

Original Research Article

Agronomic and Yield Parameters of CHC202 Maize (*Zea mays* L) Variety Influenced by Different Doses of Chemical Fertilizer (NPK) in Bali Nyonga, North West Region Cameroon

ABSTRACT

Aims: The aim of this study was to evaluate the agronomic and yield performance of CHC202 maize (*Zea mays*) variety as influenced by different doses of chemical fertilizer (NPK – 20:10:10) in Bali Nyonga, North West Region of Cameroon.

Study design: Four treatments (0g, 4g, 8g and 12g of NPK/plant) were evaluated in a Randomized Complete Block Design. Commercial NPK (20:10:10) fertilizer was used.

Place and Duration of Study: The experiment was conducted in Bali Nyonga, a village located in Bali sub- Division, North West Region of Cameroon. This research was conducted in 2014 from March to July.

Methodology: Please write main

There were four blocks, each with a surface area of 38.2m². Each block was divided into raised beds (3m x 0.4m x 0.4m) separated by 40cm. Maize seed were sown on the 25th on March 2014 after two consecutive heavy rain falls. Two fertilizer applications were made in the experiment; on the day of sowing and five weeks after emergence. On the day of sowing, the fertilizer was applied in shallow trenches then mix with soil and the maize seed 3cm deep. Five weeks after germination, the second application of fertilizer was made: fertilizer was applied in a ring manner around and 4cm away from the plant. Plant spacing and fertilizer application was done based on farmer's practice. Data was collected on growth and yield parameters.

Results: Results indicated that different doses (0g, 4g, 8g and 12g per plant) of NPK fertilizer in two applications influenced agronomic (plant emergence, plant height, stem diameter, leaf area index, plant vigour, and number of plants at harvest) and yield parameters of maize. The highest plant emergence was recorded from with 0g of NPK application ($P = .05$). The highest plant height 222.5cm resulted from treatment with 12g/plant ($P = .05$). Maize plants treated with 12g/plants also gave the highest yield 2.4kg ($P = 0.05$). There was also a strong correlation ($r = 0.75$, $P < .01$) between plant vigour and yield.

Conclusion: From the findings of this experiment judicious application of NPK fertilizer can improve agronomic and yield parameters of maize. Farmers are recommended to use 12g of NPK for optimal growth and maximum yield. ~~Other implications are discussed.~~

Keywords: NPK fertilizer, CHC202, agronomic and yield parameters, Cameroon.

1. INTRODUCTION

Agriculture which was developed through invention of a series of complex related technologies involving an intimate relationship between crops and animals contributes a lot to Cameroon's economy. About 75% of Cameroonians earn their living from agriculture and it provides among others, food, raw materials for local and foreign industries [1].

Amongst other crops, until the late 1980s maize was regarded by the majority of people as a crop solely for home consumption rather than for cash. During the last three decades, characterized by a drastic drop in the prices of the two main cash crops (coffee and cocoa), Maize (*Zea mays* L) has witnessed a steady soaring in prices and demand in Cameroon and the world at large [2].

Maize (*Zea mays* L) is a cereal crop belonging to the Family Poaceae [3]. Maize is the third most important cereal crop in the world next to rice and wheat and has the highest potential among the cereals [4]. It is important to mention that maize serve as the most important nutrient for people in central and South America, Africa and China [5][6]. Average productivity of maize is 6.7 t/ha in developed countries and 2.4 t/ha in developing countries [5]. Maize is one of the most important cereal crops that allow the food self-sufficiency program of the country, playing a key role in the human diet and animal feed, providing adequate amounts of energy and protein [6]. Maize can be

seen in Cameroon's weekly markets where it is sold in tins, buckets and bags by small scale farmers for direct consumption. Mega buyers such as Societe Camerounaise de Transformation des Cereals (SCTC), Societe Anonyme des Brasseries du Cameroon (SABC), Union Camerounaise des Brasseries (U.C.B), animal feed mills, Societe des Provenderies du Cameroon (S.P.C), Belgocam, Nutricam and larger section of the urban elite has mounted pressure on maize production in Cameroon [2].

Cameroon, like many other African countries in the face of climate change is facing a myriad of challenges hampering maize production; access to new and genetically diverse varieties, fertilizer acquisition and application, pests and disease management [7]. In the North West Region of Cameroon as many other parts, maize production is in the hands of small scale farmers who are conducting their activities with very limited resources like hoes, machetes, low quality seeds, limited land area, low mechanization and inadequate use of fertilizer.

