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Evaluation of the Agronomic Performance of Okra (*Abelmoschus esculentus*): Selection and Fertilization of the Crop Site

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Okra (*Abelmoschus esculentus* L Moench) is among the most appreciable fruit vegetables in terms of nutritional elements. A study was carried out to determine the suitability of the soil in the locality of Nkoévome (South Cameroon) in order to propose fertilization strategies helping to improve okra yields for sustainable agriculture. The study took place at the Nkoemvone Agricultural Research Institute for Development (IRAD) Station. The plant material used was the Hire variety. The experimental design used is a randomized complete block design with 7 treatments repeated 3 times which are: T0 (no fertilizer application), T1 (275 kg/ha N), T2 (165 kg/ha of NPK 20:10:10 + 150 kg / ha of urea), T3 (10 t / ha of (FP), T4 (5 t / ha of FP), T5 (½ dose of mineral fertilizer (T2) + ½ dose of 10 t /ha FP (T3); T6 (½ dose of mineral fertilizer + ½ dose of 5t/ha FP (T3). The data collected was analyzed using Genstat software. the WRB was of the Rhodic Ferralsols type and unsuitable due to the climate and fertility due to PH, CEC, phosphorus which were low in the soil. The treatments applied had a significant effect on the growth parameters (width, length, number of leaves, branches), and on yields in weight and the number of fruits of the okra but not on the diameter at the collar and the height of said speculation. Thus, the organic fertilizers in this study significantly improved certain growth and yield parameters of okra compared to the different doses of mineral fertilizers and the control.

Keywords: Okra; phosphorus; chicken droppings; mineral fertilizer; soil suitability.

1. INTRODUCTION

The agricultural sector in Cameroon occupies 22.9% of GDP and employs 62% of the active population [1]. It is characterized by a varied range of agricultural products including vegetables in general and okra in particular. Indeed okra (*Abelmoschus esculentus (*L.) Moench) is a plant cultivated in tropical and subtropical regions of the world [2]. It is an exceptional and original plant because all of its root, stem, leaf, fruit and seed parts are used for food, medicinal, artisanal and even industrial purposes [3]. It is among vegetables, a plant providing products with nutritional value even exceeding that of the tomato [4] and [5]. Its high contents of carbohydrates, proteins, vitamins A and C, iron, phosphorus, potassium and magnesium have been demonstrated by [6,7] and [8]. According to [3] the young okra fruits contain mucilage with various dispersion-stabilizing properties, a substitute for blood plasma, and a fluidizer of liquid and blood systems. Fruits are rich in vitamin C and calcium while dried fruits are rather rich in protein and vitamins A, B and C [9]. According to, [10] the okra fruit contains 86% water, 2.2% protein, 10% carbohydrates, 0.2% fatty products. Okra seeds are a source of oil and proteins: In addition, certain prospective and epidemiological studies support that a high consumption of fruits and vegetables would reduce the risk of cardiovascular diseases, certain cancers and other chronic diseases [11]. Roasted okra seeds are used in some parts of Nigeria as a coffee substitute [12]. Its global production amounts to nearly 7.5 million tonnes and more than 69.7% is supplied by the Asian continent and mainly India [13]. In Africa its production is estimated at nearly 2.18 million tonnes and 83% is mainly provided by sub-Saharan Africa [14]. In Cameroon, okra is one of the most consumed vegetables in households, in response to strong national and regional demand [15]. Its production is 2.8 t/ha unlike the ideal yield which is 12-15 t/ha [14]. Okra cultivation in several tropical countries faces multiple constraints that negatively affect its production [16]. According to [17,18,19,20,21], this culture is faced with lack of adequate inputs, qualified labor, poor cultivation practices, decline in soil fertility, problems of climate change, diseases, and by pests [17]. It is important to note that the low production noted above is closely linked to the drop in the level of soil fertility, the most apparent negative effects of which are the reduction in the rate of organic matter associated with the reduction in the quantity of nitrogen. in the soil and the invasion of cultivated land by weeds [22]. However, maintaining soil fertility is essential in order to obtain and maintain high crop yields in the long term [23]. However, increasing yields of okra therefore becomes a great concern given that the demand for its by-products far exceeds the supply [14]. The general observation is that producers launch into production without worrying about a pedoclimatic assessment of their growing plot, making it easier to choose a suitable production site for a given crop and ultimately to carry out a fertilization strategy.

While rigorous knowledge of soil and climate assessment allows for better management of cultivated land; to quantify the degree to which land is suitable for certain uses based on its requirements and characteristics [24]; serves as a reference to prescribe crops adapted to specific soil to optimize agricultural yield per unit of land [25]. In view of these elements and added to the fact that, the fertilization of soils with mineral or organic fertilizers improves the properties of the soil for the potential production of crops since it reduces the loss of nutrients such as nitrogen which is an element unstable in the soil, being lost mainly through leaching, export of crops, volatilization or evaporation [26]. This study was aimed set itself the objective of evaluating the agronomic performance of okra in order to recommend adequate fertilization that could increase yields in the locality of Nkoémvone which is dominated by ferralitic soils.

2 MATERIALS AND METHODS

2.1 Materials

2.1.1 Biophysical characteristic of the study area

The study is being carried out at the IRAD Nkoemvone Research Station created in 1949 in a forest area. This station is located between 11.1o - 12.2° west longitude and between 2.4°-2.8o north latitude at an altitude of 630 m, 15 km from Ebolowa on the Ebolowa – Ambam road in the South Cameroon region [27]. This site is subject to an equatorial climate (the Koppen – Geiger classification), with significant annual precipitation which reaches 1755 mm with an average of 865.8 mm and an average temperature of 24.4 °C [28]. This climate is subdivided into four seasons: A long dry season (December-March), a short dry season (June-August), a long rainy season (September - November), and a short rainy season (April - May).

2.1.2 Hardware

The plant material used is Hire variety okra, which was created on the coast Ivory by the Technisem brand, whose characteristics are as follows: light green color, first harvest 60 to 65 days after sowing (DAS); average size 25 cm; quantity of seeds per hectare equal to 1kg; harvest duration of 1 to 2 months. This variety is one of the most used by farmers in the area.

2.1.2.1 Fertilizers used

The fertilizers used in our trial were organic and mineral fertilizers. As organic fertilizers there was: Chicken droppings purchased at a rate of 500 FCFA per 50 kg bag from breeders in the village of Nkoemvone. The mineral fertilizer used in our test was 20:10 :10 NPK and urea which are the chemical fertilizers most used in the locality of Nkoémvone by okra producers.

