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The Effect of Different Rates of Nitrogen Fertilizer and Cow Dung on Yield and Yield Components of Maize Varieties (*Zea mays* L.) in Mubi, Adamawa State, Nigeria

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Field experiments to study the performance of maize varieties (*Zea mays* L.) under different rates of nitrogen fertilizer and cow dung in Mubi, Adamawa State, Nigeria were conducted in 2014 and 2015 cropping seasons at the Food and Agricultural Organization/Tree Crops Plantation (FAO/TCP) Farm of the Faculty of Agriculture, Adamawa State University Mubi. A split plot design was adopted for the study with two maize varieties assigned to the main plots and nitrogen with cow dung assigned to the subplots in a factorial combination. Nitrogen rates of 0, 60 and 120 kg N ha^{-1} and cow dung 0, 1 and 2 ton ha^{-1} were used. Data were collected on number of cobs per plant, cob length, 100 grain weight and grain yield per hectare. Data collected were subjected to analysis of variance using SAS system for windows 9.2 version 2005 and treatment means were separated using Duncan Multiple Range Test. Result showed that the effect of nitrogen fertilizer on the yield and yield parameters increased significantly with the use of 120 kg N per ha^{-1} recording the highest for cob length (17.68 cm) 100 grain weighs (32.89 g) and grain yield (5658.3 kg). The control plot produced the least. Application of 2 ton ha^{-1} cow dung exhibited the highest yield. there was an interaction of variety with nitrogen on cob length and grain yield. Application of 120 kg N ha^{-1} significantly increased the yield of Quality Protein Maize (QPM) along with 2 ton ha^{-1} cow dung.

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1. INTRODUCTION

Maize (*Zea mays* L.) is among the first three most important cereal crops grown in the world, coming after wheat and rice [1,2] and the most important cereal crop in the farming systems of the savanna zone of Nigeria [3].

Maize is a good source of energy for humans and animals and has been discovered to be very easy to process and readily digestible [4]. Due to its expanded use in agro industries, it is recognized as a leading commercial crop of great agronomic value [5]. Of utmost importance is the protein component of quality protein maize (QPM) which contains double amount of lysine and arginine, higher levels of tryptophan and cystein and no change in either amino acid except lower levels of leucine.

In recent years, the focus of soil fertility research has been shifted towards the combined application of organic and inorganic fertilizers as a way to arrest the ongoing soil fertility decline in sub-Saharan Africa [6]. The organic sources can reduce the dependency on costly fertilizers by providing nutrients that are either prevented from being lost (recycling) or are truly added to the system (biological N- fixation). When applied repeatedly, the organic manure leads to build-up of soil organic matter, thus providing a capital of nutrient that are slowly released [7] and at the same time increasing the soils buffering capacity for soil chemical reactions [8].

Nitrogen is an essential macro nutrient needed by all plants to thrive. It is an important component of many structural, genetic and metabolic compounds in plant cells. It is also one of the basic components of chlorophyll; the compound by which plants use sunlight energy to produce sugars during the process of photosynthesis. When there are high levels of nitrogen in crops, it promotes vegetative growth at the expense of yield. On the other hand with nitrogen deficiency, the plants leaves may turn yellow and drop [9].

The utilization of cattle manure as a soil amendment is an integral part of the Nigerian Guinea Savanna farmers [10,11]. However, information that is lacking to most farmers is the methods of manure management practices, rate and time of application for optimum crop production.

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was conducted at the Food and Agricultural Organization/Tree Crops Plantation (FAO/TCP) Farm of Faculty of Agriculture, Adamawa State University, Mubi, Nigeria. Mubi is located at latitude $10^{o}15^{1}$N and longitude $13^{o}16^{1}$E at an altitude of 696 m above sea level. Metrological information during the period of experiment was obtained in the metrological unit of the Adamawa State University Mubi.

2.2 Soil Sampling

Soil Samples were collected using soil augar at a depth of 0-15 cm randomly in the field at 10 different points. The physical and chemical properties of the soil, soil texture, soil pH, organic carbon, cation exchange capacity, total nitrogen and available phosphorus, potassium, magnesium, sodium and calcium were determined.

2.3 Land Preparation, Sowing and Experimental Design

Land for the experiment was ploughed using tractor; the field was pulverized with hoe and later leveled to make it suitable for seed germination and establishment. The land was then marked into plots and replicates. Total land area per experiment was 30.5 m x 31 m which gave 945.5 m^2. Gross plot size was 4.5 m x 3 m (13.5 m^2) and net plot size of 1.5 m x 3 m which gave 4.5 m^2, with path ways of 0.5 m between plots and 1 m between replications.

