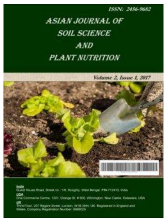

Asian Journal of Soil Science and Plant Nutrition

2(4): 1-9, 2017; Article no.AJSSPN.39583
ISSN: 2456-9682

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

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Authors' contributions

This work was carried out in collaboration between all authors. Authors MHM and DN designed the study, wrote the protocol and managed the literature searches. Author DTA performed the statistical analysis and wrote the first draft of the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJSSPN/2017/39583
Editor(s):
(1) Abhishek Naik, Department of Area Manager in Technology Development, Vegetable Crops Organization-United Phosphorus Limited, India.
Reviewers:
(1) Leyla Idikut, Sutcu Imam Universty, Turkey.
(2) Diony Alves Reis, Federal University of Western Bahia, Brazil.
Complete Peer review History: http://www.sciencedomain.org/review-history/23271

Original Research Article

Received 23rd January 2018
Accepted 16th February 2018
Published 21st February 2018

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 (0 g, 4 g, 8 g and 12 g 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: There were four blocks, each with a surface area of 38.2 m2. Each block was

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divided into raised beds (3 m x 0.4 m x 0.4 m), raised beds within a block were separated by a 40 cm gap. Maize seeds were sown on the 25th of 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 mixed with soil and the maize seed 3 cm deep. Five weeks after germination, the second application of fertilizer was made: fertilizer was applied in a ring manner 4 cm 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 (0 g, 4 g, 8 g and 12 g 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 0 g of NPK application (P = .05). The highest plant height 222.5 cm resulted from treatment with 12 g/plant (P = .05). Maize plants treated with 12 g/plants also gave the highest yield 2.4 kg (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 12 g 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 soar 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, 120 kg N/ha + 40 kg P/ha is highly recommended for optimal harvest [10]. However, most N products sold in Cameroon are sold as compound fertilizers, Nitrogen, Phosphorus, and Potassium (NPK) in different ratios. 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 of maize 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 maize farmers in the North West Region of Cameroon.

2. MATERIALS AND METHODS

2.1 Experimental Design, Field Layout and Cultural Practices

A randomized complete block design with four blocks and four fertilizer treatments (0 g, 4 g, 8 g and 12 g 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 38.2 m^2. Each block was divided into raised beds (3 m x 0.4 m x 0.4 m). These dimensions were developed based on farmer's recommendation. Each block was separated by a 1.5 m gap. There were two rows with 12 holes of maize per raised bed. Intra-row and inter-row spacing was 25 cm and 60 cm respectively. Two maize seeds were planted per hole. Maize seeds were sown on the 25th of 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 mixed with soil and the maize seed 3 cm 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 4 cm 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.

2.2 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 their mean was considered a sample for the bed. 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 circumference (c) was measured at 2/3 the plant height and using the relationship given below to estimate the stem diameter (d)

$$d = \frac{c}{\pi}$$

where π ≈3.14 and c = circumference of the maize stem.

Plant selection for sampling of 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 the Leaf Area Index using the expression below

$$LAI = LWK$$

where L= Length of leaf, W = Width of leaf. K = constant ≈ 0.75 [14]. Plant selection for sampling of LAI 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 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. Categorization of the maize stem was made based on the size of the maize stem, number of stem borer exit holes and number of damaged leaves.

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.

2.3 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 (0 g 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].

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 225.8 cm (172.0 – 293.0) resulted from treatment of 12 g NPK per plant while the smallest plant 157.9 cm (109.0 – 206.0) resulted from treatment

Table 1. ANONA analyses for maize growth and yield parameters

Parameter	Source of Variation	Degree of freedom (Df)	Sum of squares	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			

Table 2. Results of agronomic parameters

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

Means in the same column with the same letter are not significantly different (P>.05) using Duncan's Multiple Range test. (sem – standard error of means, LAI – leaf area index) with no fertilizer. The mean plant height showed a progressive increase from 4 g NPK (212.1), 8 g NPK (219.6) and 12 g NPK (225.0) treatments though not significant different, however significantly different from that of 0 g 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 20 kg/ha, 40 kg/ha and 60 kg/ha of NPK fertilizer but significantly different from plant height of 0 kg/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 2.31 cm (1.6 – 2.9) and 2.32 cm (1.8 – 2.7) was recorded from plant treated with 12 g and 8 g of NPK per plant respectively. The smallest stem diameter 1.8 cm (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 developed thin and spindly stems. They further explained that such stems were 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 with respect to leaf area index (LAI). The LAI 646.12cm2 (348.0 – 948.0) was the highest from maize treated with 8 g of NPK per plant, though not significantly different (P > .05) from the LAI of maize treated with 12 g of NPK per plant. The smallest LAI 313.0 cm2 (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 increased NPK fertilizer level (Table 2). The highest mean plant height vigour 4.2 (3.8 – 4.6) was recorded from maize plants treated with 12 g 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 previous experiment [26], plant vigour had the same results and it was 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 plants with increased plant vigour (that is increased N) tend 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.