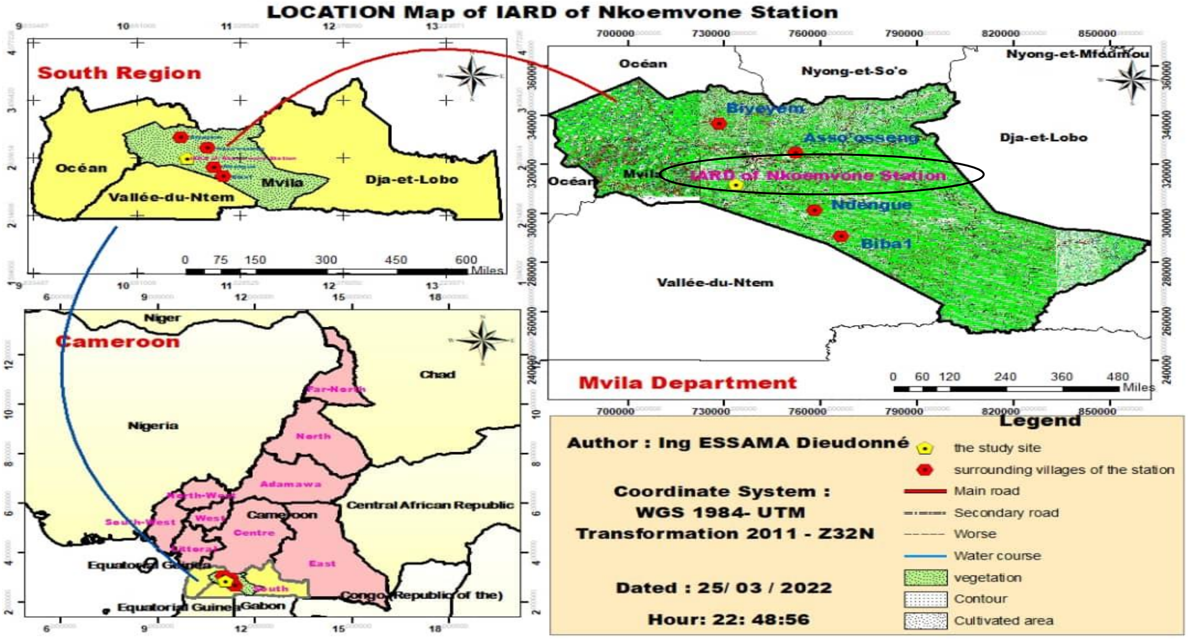

Fig. 1. Location of the study area

Fig. 2. Presentation of Okra Hire seed

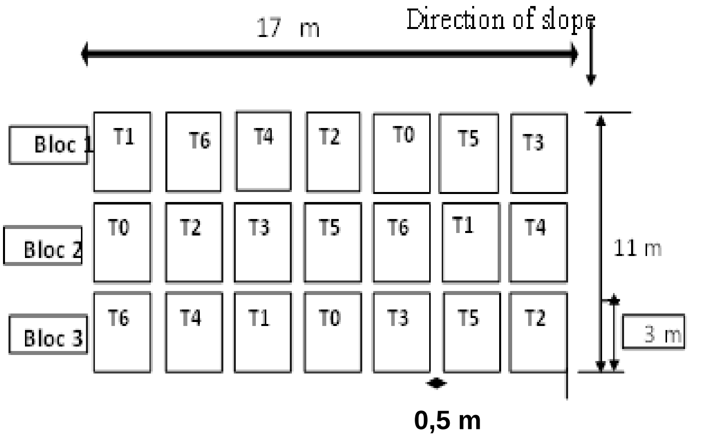

Fig. 3. Diagram of the experimental device

2.2 Method

2.2.1 Experimental device

As part of this study, the experimental design is that of complete randomized blocks with 7 treatments and three repetitions (Fig. 2). The surface area of each experimental unit was 3 m long by 2 m wide, i.e. 6 m^2 with 0.5 m of distance between experimental units and 1 m between blocks. The total area was therefore 187 m^2.

2.2.2 Treatments

Treatments used for mineral fertilizers here are doses recommended by manufacturers. The recommended dose for organic fertilizers in Cameroon is 10 tonnes/ha [29]. For the case of mineral fertilizers, we have two doses: that recommended in Cameroon for okra which is 275kg/ha/Na [30]. Which corresponds to 450 kg/ha NPK 20:10:10 + 400 kg/ha of urea and the dose required for okra in NPK fertilizing elements used by most fertilizers, i.e. 100 kg N, 10 kg P, 60 kg K, 80 kg Ca and 40 kg Mg per hectare [29], which corresponds to 165 kg/ha NPK 20:10:10 + 150 kg/ha of urea. These doses were used to see to what extent to boost okra yields from producers in the locality of Nkoémvone which are alarming. The different treatments are as follows presented in Table 1.

2.2.3 Testing

2.2.3.1 Site preparation

The experimental site was chosen and delimited according to calculations of the total area occupied by the latter in advance. The rest of the operations were the manual clearing of the site, plowing, and the creation of experimental units. Clearing took place on April 20, 2023. The next day, plowing took place. Plowing was carried out to a depth of 25 to 30 cm. The fertilization operation was carried out with the spreading of chicken droppings from 20:10:10 and urea.

Table 1. The different treatments of the experiment

Treatments	Fertilizer
T0	No input
T1	275 kg/ ha / N (450 kg/ ha NPK 20 :10 :10 + 400 kg/ha urea)
T2	165 kg/ha NPK 20 :10 :10 + 150 kg/ha urea
T3	10 tonnes / ha of chicken droppings (FP)
T4	5 tonnes of ha of chicken droppings
T5	½ dose of mineral fertilizer (T2) + ½ dose of 10 t /ha FP (T3)
T6	½ dose of mineral fertilizer + ½ dose of 10 t/ha FP (T3)

Source: Autor 2023

2.2.3.2 Spreading organic fertilizers

The chicken droppings were analyzed at the environmental chemistry laboratory of the University of Dschang at the dose and applied at the recommended dose in Cameroon which is 10 tonnes/ha or 6 kg per incorporated bed and the tested dose of 5 tonnes/ha or 3 kg per incorporated board. The mineral fertilizer NPK (20:10:10) was applied 14 days after sowing (DAS) while the urea was applied at 35 DAS at the doses recommended by the manufacturers. For treatments T1 and T2, these two fertilizers were were applied to provide increasing doses of 100 kgN/ha + 16.5 kgP_2O_5 and 275 kgN/ha + 45 kgP_2O_5. Their application was made in a crown 5cm from the plants.

2.2.3.3 Preparation of seeds and sowing

The seeds were sown manually with a spacing of 80 cm x 60 cm, i.e. a density of 20,833 pockets/ha. The sowing of okra was carried out at 3 seeds per pocket as recommended by local producers through surveys and at a sowing depth of 2 to 5 cm. The plants were demarcated 17 days after sowing (DAS) and each pocket remained with a single, more vigorous plant selected.

2.2.3.4 Maintenance of the plot

The rains not being constant enough, the water supply was done by watering with 3 watering cans titrated at 10 liters per bed according to the watering system carried out by, [31] to make up for the precipitation deficit of rains which were so unstable with a frequency of every 2 days.

2.2.3.5 Phytosanitary treatment

Phytosanitary treatments were carried out preventively using fungicide and insecticide. Among these products we used plantineb (80 EC) at a dose of 2 tablespoons/16-liter spray, cypercot (cypermethrin 100 EC) and K –optimal (aceamiprid 200 g/kg; SP. Phytosanitary treatment It is applied as soon as the first attacks of diseases and damage on the okra leaves are noted (2 weeks after sowing). The treatments took place every week and alternately with an insecticide (k-optimal or cypercot).

2.2.3.6 Fruit harvesting and weighing

Okra fruits were harvested manually when ripe using a pair of scissors. The first harvest occurred at 64 WAS and subsequent harvests every 03 days thereafter [9]. As part of this work, 12 harvests were carried out. Fruits were considered ripe when they were tender and their upper tip was easily broken with a fingertip.

2.2.3.7 Data collection

Two parameters were taken into account, namely: Growth parameters and yield parameters The collection was carried out as indicated in the Table 2.

2.2.3.8 Data collection device

The data were collected from four pockets chosen in the center of each of the experimental units (noted in orange) to minimize the edge effect. The outer seeding line on each side was excluded for each experimental unit in order to delimit our sampling area.

2.2.3.9 Yields

Weight of ripe fruit: Using a digital scale, the cumulative weight of the ripe fruit harvest obtained on the four plants of the effective surface area was measured. The value of the harvest weight of these plants in kilograms per hectare was determined by the following formula:

$$Yield\ by\ weight = \frac{Cumulative\ yield\ of\ four\ plants\ X\ 10.000}{1{,}6}$$

Number of ripe fruits: The number of fruits was obtained by counting the number of fruits for the 4 plants in the effective area. Once this number was obtained, it was reduced to the hectare by the following formula:

$$X = \frac{Number\ of\ fruits\ on\ four\ plants\ x\ 10.000}{1,6}$$

2.3 Taking Soil Samples

Three composite samples from each soil block were taken from the trial in the said plot 0 to 30 cm depth using an auger before spreading fertilizer and 04 others using a ring in the soil profile preserved in polyethylene bags, and then sent to the Laboratory of Soil Analysis and Environmental Chemistry of the University of Dschang for analysis. The following parameters were determined: pH-water, pH-kcl, total carbon, total nitrogen, total phosphorus, assimilable phosphorus and total potassium.

2.4 Laboratory Analysis

2.4.1 Sample preparation

Before measuring the chemical parameters, the soils collected were dried in the shade, weighed, crushed and sieved two (02) times: once at 2 mm and another at 0.5 mm. The underground and aboveground biomass samples were also dried in the shade. Then, they were crushed and sieved directly to 0.5 mm.

2.5 Methods for Chemical Analysis of Soil Samples

2.5.1 Particle size

The grain size consists of determining the different particle size fractions of the soil (sand, clay, silt). It is done using the Robinson Köhn pipette method. The determination of the textural class is done based on the results obtained and using the USDA textural triangle according to [32].

