International Journal of Plant & Soil Science

32(5): 94-103, 2020; Article no.IJPSS.55457
ISSN: 2320-7035

Growth and Yield Stability of Maize Varieties (*Zea mays* L.) as Affected by Different Rates of Nitrogen Fertilizer and Cow Dung in Mubi, Adamawa State, Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Author IA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author RI managed the analyses of the study and managed the literature searches. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2020/v32i530285
Editor(s):
(1) Dr. Francisco Cruz-Sosa, Metropolitan Autonomous University, México.
Reviewers:
(1) Lennin Musundire, South Africa.
(2) Binoy Chhetri, Uttar Banga Krishi Viswavidyalay, India.
(3) Moataz Eliw, Al-Azhar University, Egypt.
Complete Peer review History: http://www.sdiarticle4.com/review-history/55457

Original Research Article

Received 15 March 2020
Accepted 22 May 2020
Published 04 June 2020

ABSTRACT

A field experiment to study the growth and yield stability of maize varieties (*Zea mays* L.) to different rates of nitrogen fertilizer and cow dung in Mubi Adamawa State, Nigeria was conducted in 2014 and 2015 cropping seasons at the Food and Agricultural Organization/Tree crops Plantation (FAO/TCP) Farm of Faculty of Agriculture, Adamawa State University Mubi. Two maize varieties; viz. Quality Protein Maize (QPM) and Extra Early White (EEW) were selected for sowing. They were assigned to the main plots and nitrogen with cow dung assigned to the subplots in a factorial combination with nitrogen at the rates of 0, 60 and 120 kg N ha^{-1} and cow dung at 0, 1- and 2-ton ha^{-1} in split plot design. Data were collected on plant height, leaf area per plant, leaf area index and grain yield per hectare. Data collected were subjected to analysis of variance and treatment means were separated using Duncan Multiple Range Test. The result showed that EEW had the highest

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plant height (190.77 cm), higher leaf area per plant (535.6 cm^2) and leaf area index (0.40 cm) than QPM. The effect of nitrogen fertilizer on the growth and yield parameters increased as the nitrogen fertilizer was increased. 120kg N ha^{-1} gave the highest plant height (195.68 cm) and grain yield (5658.3 kg). The control plot produced the least; 164.77 cm (plant height) and 2662.50 kg ha^{-1} (grain yield). Application of 1ton ha^{-1} cow dung exhibited the highest plant height, (95.00 cm), leaf area per plant (518.91 cm^2) and leaf area index (0.37 cm). There was an interaction of variety with nitrogen on plant height and grain yield. High interaction of variety with cow dung on plant height and leaf area per plant was recorded. There was an interaction of nitrogen with cow dung on plant height, leaf area per plant and leaf area index. However, there was an interaction of variety with nitrogen and cow dung on plant height, leaf area per plant and leaf area index. Application of 120 kg N ha^{-1} significantly increased the yield of QPM maize along with 2-ton ha^{-1} of cow dung.

Keywords: Growth; yield; stability; varieties; nitrogen; cow dung.

1. INTRODUCTION

Maize has an erect solid stem, rather than the hollow stem of most other grasses and varies widely in height, some dwarf varieties being little more than 60cm at maturity whereas other types may be taller up to 193.63 cm. The main stalk terminates in a staminate in a male inflorescence or tassel which produces pollen grains [1]. Maize is a good source of energy for human, animal and has been discovered to be very easy to process and readily digestible [2]. Due to its expanded use in agro industries, it is recognized as a leading commercial crop of great agronomic value [3]. Maize is also widely believed to have the most significant potential among food crops for attaining technological breakthrough that will improve food production [4]. 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 [5]. 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 [6] and at the same time increasing the soils buffering capacity for soil chemical reactions [7].

The utilization of cattle manure as a soil amendment is an integral part of the Nigerian Guinea Savanna farmers [8,9]. The objective of the experiment is to study the growth and yield stability of maize varieties (*Zea mays* L.) to different rates of nitrogen fertilizer and cow dung in Mubi Adamawa State, Nigeria.

2. MATERIALS AND METHODS

2.1 Experimental Site

The site of the experiment was the Food and Agricultural Organization/Tree Crops plantation (FAO/TCP) Farm of Faculty of Agriculture, Adamawa State University, Mubi, Adamawa State Nigeria. Mubi is located at latitude 10^o15^1N and longitude 13^o16^1E at an altitude of 696m above sea level. Metrological information during the period of the experiment was obtained in the metrological unit of the Adamawa State University Mubi.

2.2 Soil Sampling

Soil Samples was collected using soil augar at a depth of 0-15 cm randomly in the field at ten 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.