Sowing for 2014 and 2015 rainy season were done on 9th July, 2014 and 3rd July, 2015, respectively. Two seeds of each of the maize varieties were sown per hole using the spacing of 0.75 m x 0.25 m and the plants were later thinned to a plant per stand at two weeks after sowing (WAS) to give a plant population of 53,333.33 plants ha^{-1} .

A split plot design was used with two maize varieties; Extra Early White (EEW) and Quality Protein Maize (QPM Oba 98) on main plot with mixture in all possible combination of three levels of nitrogen (0, 60 and 120 kg/ha^{-1}) and three levels of cow dung (0, 1 and 2 ton/ha^{-1}) on the sub plot replicated three times.

2.4 Fertilizer Application

Nitrogen fertilizer was applied in two split doses, first dose was applied together with cow dung at 3 WAS. The source of the first dose of N was from NPK (15-15-15). The NPK (15-15-15) also supplied the recommended 26 Kg ha^{-1} P and 50 kg ha^{-1} k. Thereafter, the second dose of N was applied at 5 WAS through Urea.

2.5 Weed and Pest Control

Weeds on the field were controlled by applying pre-emergence glyphosate (N-(phosphonomethyl) glycine), one litre before ploughing and atrazine (6 chloro-N-ethyl-N^1-(1methyl ethyl) at rate of 2.4 kg/ha^{-1} immediately after sowing. Spraying of the herbicides were done using knapsack sprayer CP 15. This was supplemented by hand hoe at 3 and 9 WAS to keep the plots free from weeds. Chemical disodium octaborate tetrahydrate (DOT) was used to control termites which were noticed in some plots.

2.6 Data Collection

Data were collected on the following parameters:

2.6.1 Number of cobs per plant

Cobs of five tagged plants from each plot were counted and the mean determined and recorded.

2.6.2 Cob length

Lengths of five cobs from the tagged plants in each plot were measured and the mean determined and recorded.

2.6.3 100 grain weight

After harvest and threshing of cobs, 100 grains per net plot were counted, weighted and values recorded.

2.6.4 Grain yield per hectare

Net plot cobs were harvested and grain weights were converted to yield per hectare using the following equation:

2.7 Data Analysis

Data collected was subjected to analysis of variance (ANOVA), using SAS system for windows 9.2 version 2005 and treatment means were separated using Duncan's Multiple Range Test (DMRT) at 5% level of probability.

3. RESULTS

3.1 Number of Cobs Per Plant

The effect of nitrogen and cow dung on number of cobs per plant of maize in 2014 and 2015 cropping seasons and the combined showed that there was no significant difference between the varieties in the seasons. Similarly, there was no significant effect of nitrogen as well as cow dung on the varieties. Furthermore, no interactions between variety with nitrogen and variety with cow dung were recorded.

3.2 Cob Length

The effect of nitrogen and cow dung on cob length of maize in 2014 and 2015 cropping seasons and the combined showed no significant difference on the varieties.

There was a highly significant effect of nitrogen in the seasons and the combined. Application of 120 kg N ha^{-1} exhibited the highest cob length (17.51 cm, 17.84 and 17.68 cm) respectively, which was statistically similar to 60 kg N ha^{-1} and the smallest cob length was with the application of 0 kg N ha^{-1}. No significant effect of cow dung on cob length of maize in the season and the combined.

There was no interaction between varieties with nitrogen, nitrogen with cow dung and variety with nitrogen and cow dung, except in 2015 rainy season, where variety and nitrogen had an interaction effect.

In Table 1, the interaction that manifested the highest effect was, EEW with 120 kg N ha^{-1} (17.98 cm) followed by EEW 60 kg N ha^{-1} and smallest cob length was EEW 0 kg N ha^{-1} (14.02 cm).

3.3 Weight of 100 Grains

The effect of nitrogen and cow dung on 100 grain weight of maize in 2014, 2015 cropping seasons and the combined showed no significant difference between varieties.

There was a significant effect of nitrogen on 100 grain weight of maize in 2015 rainy season and the combined. Application of 120 kg N ha^{-1} exhibited the highest grain weight (32.89 g and 29.67 g) and was statistically similar to 60 kg N ha^{-1} and the smallest grain weight was with 0 kg N ha^{-1}.