Table 2. Quantitative characteristics used for data collection

Characteristics	Periods	Methods
Plant height (cm) (HT)	3 DAS to 7 WAS	Measured with a ruler
Stem diameter (mm)	3 DAS to 7 WAS	Caliper measurement
Number of branches	3 DAS to 7 WAS	Counting
Length of largest leaf (cm)	Length of largest leaf (cm)	Measurement using a ruler (cm)
Width of largest leaf (cm) 3 WAS to 7 WAS	Width of largest leaf (cm) 3 DAS to 7 WAS	Measurement using a ruler (cm)
Fruit weight (g) (Psd)	At the time of harvest	Weighing with a sensitive scale
Number of fruits per plant (NFr)	At the time of harvest	Counting Measurement
Fruit diameter (cm)	At the time of harvest	Using the calliper

Source: Autor ,2023
WAS = week after sowing

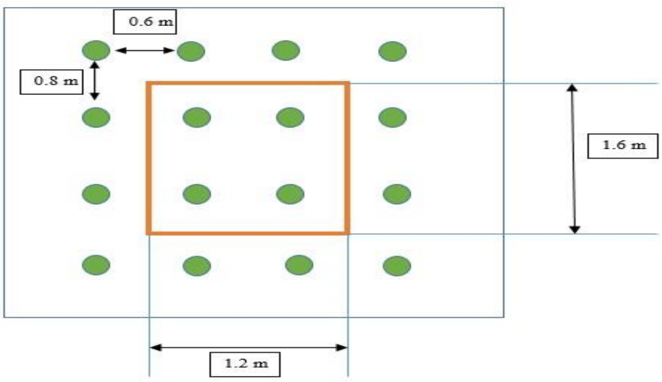

Fig. 4. Data collection device

2.6 Soil Sampling

Three composite samples of each soil block were taken from the trial in the said plot 0 to 30 cm deep using an auger before fertilizer application and 04 others using a ring in the soil profile preserved in polyethylene bags, and then sent to the Soil Analysis and Environmental Chemistry Laboratory of the University of Dschang for analysis. The following parameters were determined: pH-water, pH-kcl, total carbon, total nitrogen, total phosphorus, assimilable phosphorus and total potassium. 2.4 Laboratory analysis

2.7 Preparation of Samples

Before the chemical parameters were measured, the soil samples were dried in the shade, weighed, crushed and sieved twice (02): once at 2 mm and again at 0.5 mm. The above-ground and below-ground biomass samples were also dried in the shade. They were then crushed and sieved directly to 0.5 mm.

2.8 Chemical Analysis Methods for Soil Samples

2.8.1 Granulometry

Granulometry consists of determining the different granulometric fractions of the soil (sands, clays, silts). It is carried out using the Robinson Köhn pipette method. The textural class is determined on the basis of the results obtained and using the USDA textural triangle according to [32].

2.8.2 PH

The pH was measured using a pH meter (potentiometer) fitted with a ‘combined (pH) electrode’, which is an electrode consisting of a combination of a glass electrode and a reference electrode [33]. The actual acidity or pH-water was measured in a sample-water suspension, while the total or potential acidity or pH-KCl 1M was measured in a sample-KCl suspension. Acidity was assessed according to Table 3.

2.8.3 Organic matter

The dosage of organic matter (OM) was carried out from the dosage of organic carbon, knowing that the latter represents on average 58% of organic matter or that %CO x 1.724 = %MO. The method used was that of WALKLEY-BLACK described by [33]. It is based on the oxidation of organic carbon by potassium dichromate ($K_2Cr_2O_7$) in a strongly acidic medium (H_2SO_4). The level and quality of organic matter were assessed according to Tables 3 and 4.

2.8.4 Total nitrogen

The total nitrogen content is determined by the modified Kjeldalh method which takes place in two stages: mineralization of the sample of soil, water, plant or animal tissue hot in a mineralizer in the presence of the sulfuric acid-mixture. salicylic acid, sodium thiosulfate and a catalyst. Then, titration. Finally, dosage by distillation consisting of entrainment of nitrogen vapor in the form of NH3 after alkalization of the mineralized extract with NaOH. Thus, the distillate is captured in boric acid and titrated with 0.01N H_2SO_4 until the indicator returns to the initial color (red). Total nitrogen is assessed according to Table 6.

Acid and titrated with H_2SO_4 0.01N until the initial colour of the indicator (red) returns. The total nitrogen is assessed according to Table 6.

2.8.5 Exchangeable bases

The exchangeable bases Ca++, Mg++, K+ and Na+ were extracted from the soil by saturation with a 1N ammonium acetate (NH_4Ac) solution, determined by complexometry for Ca++ and Mg++; and by flame spectrophotometry for K+ and Na+ [33]. Exchangeable base contents were assessed using Table 7.

Table 3. Assessment of acidity

Level	pH value
Very acidic	<4.0
Acidic	4.0 – 5.3
Moderately acidic	5.3 – 6
Slightly acidic	6 – 7
Moderately alkaline	7– 8.5
Alkaline	>8.5

Source: Beernaert and Bitondo, 1992

Table 4. Assessment of organic matter content

Level	Very low	LOW	Medium	High	Very High
Value MO (%)	< 1.0	1.0- 2.0	2.0 – 4.2	4.2 – 6.0	> 6.0

Source: Beernaert and Bitondo, 1992

Table 5. Assessment of the quality of organic matter

Quality	Very poor	Poor	Good	Very good
Value C/N	>20	14 – 20	10 – 14	< 10

Source: Beernaert and Bitondo, 1992

Table 6. Assessment of total nitrogen

level	Very poor	poor	Medium	high	Very high
Value N(%)	< 0,050	0,050- 0,125	0,125 – 0,225	0,225 – 0,300	> 0,300

Source: Euroconsult, 1989

Table 7. Assessment of exchangeable base content in soil (meq/100g soil)

Level	Ca^{++}	Mg^{++}	K^{+}	Na^{+}
Very high	>20.0	>8.0	>1.2	>2.0
high	10.0 – 20.0	3.0 – 8.0	0.6 – 1.2	0.7 – 2.0
Medium	5.0 – 10.0	1.5 – 3.0	0.3 – 0.6	0.3 – 0.7
poor	2.0 – 5.0	0.5 – 1.5	0.1 – 0.3	0.1 – 0.3
Very poor	<2	<0.5	<0.1	<0.1

Source : Euroconsult, 1989

Table 8. Assessment of S, CEC and V

Level	S (méq/100g soil)	CEC (méq/100g soil)	V (%)
Very poor	<2	<5	0 – 20
poor	2 – 5	5 – 10	21 – 40
Medium	5 – 10	10 – 25	41 – 60
high	10 – 15	25 – 40	61 – 80
Very high	>15	>40	81 – 100

Source: Beernaert and Bitondo, 1992

Table 9. Assessment of assimilable phosphorus content

Level	Very Poor	Poor	Medium	High
Concentration P (ppm)	< 7	< 16	< 46	> 46

Source : Euroconsult, 1989

2.8.6 CEC and base saturation rate

The CEC is determined using a solution of NH_4Ac 1N at pH 7 in 4 steps: saturation of the adsorbent complex with the NH4+ ion and extraction of the exchangeable bases; washing of the soil with alcohol to eliminate the saturating solution; quantitative desorption with K+ and determination of the NH_4+ by Kjeldalh distillation. The saturation rate V is deduced from the sum of the exchangeable bases S and the CEC at pH7 using the formula V(%) = 100*S/CEC. The sum of the exchangeable bases, the CEC and the saturation rate were assessed as shown in Table 8.

2.8.7 Assimilable phosphorus

This is determined by the Bray 2 method, which combines extraction of P in an acid medium with complexation of aluminium bound to phosphorus by ammonium fluoride. The extraction is carried out using 0.03M NH_4F + 0.1 M HCl. After complexation, the assay was carried out by UV spectrophotometry using molybdenum blue, and the reading was taken at 665nm. The assimilable phosphorus content was assessed using Table 9.

2.8.8 Description of the soil profile

The soil profile was developed to dimensions of 2 m width, 2 m length and 1.20 m depth at which the parent rock was reached. This profile was sectioned into four horizons so the soil samples were taken using a 5-liter bucket, a hammer, a machete and the rings were used to take the different density samples of soil of these horizons. The description of these different horizons was done using the Munsell code. The different characteristics of the profile described are as follows. Color, texture, structure, porosity, presence of stones, rooting, biological activity and limit.