Soil fertility is among the major factors affecting maize production in Cameroon [6]. Organic manure from farm debris and animal has played a fundamental role to supply this extra nutrient. However, nutrient inputs from chemical fertilizers are needed to replace nutrient which are removed and lost during cropping in order to maintain positive nutrient balance and increase yield [8]. Nitrogen (N) together with phosphorus (P) is one of the most limiting macronutrients to maize grain yield worldwide [9]. Nitrogen availability influences the uptake not only of itself, but also of other nutrient [10] as N-fertilized plants usually have larger roots systems, which enhances the capture of other nutrients [11]. Nitrogen is highly mobile, thus its demand and use is continuously increasing as it is subjected to high loss from the soil-plant system. Thus, standardize amounts of fertilizers required for optimum growth and yield is important in different agro ecological zones.

For most tropical countries, 120kg N/ha + 40kg P/ha is highly recommended for optimal harvest [10]. However, most N products sold in Cameroon are sold as compound fertilizers, Nitrogen, Phosphorus, Potassium (NPK) indifferent rations. Common ratio includes 10:10:10, 25:25:40. Nitrogen is also sold in Cameroon as Urea (per communication). In Cameroon, white and yellow varieties are preferred based on the region [12].

Maize improvement programs aim at the selection of highly productive cultivars, which are, in general, very demanding in terms of soil fertility and plant protection. Cameroon highland composite (CHC), CHC201, CHC202, CHC203 and CHC204 maize varieties were developed by IRAD (Institute of Agricultural Research and Development) Bambui to adapt to different agro-ecological conditions. Cameroon Highland Composite is especially adapted for use by Cameroon farmers and seed producers in highland zones. The CHC varieties are open-pollinated varieties best suited for use by small-scale farmers who can use seed from their own field for three cycles before buying new seed [13]. In this study, we sought to understand the effect of NPK fertilizer on CHC202 variety which is commonly used by small scale vegetable farmers in the North West Region of Cameroon.

2. MATERIAL AND METHODS

2.1. Experimental site

This experiment was conducted in Bali Nyonga, a village located in Bali sub-Division, North West Region of Cameroon. Bali has a compelling historical attribute that dates back to colonial days in Cameroon. Bali lies west of Bamenda, the Capital City of North West Region and it has a population of about 500,000 people (2014 estimates). The geographical coordinates of Bali are 5°53'0" North, 10°0'0" East with a humid tropical climate. Annual rainfall ranges between 5.8mm to 10.4mm with average temperatures between 17.0 °C - 27.0 °C. The principal activity of the inhabitants was agriculture: Chief crops grown included maize, beans, potatoes and vegetables. This research was conducted in 2014 from March to July. Site and soil preparation took place in March, planting in late March harvesting took place in July. Average humidity was 72.2%.

2.2. Experimental design, field layout and cultural practices

A randomized complete block design with four blocks and four fertilizer treatments (0g, 4g, 8g and 12g per plant) was used in this experiment. The fertilizer used was a commercial NPK composite in ratio of 20:10:10. There were four blocks, each with a surface area of 38.2m². Each block was divided into raised beds (3m x 0.4m x 0.4m) separated by 40cm gap. These dimensions were developed based on farmer's recommendation. Each block was separated by a 1.5m gap. The beds were grouped into groups of four and each treatment was randomly assigned per group (four-bed group). Two seeds of CHC202 variety were sown per hole on raised beds. Two rows of maize with 12 holes each were planted per bed (24 holes per bed). Intra-row and inter-row spacing was 25cm and 60cm respectively. Maize seed were sown on the 25th on March 2014 after two consecutive heavy rain falls. Two fertilizer applications were made in the experiment; on the day of sowing and five weeks after emergence. On the day of sowing, the fertilizer was applied in shallow trenches then mix with soil and

the maize seed 3cm deep. The maize was thinned to 1 plant per hole two weeks after germination. Five weeks after germination, the second application of fertilizer was made: fertilizer was applied in a ring manner around and 4cm away from the plant. Insect pests and disease were not a major problem in the field: thus no control measure was applied. However, hand weeding, and hoeing was done when necessity in all blocks. Plant spacing and fertilizer application was done based on farmer's practice.