There was no significant effect of cow dung on the varieties. No interaction effect of variety with nitrogen, variety with cow dung, nitrogen with cow dung recorded except for the three way interaction of variety, nitrogen, cow dung in the combined seasons. QPM with 60 kg N ha^{-1} with 2 ton ha^{-1} Cow dung exhibited the highest 100 grain weight (30.82 g) which was statistically similar to QPM 60 kg N ha^{-1} with 1 ton ha^{-1} cow dung (30.82 g) and the smallest 100 grain weight was EEW with 0 kg N ha^{-1} and 0 ton ha^{-1} cow dung (25.43 g) Table 2.

3.4 Grain Yield

The effect of nitrogen and cow dung on grain yield of maize in 2014 and 2015 cropping seasons and the combined is presented in Table 3. No significant difference in the varieties was recorded.

There was a significant effect of nitrogen in season and the combined. Application of 120 kg N ha^{-1} exhibited the highest grain yield (4100.0 kg, 5658.3 kg and 4878. 2 kg) respectively and was statistically similar to 60 kg N ha^{-1}, the smallest grain yield was with 0 kg N ha^{-1}. No significant effect of cow dung in the season and the combined.

There was no interaction between variety with nitrogen, variety with cow dung, nitrogen with cow dung, and variety with nitrogen with cow dung except in 2014 rainy season where highly significant interaction between variety with nitrogen was recorded. QPM with 120 kg N ha^{-1} exhibited the highest grain yield (4264.20 kg) followed by EEW with 60 kg N ha^{-1} (4066.67 kg) and the smallest grain yield was QPM with 0 kg ha^{-1} (3028.96 kg).

4. DISCUSSION

4.1 Effect of Nitrogen on the Yield of Maize

Maize is known to respond significantly to nitrogen. Nitrogen is among the macro nutrients needed for growth and development of maize, adequate supply of nitrogen will give a maximum economic yield, and when applied in excess will promote vegetative growth at the expense of

Table 1. Effect of nitrogen and cow dung on the number of cobs per plant of maize in 2014 and 2015 rainy seasons and combined

Treatment Varieties (V)	2014	2015	Combined
Extra Early White	1.01	1.01	1.01
Quality Protein Maize	1.08	1.00	1.04
Level of Significance	NS	NS	NS
SE±	0.02	0.01	0.01
Nitrogen (N)			
0	1.01	1.00	1.01
60	1.07	1.01	1.03
120	1.07	1.00	1.03
Level of Significance	NS	NS	NS
SE±	0.05	0.04	0.02
Cow dung (C)			
0	1.02	1.00	1.01
1	1.11	1.00	1.06
2	1.00	1.01	1.01
Level of Significance	NS	NS	NS
SE±	0.05	0.04	0.02
Interaction			
V x N	NS	NS	NS
V x C	NS	NS	NS
N x C	NS	NS	NS
V x N x C	NS	NS	NS

NS = Not Significant

Table 2. Effect of nitrogen and cow dung on 100 grain weight maize (g) in 2014 and 2015 rainy seasons and the combined

Treatment Varieties (V)	2014	2015	Combined
Extra Early White	26.01	30.62	28.32
Quality Protein maize	26.48	31.51	28.99
Level of Significance	NS	NS	NS
SE±	0.48	0.99	0.55
Nitrogen (N)			
0	25.73	26.01b	26.87b
60	26.57	32.30a	29.44a
120	26.44	32.89a	29.67a
Level of Significance	NS	**	**
SE±	0.47	1.05	0.58
Cow dung (C)			
0	26.42	31.23	28.83
1	26.51	30.58	28.55
2	25.81	31.38	28.59
Level of Significance	NS	NS	NS
SE±	0.47	1.05	0.58
Interaction			
V x N	NS	NS	NS
V x C	NS	NS	NS
N x C	NS	NS	NS
V x N x C	NS	NS	*

*Means in the same treatment group followed by the same letter are not significantly different using DMRT * = significantly at 5% using DMRT, ** = Highly Significant at 1% using DMRT, NS = Not Significant*

yield. As the plants increase in height and size, more photosynthetic area will be created, facilitating photosynthetic ability of the plants. Consequently, it leads to increase in yield and yield components. This collaborate with the findings of Aziz et al. [12] who reported that nitrogen increased the yield of maize plants, which also confirms with those of Khan et al. [13] and Ayuba et al. [14], who reported that yield increased with increased nitrogen rates. The results are in accordance with Ahmed and Benjamin [15] and Fagam et al. [16] that grain yield of a crop is the ultimate objective, thus, density and nutrient availability should be well considered. Increase or decrease in any of these factors may influence crop yield. Based on the study, the application of 120 kg N ha^{-1} significantly had an effect on the yield and yield parameters.