2.9 Pedoclimatic Assessment of the Study Area

2.9.1 The climate index

Obtaining the climatic index (CI) was first done by grouping the different climatic characteristics of Okra into two (2) groups, namely: precipitation and temperatures, then this climatic index (CI) was obtained by the square root formula according to [34]: IC= Rmin Rmin $\sqrt{\left[\left(\frac{X}{100}\right) * \left(\frac{Y}{100}\right)\right]}$ Where Rmin is the lowest value of all the groups; X, Y are the other remaining lowest parametric values of the other groups. The parametric value of the climate (VPc) is obtained by converting the IC according to the following relationships:

• If 25 < CI < 92.5 VPc = 16.67+0.9 x CI

• If IC < 25 VPc = 1.6 x IC.

2.9.2 Final earth assessment

The final evaluation is based on the calculation of the Earth Index (IT). Land characteristics include both climatic and pedological characteristics. For each crop, the soil characteristics each receive a parametric value from the FAO requirements tables. The calculation of the IT also uses the formula from [6], IT = Rmin √(X/100 xY/100x).

Where IT = Earth Index, Rmin = lowest parametric value of pedoclimatic groups, and X, Y, = other lower parametric values of other pedoclimatic groups.

The IT value obtained is corrected (ITc) according to the following relationships [34]:

- If IT ≤ 25 ITc = IT
- If 25 < IT ≤ 50 ITc = 25+ (IT- 5) x 0.455
- If 50 < IT ≤ 75 ITc = 50+ (IT- 24) x 0.41
- If 75 < IT ≤ 100 ITc = 75 + (IT- 60) x 0.625

The habit classes are then arbitrarily defined according to the ITC. Table 10 presents the interval of parametric value of the index associated with the degrees of limitation to aptitude classes and optimal performance.

2.10 Data Analysis

The Microsoft Excel version 2016 software was used for data entry and the “GENSTAT 9.2” software was used to analyze the variance at the 5% threshold of the main variables of the test (the growth and yield parameters); therefore, the least significant difference (PPDS) was used for the comparison of treatment means.

Table 10. Interval of parametric values of the index associated with the degrees of limitation, the aptitude classes and the optimal performance

Hint	Degree of limitation	Aptitude Classes	Optimal yield
100-90	0	S1-0 (High Aptitude)	100-90
90-75	1	S1-1 (High Aptitude)	90-75
75-50	2	S2 (Average aptitude)	75-50
50-25	3	S3 (Marginal aptitude)	50-25
25-0	4	N1 (Current incapacity)	25-0
	5	N2 (Permanent incapacity)	

Source : Sys and al [35]

3 RESULTS AND DISCUSSION

3.1 Result

3.1.1 Description and analytical results of the Nkoémvone soil profile

Table 11, presents the physicochemical characteristics of the different horizons of the study site profile.

The description of the profile shows us that it is made up of 4 clearly subdivided horizons (AP, BA, BO 1, BO2), all having a Clayey textural class.

- The AP horizon has a depth of (0 – 20 cm), an acidic PH between (4.0-5.3) very high organic matter > 6.0, an average nitrogen level but of poor quality because C/N >20. The exchangeable bases therefore the calcium Ca 2+ content is low (2.0 – 5.0), the sodium Na + very high (>2.0), the magnesium Mg2+ is average (1.5 – 3.0 meq /100g of soil) and potassium k+ is low.
- The BA horizon between (20 - 47 cm) at an acidic PH (4.0 - 5.3), the organic matter is average between (2.0 - 4.2) of poor quality, a capacity of high cation exchange (CEC) between (25 – 40 meq/100g of soil). The assimilable phosphorus is average, the nitrogen rate low, the exchangeable bases (Ca 2+ low with a value in the range (2.0 – 5.0). Magnesium (Mg++) average; potassium k+ low. The CEC is high and the base saturation low (V (%) with very low assimilable phosphorus.
- The BO1 horizon (47-90) is characterized by a dominance of iron oxide, an acidic PH, average organic matter MO of good quality, a low nitrogen level. Exchangeable bases (Ca 2+ average, magnesium (Mg++) average, potassium (k+) is high, sodium (Na+) very low. CEC is high and assimilable phosphorus is average and base saturation low.
- The BO2 horizon (90 – 130 m) this horizon also has a predominance of iron or aluminum oxides. An acidic PH, an average MO organic matter of poor quality, a low nitrogen level. Exchangeable bases (Ca 2+ average, magnesium (Mg++) average, potassium (k+) is high, sodium (Na+) very low. CEC is high and assimilable phosphorus is average. Organic matter (OM) low but of good quality, a high CEC, a low nitrogen rate and a very low phosphorus rate.

3.1.2 Physico-chemical characteristics of the soil and the amendment

Table 12 shows the results of the analyzes of the physico-chemical characteristics of the amendment and the study soil which is located below. Painting.

Table 11. Physicochemical characteristics of the different horizons of the profile of study

Code sample	**AP**	**BA**	**BO1**	**BO2**
Depth (Cm)	**0 – 20 cm**	**20 - 47**	**47 - 90**	**90 - 130**
Laboratory code	**4**	**5**	**6**	**7**
Texture (%)				
Clay	80	85	90	85
Silt	10	11	8	11
Sand	10	4	2	4
Textural class	A	A	A	A
DA g/Cm3	0.868	1.350	1.418	1.608
Soil reaction				
C E (mS / cm)	0.02	0.04	0.05	0.01
pH-water	5	4.3	4.2	4.5
pH-KCl	3.9	3.7	3.6	3.9
Δ pH	-1.1	-0.6	-0.6	-0.6
Organic matter				
CO (%)	3.61	1.41	1.10	1.10
OM (%)	6.22	2.43	1.89	1.89
N tot. (%)	0.15	0.09	0.10	XS0.10
C/N	25	16	11	12
Exchangeable cations (meq / 100g)				

Code sample	**AP**	**BA**	**BO1**	**BO2**
Depth (Cm)	**0 – 20 cm**	**20 - 47**	**47 - 90**	**90 - 130**
Calcium	4.00	3.00	5.04	5.20
Magnesium	2.40	2.80	2.16	2.00
Potassium	0.21	0.11	0.11	0.11
Sodium	0.11	0.11	0.05	0.05
Sum of bases	5.92	5.63	8.00	7.52
fCationic Exchange Capacity (meq / 100g) CEC pH7	28.00	27.00	25.00	28.00
	0.41	0.42	0.18	0.16
ESP(meq/100g)	21.14	20.84	31.99	26.85
Saturation (%)				
Assimilable phosphorus	16.24	3.51	4.12	6.46

Source: Soil and Environment Laboratory, FASA, Uds, June 2023

Table 12. Physico-chemical characteristics of the soil and the amendment

Physico-chemical characteristics of the soil	**Amendments**	**Soil**			**Moyenne des blocs**
	Chicken droppings	**B3**	**B2**	**B1**	
Sample code	1	3	4	5	
Depth (Cm)	/	0 -30	0 -30	0 -30	
Clay	/	85	86	81	**84**
Silt	/	5	5	11	**7**
Sand	/	10	9	8	**9**
Textural class	/	Clay	Clay	Clay	
DA g/Cm3	/	/	/	/	
Soil reaction					
C E (mS / cm)	/	0.76	0.32	0.16	**0.413**
pH-water	8.2	5.1	4.4	4.4	**4.633**
pH-KCl		3.9	3.7	3.7	**3.77**
Δ pH		-1.2	-0.7	-0.7	**-0.87**
Organic matter					
CO (%)	33	3.61	3.48	4.24	**3.78**
OM (%)	66	6.22	6	7.3	**6.51**
Total N (%)	3.91	0.13	0.13	0.22	**0.16**
C/N	8	27	27	20	**24.67**
Exchangeable cations (meq / 100g)					
Calcium	3840	5.4	4.4	5.2	**5.00**
Magnesium	218.7	2	2.8	1.6	**2.13**
Potassium	1370.13	0.32	0.21	0.32	**0.28**
Sodium	1113.59	0.33	0.21	0.21	**0.25**
Sum of bases		6.06	6.81	8.53	**7.13**
CEC pH7		25	26	26	**25.67**
ESP(meq/100g)		1.33	0.81	0.81	**0.98**
Saturation (%)		24.23	26.21	32.82	**27.75**
Assimilable phosphorus Bray II (mg /Kg)	6626.56	14.29	18.27	15.29	**15.95**
Ash content (%)	34	/	/	/	/
Moisture content (%)	20	/	/	/	/