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 8 g 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 increased dose of 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 from 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 Fig. 1. This study indicates that 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 2.4 Kg (1.6 – 3) was recorded from plants treated with 12 g NPK fertilizer per plant. The lowest mean 1.1 kg (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 increased yield with increased dose of fertilizer [21,23,24,27]. However this increase in mean weight of maize harvested is not sustained beyond certain doses of NPK fertilizer. [21,28] reported that beyond 90 – 92 Kg of NPK/ha, maize yield did not significantly increase.

The correlation analysis reveals that there is a strong positive correlation [r(16) = 0.75, *P* = .01) between plant vigour and mean weight of harvested maize (Fig. 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.

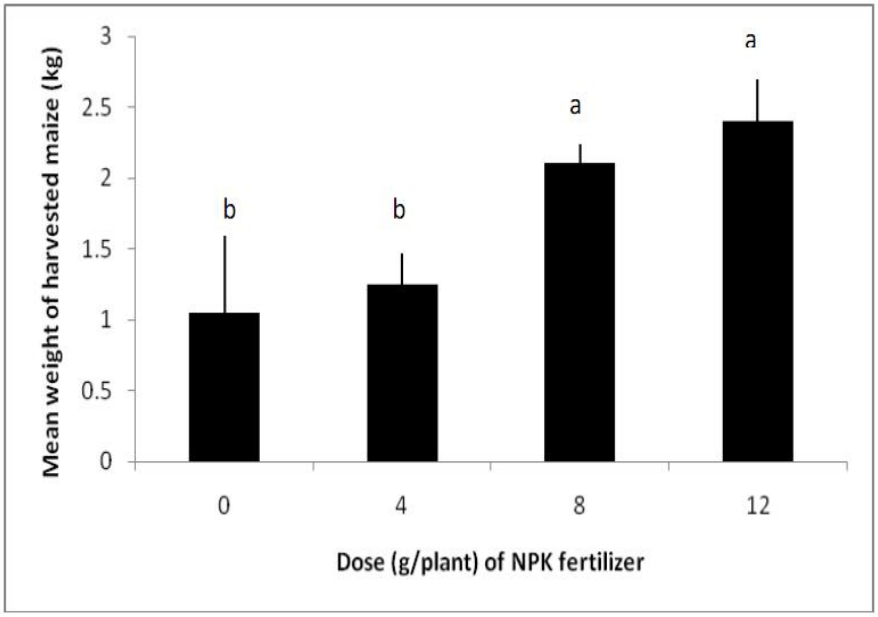

Fig. 1. The effect of different dose of NPK fertilizer on maize yield

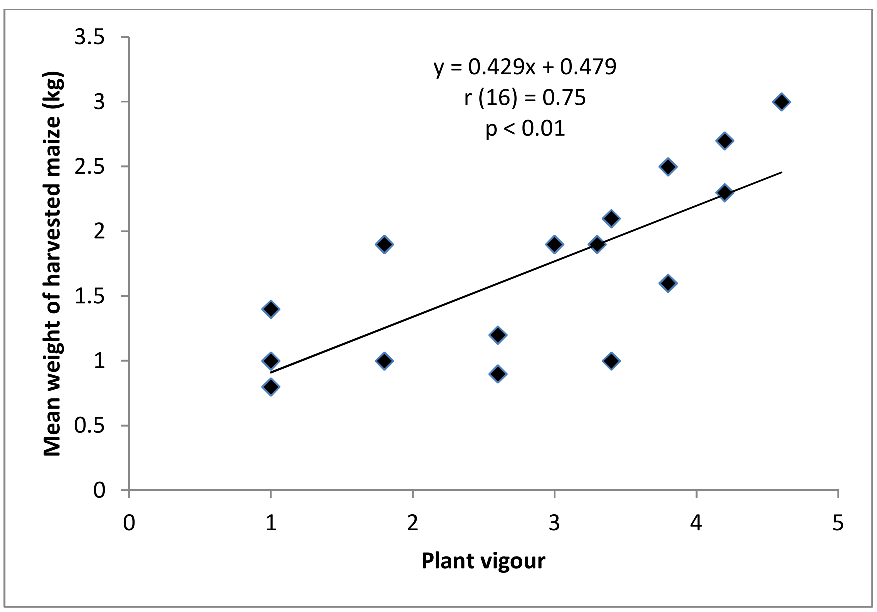

Fig. 2. Correlation between plant vigour and yield of maize

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 12 g 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.

