 t.ha⁻¹. This portrays the importance of poultry manure and NPK fertilizer in enhancing cassava root yield in very poor ferrallitic soils. Thus, a combined application of poultry manure and chemical fertilizer appears essential for a stable and sustainable cassava production.

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