Source: Soil and Environment Laboratory, FASA, Uds, June 2023

N.B: Ca2+, Mg2+, Na+, K+, and soluble phosphorus are expressed in mg/kg for chicken droppings and rabbit droppings

3.1.2.1 Physico-chemical characteristics of the soil

It appears from Table 12 that the soil analyzed has a clayey texture on the surface. Its pH-water is acidic, the ΔpH values (pH-KCl - pH-H2O) are all negative indicating that the soil has a net predominance of negative charges, giving them a good cation exchange capacity. The level of organic matter is very high (OM > 6.0). The nitrogen content is average (0.125 <N<0.225%). The C/N ratio is very poor (C/N>20%), potentially reflecting a fairly slow mineralization of organic matter by microorganisms in the soil. The level of assimilable phosphorus is low (between 7 and 16 mg/kg). Thus, a contribution of the element phosphorus either in the organic form or in the mineral form would be a prerequisite for significantly increasing the yields of okra. The exchangeable cations K+ and Na+ have a low level [32]. The CEC (meq/100g) is moderate (25 < CEC < 40 meq/100g), the base saturation rate is low (21 < V<40%).

3.1.2.2 Chicken droppings

The chicken droppings used have a moderately alkaline pH (between 7.0-8.5); its application to the soil would significantly raise the pH of the latter, making it even more favorable to the availability of plant nutrients. The level of organic matter is high (>6%) and in exchangeable bases [32], and of very good quality (10 < C/N < 14). This would help to increase the effectiveness of the clay-humic complex in retaining nutrients and water. The nitrogen level is very high (>0.3). Thus, the droppings applied to the ground could possibly alleviate some of the chemical deficiencies present, and moreover it was added a week before sowing the okra.

3.1.3 Evaluation of the study site for okra cultivation

3.1.3.1 Final pedoclimatic assessment of okra

Table 13 presents the results of the final pedoclimatic evaluation of the study site for the cultivation of okra based on the climatic requirements of that of cotton. According to the parametric method using the formula of [34], the pedoclimatic evaluation of the study site in Nkoémvone shows us that the land used for okra production was currently unsuitable (N1cf) due to climatic and fertility (basic saturation rate). This limitation is very severe, not recommended.

Table 13. Final soil and climate assessment for okra.

Final soil assessment for okra				
	values	**classes**	**limitations**	**parametric values**
Slope	1%	S1-0	0	99
Flooding	F0	S1-0	0	100
Drainage	good	S1-0	0	100
Texture	Clay (Co)	S1-0	0	100
Coarse fragments	0	S1-0	0	100
Depth of soil	120 cm	S1-0	0	100
CaCO3	0	S1-0	0	100
Gypsum	0	S1-0	0	100
Apparent CEC clay	7.1	S3	3	60
Base saturation	50.7	S1- 1	1	85
CO	4.2	S1-0	0	100
PH	5.2	N2	4	25*
Electrical conductivity	0.12	S1-0	0	100
ESP	2.85	S1-0	0	99
Rainfed climate				19
	IT= 6,72			
	IT=7	N2 c,f		
Semi-irrigated climate				71
	IT= 14,89			
	ITC= 15	N2 c,f		

** = Lowest values of each climatic characteristic to be used in the calculation of the climatic index*
NB: The pedoclimatic requirements used are those of cotton (Gossypium hirsutum) belonging to the Malvacae family in the appendix

3.2 Effects of Different Treatments on Okra Growth Parameters

3.2.1 Effects of treatments on okra leaf width

The analysis of variance of the data collected in Table 14 shows that the treatments applied had significant effects (P≤0.05) on the width of the leaves during the different data collection periods. The separation of means shows that T3 was the best compared to all other treatments with the width of, 21.33 cm, 25.33 cm and 31.75 cm at 3.5.7 WAS (week after sowing). This counterpart T0 had the smallest value on the leaf width respectively 7.67cm, 14, 67cm and 19 cm).

3.2.2 Effects of treatments on leaf length

The analysis of variances of the data collected in Table 14 shows that the different treatments applied produced highly significant values (P=0.01) during data collection. The separation of the means using the Duncan method shows a variation in the values of the different fertilizers along the length of the leaves depending on the different data taken. At the third week the largest values are recorded in treatments T4, T5 (15 cm and 14 cm). At the second week the largest values are recorded in treatments T5, T3, T4 (18.33 cm; 16.67 cm and 15.33 cm) at 7 weeks we have T5 and T3 respectively (21.25 cm, 21.10 cm).

3.2.3 Effects of treatments on leaf number

The analysis of variance of the data collected in Table 14 shows that different treatments applied produced significant values (P≤0.05) during the different data collections at week 7 W.A.S (week after sowing). The separation of the means shows that treatment T4 was better respectively 19.92 cm and T0 (10.67 cm) was the treatment having the least effect on the number of leaves.

3.2.4 Effects of treatments on neck diameter (mm)

It appears from Table 14 of the analysis of variance that the different treatments produced non-significant values (P > 0.05) during the different data collection sessions on the collar diameter parameter during all three weeks 3 W.A.S, 5 W.A.S and 7W.A.S (week after sowing)

3.2.5 Effects of treatments on plant height

Table 14 presents the effects of the treatments on the height of okra plants over the three weeks after data collection. Analysis of variance indicates that the different treatments produced non-significant values (P > 0.05) on plant height during the three weeks 3 W.A.S, 5 W.A.S and 7W.A.S (week after sowing).

3.2.6 Effects of treatments on the number of branches

It appears from Table 14 of the analysis of variance that the different treatments produced significant values (P≤0.05) over the three weeks 3W.A.S, 5 W.A.S and 7W.A.S (week after sowing) of data collection. The separation of the means by the Duncan method shows that the different treatments produced values (P≤0.05) over all weeks. However, we observe the greatest average of branches on the T3 treatment, respectively an average of 6 at 3 W.A.S, 7.33 at 5 W.A.S and 9.33 at 7 W.A.S (week after sowing).

3.3 Effects of Different Treatments on Yield Parameters

3.3.1 Fruit weight

The analysis of variance made it possible to highlight the different treatments which had a significant effect (P≤0.05) on the fresh weight of the fruits after harvest. Fig. 5 presents the histograms and the cumulative yield curve of the evolution of fruit production according to harvests. We therefore note that the bars of the histograms of the T3 treatment are the highest in all the harvests combined during our study. Which illustrates that T3 is the best treatment while the weakest treatment is T0 with the lowest histogram bars. The weight yields obtained with the T3 treatment gradually increased from 362 kg/ha at 64 DAS to reach 4175Kg/ha at 88 DAS, then decreased to 2125 kg/ha at the last harvest. While the yields of T0 increased gradually from 125 kg/ha at 64 DAS to reach 233kg/ha at the last harvest. When we observe this Fig. 5, we notice a predominance of the yellow color on the histograms corresponding to the 7th and 8th harvest, i.e. 88 DAS.

At the level of the cumulative yield curve, we notice that the best treatments are T3 (13141kg/ha); T5 (12676kg/ha); T4 (11532kg/ha); T6 (11055 kg/ha) and those with low yields are T0 (2513kg/ha); T1 (4996 kg/ha) and T2 (6973kg/ha). Separating the average of the different treatments on the yield made it possible to obtain Fig. 6.