4.2 Effect of Cow Dung on the Yield and Yield Components of Maize

The significant effect of cow dung on the performance of maize may be due to the fact that when cow dung was applied to the soil, it mineralized to release nutrients and promote growth and yield. The findings collaborate with that of Jama et al. [17] that, the increased growth and yield of maize plant observed due to cow manure application could be related to ease of mineralization of the cow manure compared to other manures, that have resulted in greater improvement of the physical and chemical properties of the soil, likewise growth and yield of the maize plant. Udom et al. [18] also reported that the growth and yield of maize due to organic fertilization application enhancement soil properties such as decreased bulk density, improved moisture storage, increased organic matter contents and enhanced cation concentration. Earlier Lekasi et al. [19] reported a similar trend. The influence of cow dung on the growth and yield parameters may also be connected to the ability to greatly improve water holding capacity, soil aeration, soil structure, nutrient retention and microbial activity [20]. Where cow dung is in excess it may promote vegetative growth at the expense of yield as observed in the study. Similarly, cow dung has less effect on some growth parameters of maize such as, plant height, leaf area per plant and plant dried weight.

Table 3. Effect of nitrogen and cow dung on grain yield of maize ($KgHa^{-1}$) in 2014 and 2015 rainy seasons and the combined

Treatment Varieties (V)	2014	2015	Combined
Extra Early White	3960.9	4240.8	4100.9
Quality Protein maize	3706.8	4533.1	4119.9
Level of Significance	NS	NS	NS
SE±	146.29	174.50	113.85
Nitrogen (N)			
0	3454.6b	2662.5c	3058.6c
60	3946.9a	4902.6b	4424.8b
120	4100.0a	5658.3a	4879.2a
Level of Significance	**	**	**
SE±	155.99	223.45	135.89
Cow Dung (C)			
0	3773.5	4366.0	4069.8
1	4084.7	4164.8	4123.8
2	3643.2	4609.6	4126.4
Level of Significance	NS	NS	NS
SE±	155.99	223.45	135.89
Interaction			
V x N	**	NS	NS
V x C	NS	NS	NS
N x C	NS	NS	NS
V x N x C	NS	NS	NS

*Means in the same treatment group followed by the same letter are not significantly different using DMRT * = significantly at 5% using DMRT, ** = Highly Significant at 1% using DMRT, NS = Not Significant*

4.3 Interaction of Nitrogen and Cow Dung on Growth and Yield of Maize

The significant interaction of variety with N, V and C, with N with C might be attributed to varietal response to nutrients. Some varieties may respond very fast to nutrient while others may respond slowly. Similarly, the nature of the nutrient in nitrogen is fast released while nutrients available in cow dung are release slowly. The synergy between cow dung and nitrogen might promote growth and yield. Earlier Ahmed Khan et al. [21] reported a significant effect on maize grain yield with organic manure when amended with inorganic nitrogen. Their results confirm to the report of Mungendi et al. [22] who reported an increase in maize yield with combined use of organic and inorganic nitrogen nutrient. Consequently, in this study there were also interactions of nitrogen with cow dung on the growth parameters of maize: plant height, leaf area per plant, leaf area index and days to 50% tasseling. However, no interaction effect of nitrogen with cow dung on yield parameters. Furthermore, there were interaction effect of variety with nitrogen and cow dung on the following growth and yield parameter; plant height, leaf area per plant, leaf area index, plant dry weight and 100 grain weight. From this study, it is possible to infer that integrated application of organic and inorganic fertilizers increased crop yield.

5. CONCLUSION

The result had shown that Quality protein Maize (Oba 98) out yielded Extra Early White Maize. Application of 120 kg N ha^{-1} showed higher performance than organic fertilizer (cow dung). No combined effects on number of cobs per plant, cob length, 100 grain weight and grain yield of maize. This study suggests the planting of Quality Protein Maize and also suggests the application of 120 kg N ha^{-1}, to be supplemented with organic fertilizer (cow dung).

COMPETING INTERESTS

Author has declared that no competing interests exist.

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