2.3. Data collection

Data was collected on the vegetative stage and at harvest. Data was collected on agronomic (plant emergence, plant height, stem diameter, leaf area index, plant vigour and number of plants at harvest) and yield (weight of harvested maize) parameters.

Plant emergence: twenty four plant holes were planted per bed and the number of plant emerging was counted 5 days after planting (DAP). All emerged plants were counted.

Plant height (cm) was measured from ground level to the collar of the upper leaf with developed leaf sheath using a meter rule on the 30th of June (three months after sowing). A pair of centralized plants/row was sampled from each border bed per treatment and the means per bed was considered a sample. Three pairs of centralized plants were randomly collected from the 2 middle beds and the mean of each pair was considered as samples: thus five sample means were collected per treatment/block (5 samples/treatment/block).

Stem diameter (cm): was measured at tasseling (2.5 months after planting). The circumstance (s) was measured at 2/3 the plant height and using the relationship given below to estimate the stem diameter (d) $d = \frac{s}{\pi}$ where $\pi \approx 3.14$. Sampling for the stem diameter was done in the same manner as that of plant height.

Leaf Area Index (LAI): The plant was divided into three equal quadrants along the plant length and a mature leaf in the middle quadrant was used to obtain LAI: LAI= LWK (where L= Length of leaf, W = Width of leaf. K = constant ≈ 0.75) [14]. Sampling for the stem diameter was done in the same manner as that of plant height.

Mean number of harvestable plants at harvest: The mean number of harvestable plants/bed/treatment was counted at harvest was considered as a sample.

Plant vigour plant: Plant vigour was estimated using a three coded scale standard: Poor (1), Average (3) and Good (5). Plant vigour measurements were made on the 30th of June. The plant vigour of one centralized plant/ bed was assessed and the average per treatment was recorded as a sample.

The mean weight (kg) of harvested cobs was measured using a scale balance at harvest (25th of July). Three plants per plot were sampled for the weight of the maize cobs. The mean cob weight was recorded as samples for each treatment per block.

Data analysis

Analysis of variance (ANOVA) was used to evaluate the means for differences. Duncan's Multiple Range Test (DMRT) was used to separate the means. All analysis was done with the use of statistical package for social sciences SPSS ver. 16 and the probability level was 0.05. Where necessary Microsoft Excel (2007) was used to produced bar charts. Correlation between plant vigour and weight of harvested cobs was evaluated.

3. RESULTS AND DISCUSSION

Table 1 shows the Analysis of variance (ANOVA) for the agronomic and yield parameters ~~in this study~~. The Blocking effect did not significantly ($P > .05$) influenced any measured parameter in this study. Thus the Blocking effect was omitted in the ANOVA analysis in order to increase the Error degree of freedom (df) consequently increasing the reliability of the analyses by increasing the error effect. The effect of NPK fertilizer was significant ($P = .05$) for all agronomic parameters except for number of plants at harvest ($p = .538$). NPK also significantly ($P = .001$) influenced the yield parameter (weight of harvested maize kg).

Table 2 shows the results (means) of agronomic parameters ~~in this study~~. The results indicate that NPK caused a significant difference [$F(3, 12) = 3.732$, $P = .04$] in the number of plant emergence. It was observed that there was a decrease in number of maize emergence with increase in fertilizer dose. More plant emerged in treatments of no fertilizer (0g NPK/plant) with a mean of 21.75 (21.0 – 23.0). The lowest mean emergence 15.75 (12.0 – 19.0) was recorded in treatment with 12g NPK per plant. Although fertilizer (NPK) has significant advantages in world of agriculture, there are still some problems associated with its use [15]. [16] and [17] alleged that the nitrogen (N) can have negative effects on seed germination, seedling growth and early plant growth in soil. Studies to account for these adverse effects have proposed many explanations: fertilizer impurities such as biuret [18], high

pH, nitrite produced through nitrification of N by soil microorganisms [19] and ammonia formed through hydrolysis [20].

Table 1: ANOVA analyses for maize growth and yield parameters.