Table 14. Separations of averages in relation to their effect on okra growth parameters

Treatments	Input	Sheet width			Sheet length			Numbers of sheets		
		3 WAS	5 WAS	7 WAS	3 WAS	5 WAS	7 WAS	3 WAS	5 WAS	7 WAS
T0	No input	7.67a	14.67a	19a	6a	8.33a	12.67a	5a	7.33a	10.67a
T1	275 N kg/ ha	11.33ab	16.33ab	21.90ab	7a	9.67ab	14.67a	10.33a	11.67a	15.92ab
T2	165 kg /ha NPK 20 :10 :10 + 150 kg / ha of urea	13.33bc	18.00abc	24.63abc	7a	10.67b	15.39bc	10a	14.33a	17.58b
T3	10 t / ha de (FP)	21.33d	25.33d	31.75d	11.67bc	16.67f	21.10c	13a	14a	19.00b
T4	5 t of FP	18.00cd	21.00bcd	27.35bcd	11.67bc	15.33def	19.98c	13.67a	15.33a	19.92e
T5	½ (T2) + ½10 t /ha FP (T3);	19.67d	22.67cd	30.19cd	15cd	15.67def	19.69c	11.33a	13.33a	17.83b
T6	½ dose T2+ ½ 5t/ha FP (T3) ;	17.33cd	22.33cd	27.64bcd	11b	14.33cde	18.21bc	9a	11a	14.07ab
		**	*	*	**	**	**	ns	ns	*

Treatments	input	Diameter of collar			Height of plant			Number of branchers		
		3 WAS	5 WAS	7 WAS	3 WAS	5 WAS	7 WAS	3 WAS	5 WAS	7 WAS
T0	No input	6.00**a**	7.33**a**	11.17**a**	14.00**a**	17.67**a**	23.11**a**	3.00**a**	4.00**a**	6.42**a**
T1	275 N kg/ ha	6.00**a**	7.33**a**	11.17**a**	15.00**a**	18.00**a**	23.09a	3.33**a**	4.33**ab**	6.33**a**
T2	165 kg /ha NPK 20:10:10 + 150 kg / ha of urea;	4.67**a**	6.67**a**	10.18**a**	17.67**a**	20.33**a**	24.92**a**	6.00**c**	7.67**c**	9.08**a**
T3	10 t / ha of (FP) ;	6.00**a**	7.33**a**	9.08**a**	21.33**a**	24.33**a**	30.21**a**	6.00**c**	7.3**3c**	9.33**a**
T4	5 t of FP	8.00**a**	9.67**a**	12.32**a**	22.00**a**	25.67**a**	30.92**a**	5**ac**	6**bc**	8**ab**
T5	½ (T2) + ½10 t /ha FP (T3);	9.67**a**	11.33**a**	14.49**a**	24.33**a**	28.00**a**	33.85**a**	6**c**	7**c**	9a
T6	½ dose T2+ ½ 5t/ha FP (T3) ;	8.33**a**	10.33**a**	13.24**a**	18.00**a**	21.00**a**	26.04**a**	5**ac**	6**abc**	7**ab**
		ns	**ns**	**ns**	**Ns**	**ns**	**ns**	*	**ns**	*

*NB : Values bearing the same letters in a column are statistically equal; ns: not significant at 5%; **: highly significant at 5%; * significant at 5%.*
WAS = Week after sowing

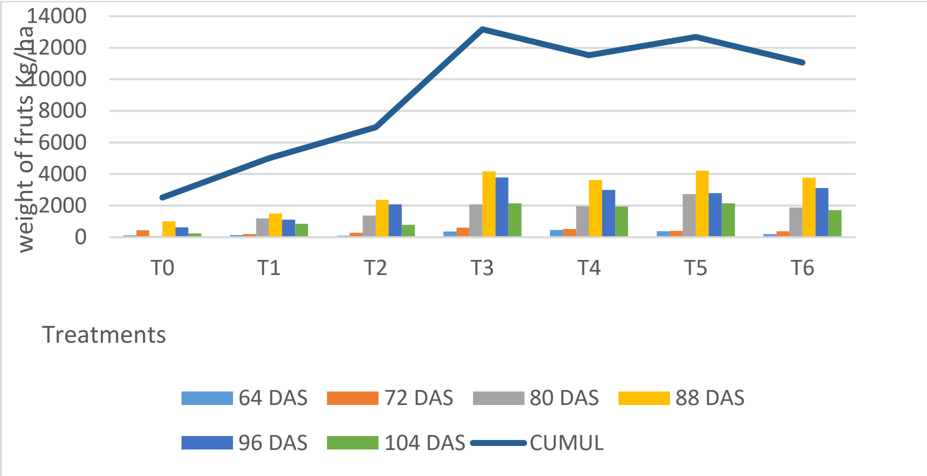

Fig.5. Response of fruit weight yields following harvests

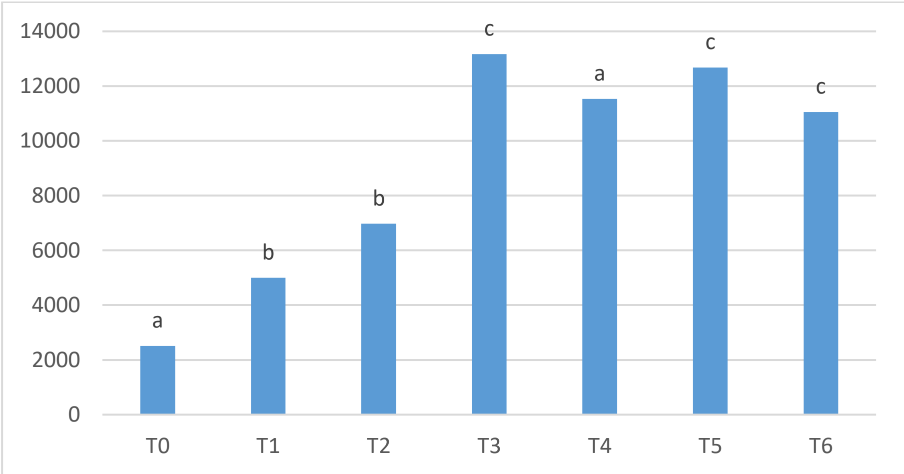

Fig. 6. Separation of average fruit weights

NB: Treatments with the same letter are statistically equal and those which are not followed by the same letter are significantly different at the 5% probability threshold (P≤0.05) according to the Duncan test

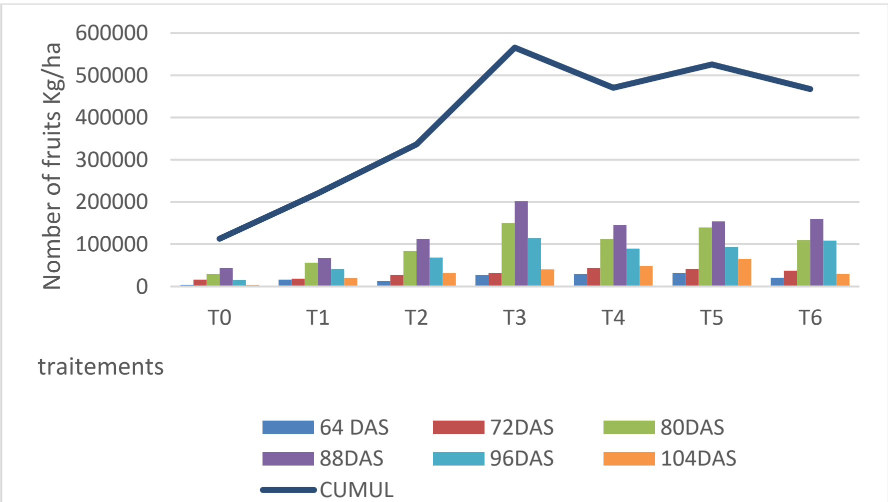

Fig. 7. Response of yields in number of fruits following harvests (number of fruits/ha)

3.3.2 Number of fruits

Fig. 7 shows the evolution curve of fruit production following the 12 harvests. Indeed, for the variable number of fruits harvested, a highly significant difference (P≤0.01) was observed at the end of the twelve harvests, the treatment having had the greatest number of fruits as illustrated by the cumulative yield curve is T3 with 565416 fruits and the T0 treatment has the lowest number of fruits, i.e. 113084 fruits. However, the greatest number of fruits is obtained on 88 DAS which corresponds to the 7th and 8th harvest.

The separation of the means (Fig. 8) allows us to indicate the best treatments in terms of number of fruits which are T3 (565416 fruits/ha); T5 (525834 fruits/ha); T4 (470,000 fruits/ha); T6 (467083 fruits/ha) and the lowest are T0 (113084 fruits/ha); T1 (220335 fruits/ha); T2 (336249 fruits/ha).