ACKNOWLEDGEMENT

The authors are extremely grateful to the farmers of Bali Nyonga who unreservedly shared their knowhow.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Amusa NA, Iken JE. Maize research and production in Nigeria. African Journal of Biotecnology. 2004;3(6):302-307.
2. Abu GA, Demo-Choumbou RF, Okpacu SA. Evaluating the constraints and opportunities of maize production in the west region of Cameroon for sustainable development. Journal of Sustainable Development in Africa. 2011;13(4):189-197.
3. Downsell CR, Paliwal RL, Cantrell RP. Maize in the third world. Winrock Development – Orientated Literature Studies. Boulder Colorado. West View Press. 1996;1–37.
4. Muthukumar VB, Velayudham K, Thavaprakaash N. Plant growth regulators and split application of nitrogen improves the quality parameters and green cob yield of baby corn (*Zea mays* L). Journal of Agronomy. 2007;6(1):2008-2011.
5. Khalily M, Moghaddam M, Kanouni H, Asheri E. Disections of drought stress as a grain production constraint of maize in Iran. Asian Journal of Crop Science. 2010;2(2):60-69.
6. Wondesen T, Sheleme B. Identification of growth limiting nutrients in Alfisols: Soil physic-chemical properities, nutrient concentrations and biomass yield of maize. American Journal of Plant Nutrient Fertilization and Technology. 2011;1(1):23-35.
7. Guei RG, Barra, Abdoulage, Silue D. Promoting smallholder seed enterprises: Quality seed production of rice, maize, sorghum and millet in northern Cameroon. International Journal of Agricultural Sustainability. 2011;9(1):91-99.
8. Buah SSJ, Marinkaara S. Response of sorghum to nitrogen fertilizer and plant density in the Guinea Savanna Zone. Journal of Agronomy. 2009;8(4):124-130.
9. Hefny M, Aly AA. Yielding ability and nitrogen use efficacy in maize in bred lines and their crosses. International Journal of Agricultural Research. 2008;3(1):27-39.
10. Onasanya RO, Aiyelani OP, Onasanya A, Oikeh S, Nmilene FE, Oyelakin OO. Growth and yield response of maize (*Zea mays* L) to different rates of nitrogen and phosphorus fertilizers in southern Nigeria. World Journal of Agricultural Sciences. 2009;400-407.
11. Masaka J. The effect of N fertilizer placement and timing on the above ground Biometric characteristic of spring wheat (*Triticum aestivum* L) on leached chernozem. International Journal of Agricultural Research. 2003;11(1):G8-75.
12. International Institute of Tropical Agriculture (IITA). Maize (*Zea mays*. L); 2010.
Available:www.lit.org
(Accessed: 05/01/2015)
13. Ndioro M. Highland maize breeding, Bambui. IRA/NCRE.ISSN.1017-6217; 2004.
14. Amanullah KH, Marwat KB, Shah P. Nitrogen levels and its time of application influence leaf area, height and biomass of maize planted at low and high density. Pakistan Journal of Botany. 2009;41:761–768.

15. Jones JB, Eck HV. Plant analysis as an aid in fertilizing corn and grain sorghum. *In* Soil Testing and Planting Analysis. Revised eds: L. M Walsh and J. D Beaton. Soil Science Society of America, Madisson, WI. 1973;349–364.
16. Goyal SS, Huffaker RC. Nitrogen toxicity in plants. *In* Nitrogen in Crop Production, ed. Hauck, R. D. American Society of Agronomy. Madison, WI. 1984;97-118.
17. Gasser JKR. Urea as a fertilizer. Soil Fert. 1964;27:175–180.
18. Wilkinson SR, Ohlrogge AJ. Influence of Biuret on corn plant growth and development. Agronomy Journal. 1960;52: 560-562
19. Court MN, Stephen RC, Waid JS. Toxicity as a cause of inefficiency of urea as a fertilizer. The Journal of Soil Science. 1964;15:42–65.
20. Bremmer JM, Krogmeier MJ. Evidence that the adverse effect of urea fertilization on seed germination in soil is due to ammonia formed through hydrolysis of urea by soil urease. Agricultural Science. 1989;86: 8185–8188.
21. Selassie YG. Te effect of N fertilizer rates on agronomic parameters, yield components and yields of maize grown on Alfisols of North-Western Ethiopia. Environmental Systems Research. 2015;4(21):1-7.
22. Umeri C, Moseri H, Onyemekonwu RC. Effects of nitrogen and phosphorus on the growth performance of maize (*Zea mays*) in selected soils of Delta State, Nigeria. Advances in Crop Science and Technology. 2016;4(1):1–3.
23. Abera K. Growth, productivity and nitrogen use efficiency of maize (*Zea mays* L) as influenced by rate and time of nitrogen fertilizer application in Haramaya District, Eastern Ethiopia; 2013.
24. Law-Ogbomo K, Law-Ogbomo JE. The performance of *Zea mays* as influenced by NPK fertilizer application. Notulae Scientia Biologicae. 2009;1(1):59–62.
25. Brady NC, Weil RR. Elements of the nature and property of soil. Printice- Hall Inc, Upper Saddle River. 2000;12.
26. Sangoi L. Understanding plant density effects on maize growth and development; and important issue to maximize grain yield. Cenlia Rural. 2000;31(1):159-168.
27. Workayehu T. Effect of N fertilizer rates and plant density on grain yield of maize. African Journal Crop Science Journal. 2009;8(2):273–282.
28. Woldesentbet M, Haileyesus A. Effect of nitrogen fertilizer on growth, yield and yield components of maize (*Zea mays* L.) in Deacha District, Southwestern Ethiopia. International Journal of Research – Granthaalayah. 2016;4(2):95-100.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/23271