Parameter	Source Variation	Of Degree Freedom (Df)	Of Sum Squares	Of Means Squares	F	Sig.
Plant Emergence	Between Groups	3	98.188	32.729	3.732	0.042
	Within Groups	12	105.250	8.771		
	Total	15	203.438			
Plant Height (Cm)	Between Groups	3	58186.6	19395.5	16.386	0.000
	Within Groups	76	89959.6	1183.67		
	Total	79	148146.2			
Stem Diameter (Cm)	Between Groups	3	3.841	1.280	11.554	0.000
	Within Groups	76	8.422	0.111		
	Total	79	12.264			
Leaf Area Index	Between Groups	3	1380390.554	460130.185	26.696	0.000
	Within Groups	76	1292678.889	17235.665		
	Total	79	2673065.443			
Plant Vigour	Between Groups	3	19.532	6.511	32.452	0.000
	Within Groups	12	2.407	0.201		
	Total	15	21.939			
Number Of Plant At Harvest	Between Groups	3	11.5	3.833	0.760	0.538
	Within Groups	12	60.5	5.042		
	Total	15	72.0			
Weight Of Harvested Maize (Kg)	Between Groups	3	5.1	1.7	9.533	0.002
	Within Groups	12	2.14	0.178		
	Total	15	7.24			

Nitrogen accounted for half (50%) the mass of NPK fertilizer used in this study. Thus high quantity of nitrogen in the NPK fertilization could have caused the reduction in seed germination observed. The findings of this study are on a par with [21].

Plant height (cm) analysis revealed that NPK fertilizer significantly [F(3, 76) = 16.386, $P = .01$] effected plant height (Table 2). The plant height 225.8cm (172.0 – 293.0) resulted for treatment of 12g NPK per plant while the smallest plant 157.9 cm (109.0 – 206.0) resulted from treatment with no fertilizer. The mean plant height showed a progressive increase from 4g NPK (212.1), 8g NPK (219.6) and 12g NPK (225.0) treatment though not significant different but significantly different from that of 0g NPK per plant. In a similar experiment conducted in Nigeria by [22], plant height though increased with increase quantity of NPK, did not also show a significant difference ($P > .05$) after 9 weeks (approximately two and a half months after planting) from treatments of 20kg/ha, 40kg/ha and 60kg/ha of NPK fertilizer but significantly different from plant height of 0kg/ha of NPK fertilizer treatment. Increase nitrogen is known to increase vegetative growth period of maize which eventually leads to increase photosynthesis and increase plant height [23].

The findings of this experiment also revealed that NPK fertilizer also had a significant [F(3, 36) = 11.554, $P = .01$] influence on the stem diameter (cm). There was an increase in stem diameter with

increase dose of NPK fertilizer (Table 2). The highest mean stem diameter 2.31cm (1.6 – 2.9) and 2.32cm (1.8 – 2.7) was recorded from plant treated with 12g and 8g of NPK per plant respectively. The smallest stem diameter 1.8cm (1.3 – 2.5) was recorded from maize plant with no fertilizer treatment. Our findings are in concordance with those of [24] who found out that, maize stem girth increased with increased NPK fertilization. [25] also reported that maize plants deficient in nitrogen develop thin and spindly stems. They further explained that such stems are more susceptibility to lodging. According to [24], the increase stem diameter is an expression of retention of considerable amount of assimilates in the stem for leaf production. There was a significant difference [$F(3, 76) = 26.696, P = .01$] among treatment means in response to leaf area index (LAI). The LAI 646.12cm² (348.0 – 948.0) was the highest from maize treated with 8g of NPK per plant, though not significantly different ($P > .05$) from the LAI of maize treated with 12g of NPK per plant. The smallest LAI 313.0cm² (148.0 – 489.0) was recorded from maize plants treated with no fertilizer (Table 2). Overall, there appears to be an increase in LAI with increase dose of NPK fertilizer. This finding is also similar to that of [24]. This increase in LAI may indicate that plants furnished with more NPK grew larger due to increased photosynthesis rates.

Different NPK fertilizer doses had a significant effect on plant vigour [$F(3, 12) = 32.452, P = .01$]. There was a progressive increase in plant vigour with increase NPK fertilizer level (Table 2). The highest mean plant height vigour 4.2 (3.8 – 4.6) was recorded from maize plants treated with 12g of NPK fertilizer per plant and least mean plant vigour 1.2 (1.0 – 1.8) was from maize plant treated with no fertilizer. In a similar experiment [26] had the same results and concluded that NPK fertilizer affects plant architecture, alters growth and other developmental patterns. Thus this could be the reason of the increase mean plant vigour with increase NPK fertilizer. Maize plant with increase plant vigour (that is increased N) to be stronger and can effectively withstand lodging from wind and rain. This claim is supported by [21] who reported increasing N-fertilizer rate linearly increased resistance of maize plant to lodging.