3.3.3 Fruit diameter

Fig. 9 below represents the evolution of the diameter according to the different harvests. It appears that no significant difference (P > 0.05) was observed between the effect of the different treatments during the twelve harvests. The results showed that T4 obtained the largest average fruit diameter of (1.68 cm), followed by T6 with an average of 1.59 cm while T0 had the lowest average, with a value of 0 .97cm

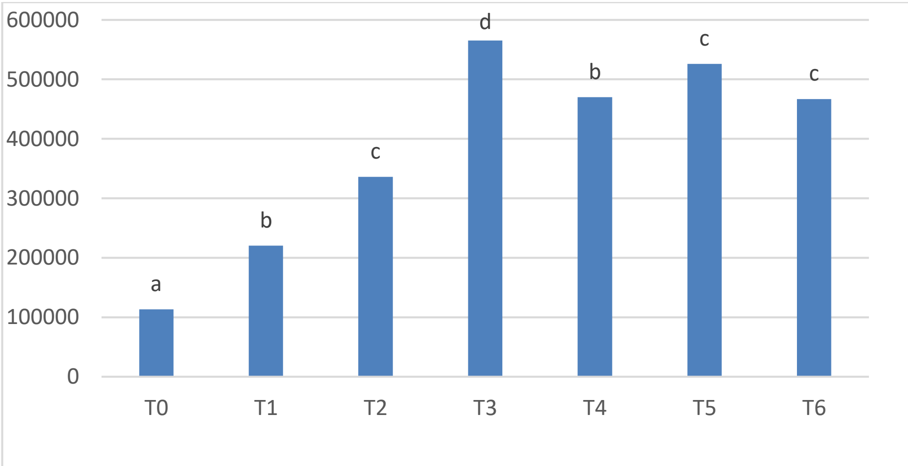

Fig. 8. Separation of means of number of fruits

NB: Treatments with the same letter are statistically equal and those which are not followed by the same letter are significantly different at the 5% probability threshold (P≤0.05) according to the Duncan test

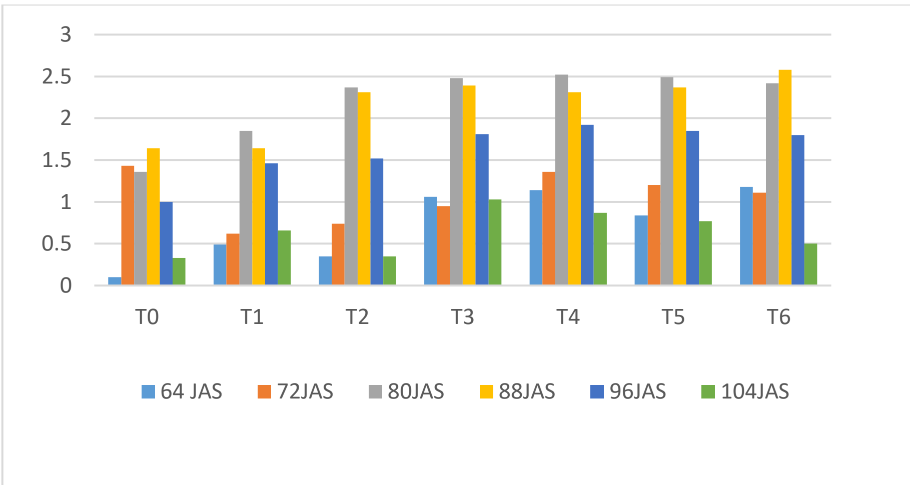

Fig. 9. Response of fruit diameter depending on harvest

3.4 Discussion

3.4.1 Physicochemical characteristics of the soil

The soil on which okra was grown had a slope of 1% [36], which indicates that the value of the slope is low, so vulnerability to water erosion is also low. This shows that ridging on this type of slope would allow infiltration of a rainfall of 60 mm/h and store more than 100 mm of water in the soil. The texture of our soil was clay. This characteristic of the soil could be a limitation to cultivation, as okra adapts better to soils with a silty, silty clay or silty clay-sandy texture, but according to previous work by [37,12]. Okra tolerates a wide variety of soils. The results of the chemical analyze of the soil showed that the soil was acidic, with a water pH value of 4.633, which should not be a constraint for okra cultivation, since according to some authors, such as [38], okra seems to be fairly tolerant of soil acidity. The organic matter content of the soil was very high (>6%), but of poor quality (14<C/N<20). This could not be a limit to okra growth, as it has been shown that okra acclimates well to soils rich in organic matter [39]. On the other hand, poor quality organic matter may not contribute effectively to plant growth and development, as organic matter decomposes poorly with a C/N ratio of between 15 and 25 [40]. The CEC (meq/100g) is moderate (25 < CEC < 40 meq/100g), so its base saturation rate is low (21 < V<40%). The concentrations of exchangeable cations, including K+ (0.28 meq/100g soil), Na+ (0.25 meq/100g soil), Ca2+ (5 meq/100g soil) were low and Mg2+ average (2.13 meq/100g soil). The soil's cation balance was therefore (67/29/4), which was out of balance in favor of Ca2+ and K+, but against Mg2+. However, soil cation balance is reached when the ratio of Ca2+, Mg2+ and K+ is 76/18/6 [35]. The Phosphorus levels are low, which is a major factor in okra production on the site, given its importance for seed and fruit production

3.4.2 Soil profile of the study site

It appears from the profile studied that our soil corresponds to Rhodic Ferralsols in the classification system [41]. It generally corresponds to Oxisol, in the USDA classification and to typical highly desaturated ferralitic or humus soils in the French system according to the commission of pedology and soil mapping. In general, these soils are characterized by an accentuated acidity (pH-H20), a low CEC, a poverty in exchangeable base and phosphorus. In addition, the calcium contents obtained in all the horizons are low with an average of 4.31 [42], results consistent with the opinions of other studies carried out in the region of South Cameroon for the production of cassava and banana. -plantain. Report [43].

3.4.3 Pedoclimatic evaluation of the study site

The unsuitability class (N2cf) of the land evaluation of the site under rainfed conditions can be explained by the insufficient precipitation during the crop cycle during said period. Under the semi-irrigated regime, given that the evaluation of land for okra cultivation turned out to be moderately suitable (S2cf), this situation could be explained by regular water supplies that we had made during the period. of the test every time it didn't rain. The average suitability (S2cf) of land obtained in a semi-irrigated regime could further improve and become a high suitability (S1) if firstly, a height of water greater than or equal to the entire crop cycle of the plant was provided. at 780 mm, because knowing that in the Sahelian climate, the water requirements of okra during a complete crop cycle are of the order of 780 to 1000 mm [37]. Secondarily, we restored the balance of the cationic balance which was unbalanced through the addition of adequate doses of amendments.

3.4.4 Effects of different treatments on okra growth parameters

3.4.4.1 Width, length, number of leaves, number of branches

The supply of fertilizers had a highly significant influence on the length of the leaves which was impacted by the treatments T5 (½ (T2) + ½10 t /ha FP), T3 (10 t/ha of FP) which were the best on the number of leaves and the width of the leaves, finally on the number of branches T6 (½ dose T2+ ½ 5t/ha FP (T3) was the best treatment. This could be explained by the fact that these treatments underwent an advanced decomposition of the different fertilizers (organic and chemical) compared to the others and that the nutrients were gradually released despite the poor state of the soil. This phenomenon certainly contributed to the assimilation of nutrients by the plant. plant Knowing that over time said elements are efficiently used by cultivated plants by increasing the leaf surface and the process of photosynthesis as shown in work previous to this study [44].

3.4.4.2 Diameter at the collar, and height of the plant

The addition of fertilizer had a non-significant effect on the diameter at the crown and on the height of the plant during our three weeks of data collection. This can be explained by the fact that our soil has not been significantly improved by a lack of sufficient quantities of nutrients such as Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Sodium (Na) and Sulfur (S) in plants lead to poor performance whose development is affected, thus leading to low yield [45,46] and [47]. observed on the treatments the treatments despite a high rate of organic matter, but of poor quality. Which does not contribute effectively to the growth and development of the plant (height and diameter at the collar) because for a C/N ratio between 15 and 25, the decomposition of organic matter is poor.[40]. This corroborates with our pedoclimatic evaluation work which showed a class of unsuitability of our soils of the study site in terms of fertility.