However, the particle size distribution was analyzed using the Bouyoucos hydrometer method in which 0.5N sodium hexameter-phosphate was used as dispersant [10]. Sand fractions with higher density settle first allowing for the hydrometer measurement of silt and clay in suspension before sequential measurement of suspended clay following the settling of silt. Soil pH was determined by the electrometric method [11]. The electrometric method makes use of pH meter, which measures the electrical potential between a reference solution and the soil solution using glass electrode. The total nitrogen was determined using the modified Kjeldahl distillation method as described by Labconco [12]. The Total Kjeldahl Nitrogen (TKN) analysis determined both the organic and inorganic forms of nitrogen. Phosphorus was determined by digestion with perchloric acid ($HClO_4$) [10]. It is simpler and more suitable for routine procedure. Hydrofluoric acid (HF) + perchloric acid ($HClO_4$) digestion; is used to determine potassium. Sodium and calcium were determined by hydrofluoric and perchloric acid digestion. Cation exchange capacity was calculated as the sum of exchangeable basis (Ca, Mg, K and Na), as described by Juo [13]. Cation exchange capacity was determined by the conventional method [14], which is a measure of the soil's ability to hold positive charge ions.

The Soil was sandy loam with normal pH, low available nitrogen, medium phosphorus and high available potassium (Table 1).

2.3 Land Preparation, Sowing and Experimental Design

Land for the experiment was ploughed using a tractor. The field was pulverized with a 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 was 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 was 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 the main plot with a 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. The first dose was applied together with cow dung at three weeks after sowing (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 after that the second dose of N was applied at 5WAS through Urea.

2.5 Data Collection

Data were collected on the following parameters:

2.5.1 Plant height

At 3 and 6 WAS and harvest, heights of five randomly selected and tagged plants were determined from each plot. Meter rule was used in measuring the height (cm). Measurement started from the ground level to the end of the terminal bud, and the means determined and recorded.

Table 1. Physico-chemical properties of the experimental site at 0 – 15 cm depth

Physical Properties	2014	2015
Particle size analysis (%)		
Sand	55.20	59.30
Silt	32.60	30.60
Clay	12.20	15.10
Soil texture	Sandy loam	Sandy loam
Chemical Properties		
Soil pH 1:2 (H_20)	6.42	6.50
Organic carbon (kg^{-1})	4.10	3.75
Cat ion exchange capacity [cm01 (+) kg^{-1}]	3.10	3.25
Available nitrogen (g/kg^{-1})	0.20	0.21
Available phosphorus (mg/kg^{-1})	7.21	6.81
Available Potassium (Mg Pkg^{-1})	0.50	0.45
Available Magnesium [cmo1 (+) kg^{-1}]	7.21	6.81
Available sodium [cmo1 (+) kg^{-1}]	0.37	0.36
Available calcium [cmo1 (+) kg^{-1}]	2.20	2.16

2.5.2 Leaf area per plant

Was done at 3 and 6 WAS and at harvest. This was determined by measuring leaf length and width of five randomly selected and tagged plants from each plot and multiplying by 0.70 [15], which was measured with meter rule and the means determined and recorded.

2.5.3 Leaf Area Index (LAI)

This is the ratio of the total area of the leaves to the ground area occupied by the crop [16]. Thus, LAI was determined using the following equation: LAI = LA/GA where LA= leaf area and GA= ground area. This was done at 3 and 6 WAS and at harvest.

2.5.4 Grain yield ha-^{1}

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

$$\text{Grain Yield} = \frac{10{,}000\text{m}^2 \times \text{yield net plot (kg)}}{\text{Net plot (m}^2\text{)}}$$

2.6 Data Analysis

Data collected were 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 AND DISCUSSION

3.1 Plant Height

The effect of nitrogen and cow dung on plant height of maize at 3 and 6 WAS and at harvest in 2014 and 2015 rainy season is presented in Table 2. Highly significant ($P \leq 0.01$) difference between varieties was recorded at 3 WAS in 2014 rainy season and the combined. Quality Protein Maize (QPM) produced taller plants (21.97 cm) than Extra Early White (EEW) (20.58 cm) in 2014. QPM (19.21 cm) and EEW (18.41cm) showed highly significant difference in 2015 (in the combined). At 6 WAS in both seasons and the combined, there was no significant difference. At harvest in the seasons and combined EEW produced taller plants than QPM.

Table 2 shows no significant ($P > 0.05$) effect of nitrogen in both seasons and the combined at 3 WAS. Highly significant ($P \leq 0.01$) effect was recorded in both the seasons and the combined at 6 WAS and also at harvest. Application of 120 kg N ha^{-1} produced taller plants at 6 WAS (99.51 cm, 85.92 cm and 92.72 cm), and at harvest (195.68 cm, 190.33 cm and 193.00 cm) respectively and were statistically similar to that of 60 kg N ha^{-1}. Shorter plants were obtained from 0 kg N ha^{-1}.

Fagam et al. [17] reported that, QPM variety produced taller plants which may be due to genetic makeup and/or influence of the environment. The result of this study is also in line with that of Yahaya [18] and Olakanle [19] that maize varieties vary in their height performance.