Table 2. Results of Agronomic parameters

Treatment: Fertilizer dose (g)/plant	Agronomic parameters					
	Plant emergence: mean ± sem	Plant height (cm): mean ± sem	Stem diameter: mean ± sem	LAI: mean ± sem	Plant vigour: mean ± sem	Number of plants at harvest: mean ± sem
0	21.75 ± 0.48a (21.0 – 23.0)	157.90 ± 6.55b (109.0 – 206.0)	1.80 ± 0.08b (1.3 – 2.5)	313.00 ± 20.02a (148.0 – 489.0)	1.20 ± 0.20d (1.0 – 1.8)	7.75 ± 1.60a (3.0 – 7.0)
4	21.50 ± 2.18a (15.0 – 24.0)	212.10 ± 9.44a (124.0 – 278.0)	2.25 ± 0.07a (1.8 – 3.0)	465.35 ± 26.99b (257.0 – 712.0)	2.60 ± 0.33c (1.8 – 3.4)	8.75 ± 1.25a (5.0 – 10.0)
8	18.25 ± 1.25ab (15.0 – 21.0)	219.60 ± 7.41a (167.0 – 290.0)	2.31 ± 0.06a (1.8 – 2.7)	646.12 ± 34.27c (348.0 – 948.0)	3.38 ± 0.17b (3.0 – 3.8)	10.00 ± 0.41a (9.0 – 11.0)
12	15.75 ± 1.49b (12.0 – 19.0)	225.80 ± 4.84a (172.0 – 293.0)	2.31 ± 0.09a (1.6 – 2.9)	613.15 ± 34.89c (100.0 – 936.0)	4.20 ± 0.16a (3.8 – 4.6)	9.50 ± 0.87a (7.0 – 11.0)

However, farmers should be cautioned that excessive nitrogen application will result to inordinate vegetative growth and top-heavy plants are prone to lodging in events of heavy rainfall and high-speed wind [25].

The number of plants harvested was not significantly [$F(3, 12) = 0.76, P = 0.538$] influenced by different doses of NPK fertilizer in this experiment (Table 2). The maximum mean number of plant at harvest 10.0 (9.0 – 10.0) was recorded from plant treated with 8g of NPK per plant. The minimum mean number of plants at harvest 7.75 (3.0 – 7.0) was recorded from maize plants treated with no fertilizer treatment. Though not significantly different, unlike mean plant emergence, more plants were counted with increase dos NPK fertilizer at harvest. This indicates that the number of emerging plants do not necessarily reflect the number of viable, standing and harvestable plants. The discrepancy observed between mean plant emergency and mean number of plant at harvest may results inadequate NPK fertilizer supply leading to weaken, lodged or dead plants.

The effect of NPK fertilizer doses on yield (weight kg of harvested maize) is presented in Figure 1. In this study the different doses of NPK fertilizer significantly [$F(3, 12) = 9.533, p = 0.002$] influenced the mean weight of harvested maize. The highest mean weight 2.4Kg (1.6 – 3) was recorded from plants treated with 12g of NPK fertilizer per plant. The lowest mean 1.1kg (0.80 – 1.40) was recorded from plants treated with no NPK fertilizer. This finding indicates that there is a progressive increase in the mean weight of harvested maize with increased dose of NPK fertilizer. Many studies have reported the same pattern of increase yield with increase dose of fertilizer [21][23][24] and [27]. However this increase in mean weight of maize harvested is not sustained beyond certain doses of NPK fertilizer. [21] and [28] reported that beyond 90 – 92Kg of NPK/ha, maize yield did not significantly increase.