3.4.5 Effects of different treatments on yield parameters

3.4.5.1 Weight, number and diameter of fruits

The effect of the amendment treatments (chicken droppings) and different combinations with chemical fertilizers showed a significant difference ($P \leq 0.05$) on the weight of the fruits and highly significant ($P \leq 0.01$) on the number fruit during the twelve harvests carried out. However, T0 (0 fertilizer input) gave the lowest yield in weight (2513kg/ha) and number of fruits (113084 fruits/ha) throughout our trial. This can be explained by the fact that the land evaluation of the ferralitic soils of the Nkoémvone station for the production of okra was currently unsuitable (N1cf) due to climatic and fertility constraints (basic saturation rate which is $21 < V < 40\%$). Because This limitation is very severe, not recommended and the poverty of these soils in phosphorus would explain the non-significant values of the fruit diameter. This corroborates with the results of [31] who had obtained the same similar results with T0 in his test in a ferralitic soil on the identification of some formulations of organic and mineral fertilizers that could be recommended to market gardeners growing okra in certain localities of western Cameroon.

Chicken manure T3 (10t/ha) had the best treatment in terms of fruit weight of 13t/ha and number of fruits of 565/ha of fruit throughout the trial compared to doses of chemical fertilizers (T1; T2) and different combinations T5 and T6 Cas there found [31] because numerous works have indicated that organic amendments play an important role on various soil properties [48]. Which firstly confirms the hypothesis that 10 t/ha of okra is the best recommended dose of amendment for better okra production, which corroborates with the recommendation work of [30]. In the same vein [31], found a similar result with 11 t/ha of chicken droppings on the production of okra crops. This can be explained by the fact that phosphorus being a limiting element in the ferralitic soils of Nkoémvone which is one of the major limiting factors for production, and then according to the law of the minimum or law of LIEBIG stipulates that the the importance of the yield of a crop is determined by the element which the lowest quantity in the soil compared to the needs of the plants [49]. Therefore, physicochemical analyzes of chicken droppings showed a high phosphorus level which was therefore able to compensate for these deficits in the soil by increasing its PH and its cation exchange capacity (CEC); which contributed to increasing the yield in weight and number of fruits compared to the doses of chemical fertilizers (T1, T2) and the different combinations (T5, T6). On the other hand, this could also be explained by the fact that the organic amendment satisfied the needs for nitrogen and phosphorus which regulate vegetative development [50,51], compared to T5. We can therefore say that the organic contribution made in this experiment made it possible to create better conditions for growth and nutrition of the culture as reported by [52]. In addition, the nutrient requirements of plants fertilized with poultry droppings are thus covered throughout the entire production cycle [53] on okra during studies carried out in Nigeria. The yield of T6 (½ dose T2+ ½ 5t/ha FP (T3) can also be explained by the fact that [5] on okra or [13] on yam, reported that the combined use of poultry manure and mineral fertilizer significantly improved growth compared to the application of each fertilizer separately [54-57].

4. CONCLUSION

At the end of this study, it clearly appears that production remains very complex which would require the characteristics of the climate and soil to be taken into account. As part of this test, the description of the soil showed that the study soil corresponded to the Rhodic Ferralsols type which generally corresponds to oxisol, in the USDA classification and to typical highly desaturated ferralitic or humus soils in the French system and generally poor in calcium and phosphorus. The pedoclimatic evaluation showed that with insufficient precipitation during the experimental period, the study soil had an unsuitability class (N2c) in rainy regime. Furthermore, under the semi-irrigated regime, the land rating for okra cultivation was found to be moderately suitable (S2cf). Further, the final assessment showed that the study site was unsuitable in terms of soil fertility and climate (N2cf). The treatments of the different fertilizers had a significant effect on the one hand on the growth parameters therefore the width of the leaves (T3), the length of the leaves (T5), the number of branches (T6) and on the other hand an effect not significant on (the diameter at the collar and the height of the plant) during the data collection period. On the other hand, on the yield parameters, where the treatments had, a non-significant effect on the diameter of the fruits, (T4) was the best treatment. The yields in fruit weight were highly significant and the T3 treatment (10t/ha of chicken droppings) was the best with 13t/ha in fruit weight and 565416 fruits/ha compared to the different doses of mineral fertilizers. and to the witness during data collection. Thus, we can recommend to the populations of Nkoémvone the dose of organic fertilizer of 10t/ha of chicken droppings which corresponds to the treatment (T3), and (T5); for a better and average yield we recommend the dose (T4) and (T6); Okra cultivation in this locality could well occur and have better yields in the rainy season.

5. OUTLOOKS

In perspective, it would be appropriate to exploit the results not yet available from the soil analyzes carried out before and after the experiment in future work. These analyzes will make it possible to measure the respective effects of different organic materials on the physicochemical and biological variables of the soil. Renewal of the trial for two to three campaigns would make it possible to confirm or refute the results obtained. In these trials, it would be essential to explore other organic materials to boost okra yields in these phosphorus-poor soils in the locality of Nkoémvone.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors did not use artificial intelligence and text-to- image generators have been used during wrtiting or editing of manuscripts

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Appendix 1. Climatic requirements for cotton (150-160 day growth cycle)

Climatic characteristics	**Climate classes, degree of limitation and assessment**					
	S1 -0 **0**	**S1 - 1** **1**	**S2** **2**	**S3** **3**	**N1** **4**	**N2**
	100	**95**	**85**	**60**	**40**	**25**
Precipitation during growth cycle (mm)	900 – 1200	750 - 600 1200 -1400	625 – 750 1400 - 1600	500 - 625 >1600		<500 --
Precipitation at vegetative stage 1st + 2nd month	35 -65	> 65 < 35				
Precipitation at yield formation stage 5th month	150 - 300	100 - 150 300 - 400	50 -100 > 400	< 50	-- --	< 15 > 34
Precipitation at ripening stage (mm): 6th month	< 25	25 - 50	50 - 75	75 -100	-	> 100
Average temperature of growth cycle (C)	> 26	24 - 26	22 - 24	20 - 22	---	< 20
Average maximum temperature of growth cycle (C)	> 32	28 > 32	26 < 28	24 - 26	_	< 24
Average maximum temperature of the warmest month (c)	> 34	30 - 34	< 30			
Average temperature of the vegetative stage of the 1st month + 2nd month	> 30	25 - 30	20 - 25	< 20		
3-4 months average daily temperature of flowering stage:	20 – 30	30 - 35	35 - 40	> 40		
average night temperature of flowering stage: 3-4 months	12 -18	18 - 22	22 -27	> 27		
average temperature of the maturation stage: 6th month	> 26	24 - 26	22 - 24	20 -22	-	< 20
	0 - 50	50 - 65	65 -75	75 - 80	-	> 80

Appendix 2. Soil requirements for Cotton

Characteristics of the land	**Class, degree of limitation and ratio**						
	S1 -0 **0**	**S1 - 1** **1**	**S2** **2**	**S3** **3**	**N1** **4**	**N2**	
	100	**95**	**85**	**60**	**40**	**25**	**0**
	900 – 1200	-	-	F1	--	<500	
	0 – 1	-	Moderate	Imperfe	--	--	
	0- 2	-	moderate	ct tense	-	F2+	
	0- 4			good	Poor but	Poor not	
					drainabl	drainable	
	Fo				e		
	good						
	imperfect						
Topography	35 -65	3- 15	C > 60v,	fs,S	-	Cm,Si,C	
	C <	5- 100	SL	LS	-	m	
	60s,SiC	10- 20	SCL	,LCS	-	cS	
	Co,SiCL,	3- 6	15 - 35	35 - 55	-	> 55	
	Si ,SiL,CL	15 - 24	50- 75	25- 50	<0.8	< 25	
	0 – 3	100 – 80	20- 30	30 – 40	-	> 40	
	>100	2- 2.0	6 - 10	10 - 15	16 – 22	> 15	
	0 – 10	0- 8 – 1.2	< 16 (-)	< 16 (+)	-	< 5.5	
	0 - 3	0- 4-0.8	35- 50	< 35		> 8.2	
	> 24	6 0-6.3	0.8 – 1	35 – 50		> 22	
	80 - 100	7 1-7.5	<0.8	5.5 -5.8		>40	
	> 2.0	8 – 10	< 0.4	8.0 – 8.			
	> 1.2	5 - 20	5.8- 6.0	2			
	> 0.8		7.5- 8.0	12 – 16			
	6.3-7		10 -12	30 - 40			
	0-8		20 - 30				
	0 - 15						

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