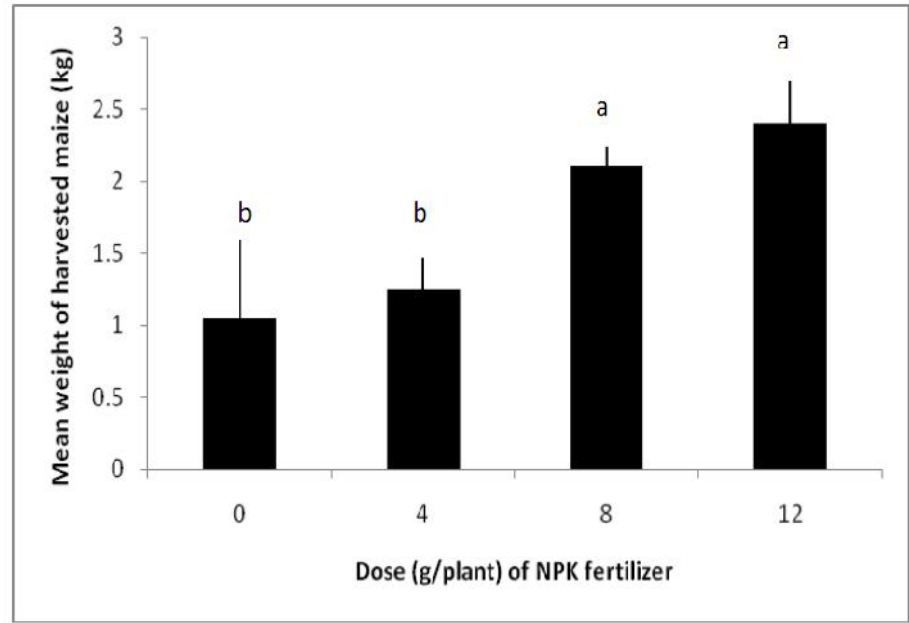


Figure 1. The effect of different dose of NPK fertilizer on maize yield
The correlation analysis reveals that there is a strong positive [$r(16) = 0.75, P = .01$] between plant vigour and mean weight of harvested maize (Figure 2). This indicates the necessity of a vigorous plant for better yield. Plant vigour is directly influenced by NPK fertilizer as shown in Table 2.

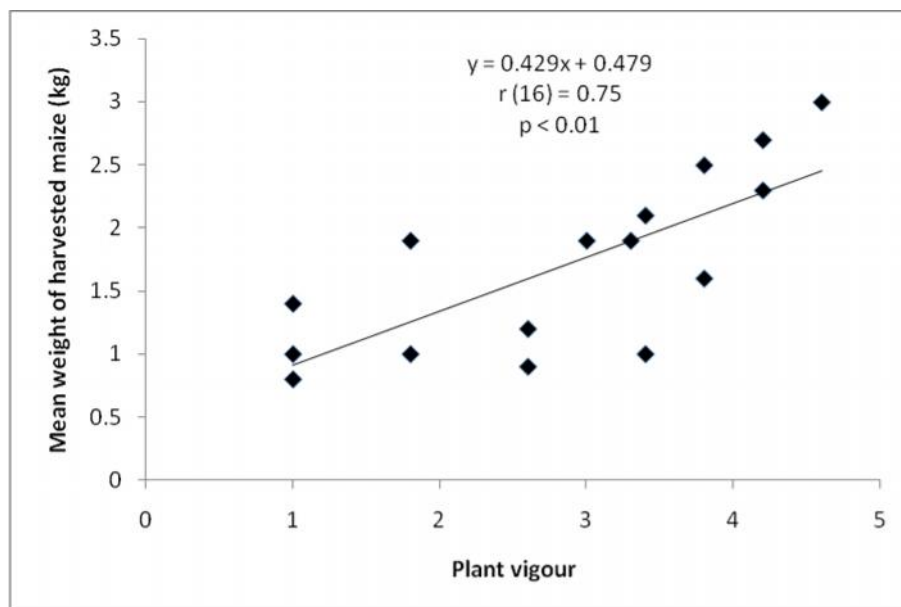


Figure 2. Correlation between Plant vigour and yield of maize

4. CONCLUSION

From the results of this experiment, NPK (20:10:10) fertilizer doses have a profound effect on the agronomic and yield parameters of maize. Doses of NPK fertilizer used in this experiment had significantly affected the number of plant emergence, plant height (cm), Leaf Area Index LAI (cm²), plant vigour and weight (kg) of harvested maize. The findings also revealed that there was a strong positive correlation between the plant vigour and the weight of harvested maize. These findings demonstrate the essential role of NPK fertilizer in maize agro-ecosystem for increased yield. We recommend that farmers in Bali Nyonga Cameroon should use 12g per plant for optimum yield. Farmers are also advised that excessive use of NPK fertilizer does not always lead to increase profit margins. Thus, further studies are recommended to ascertain the chemical composition of the soil of the study area that may have any impact on the level of NPK fertilization of the area. Such information is relevant to give optimum harvest and maximize profit on investment of the poor-resourced small scale farmers in Bali Nyonga and other areas.

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