3.2 Leaf Area per Plant

The effect of nitrogen and cow dung on leaf area per plant of maize at 3 and 6 WAS and at harvest in 2014 and 2015 rainy seasons and the combined is presented in Table 3. At 3 WAS in the seasons and the combined, there was no significant difference between the varieties. Similarly, at 6 WAS in 2014 rainy season and the combined, no significant differences were recorded as well as at harvest in 2015 rainy season and the combined. However, EEW manifested higher leaf area at 6 WAS and at harvest in 2015 and 2014 (565.40 cm^2 and 531.61 cm^2) respectively.

Highly significant effect of nitrogen on leaf area per plant was recorded at 6 WAS in all the seasons and the combined and at harvest in 2015 and the combined. Application of 120 kg N ha^{-1} produced higher leaf area per plant which were 476.42 cm^2, 623.11 cm^2, 549.77 cm^2 at 6 WAS and 528.57 cm^2, 677.34 cm^2 and 602.96 cm^2 at harvest. These were statistically similar to 60 kg N ha^{-1} and 0 kg N ha^{-1}. There was no significant effect of nitrogen on leaf area per plant at 3 WAS in the seasons and combined and at harvest in 2014 rainy seasons.

There was no significant effect of cow dung at 3 WAS in the seasons, except in the combined. At 6 WAS, however, there were significant differences in 2014 and the combined. Application of 1-ton ha^{-1} cow dung exhibited higher leaf area per plant. Leaf area per plant recorded was 103.85 cm^2, 462.38 cm^2 and 518.91 cm^2.

This collaborates with the findings of Aziz et al. [20] who reviewed that, nitrogen increased leaf area of maize plants. This also confirms with those of khan et al. [21] and Ayuba et al. [22], who reported that leaf area increases with increase nitrogen rate. The results are also in accordance with Ahmed and Benjamin [23].

3.3 Leaf Area Index (LAI)

The effect of nitrogen and cow dung on leaf area index (LAI) of maize at 3 and 6 WAS and at harvest in 2014 and 2015 rainy seasons and the combined is presented in Table 4. No significant differences between varieties on LAI in all the seasons and combine at 3, and 6 WAS and at harvest in the seasons, except in 2014 rainy season and combine (at harvest) where EEW had the highest LAI (0.40 and 0.37) than QPM.

There was no significant effect of nitrogen at 3 WAS in all the season and combine. Similarly, a highly significant effect of nitrogen was recorded at 6 WAS and at harvest in all the seasons and combine. Application of 120 kg N ha^{-1} manifested the highest LAI (0.36, 0.32, 0.34, 0.37. 0.36 and 0.37) respectively and was statistically similar to 60 kg N ha^{-1}. The smallest LAI was obtained in the application of 0 kg N ha^{-1}. Massignam et al. [24] reported that under nitrogen limitation, LAI was reduced in maize apparently to match nitrogen demand and nitrogen uptake. There was a progressive increase in LAI as nitrogen was increased.

No significant effect of cow dung was recorded at 3 and 6 WAS and at harvest in the seasons and combine, except at 3 WAS and at harvest in combine seasons. 1-ton ha^{-1}cow dung exhibited the highest LAI (0.07 and 0.37) which were statistically similar to 2-ton ha^{-1} cow dung. The smallest LAI was 0-ton ha^{-1} cow dung. Mahadi et al. [25] observed that the application of cow dung manure increased the LAI of maize.

Table 2. Effect of Nitrogen and cow dung on plant height (cm) of maize (*Zea mays* L.) in 2014 and 2015 rainy seasons and the combined

Factors	3 WAS			6 WAS			At harvest		
	2014	2015	Combined	2014	2015	Combined	2014	2015	Combined
Varieties (V)									
EEW	20.58	16.25	18.41	91.36	79.74	85.55	193.63	187.91	190.77
QPM	21.97	16.45	19.21	90.84	80.48	85.68	176.66	175.38	176.02
Level of significance	**	NS	**	NS	NS	NS	**	**	**
SE±	2.49	0.76	1.30	2.67	5.61	3.11	2.90	8.96	4.71
Nitrogen									
0	93.16	16.07	54.62	81.76	67.8b	74.79	177.12	164.77	170.95
60	100.36	16.58	58.47	92.89	86.58	89.74	187.39	189.83	188.61
120	104.31	16.40	60.36	99.51	85.92	92.72	195.68	190.33	183.01
level of significance	NS	NS	NS	**	**	**	**	**	**
SE±	1.98	0.43	1.01	2.32	1.97	1.52	2.33	3.60	2.14
Cow dung									
0	96.91	15.45	56.18	83.63	76.38	80.01	181.54	182.85	182.19
1	100.10	17.14	58.62	95.00	82.60	88.80	186.36	179.41	182.89
2	100.82	16.45	58.64	94.72	81.35	88.04	187.55	182.67	185.11
level of significance	NS	**	NS	**	NS	**	NS	NS	NS
SE±	1.98	0.43	1.01	2.32	1.97	1.52	2.33	3.60	2.14
Interaction									
V x N	*	NS	**	NS	NS	NS	NS	NS	NS
V x C	**	NS	NS	NS	NS	NS	NS	NS	NS
N x C	NS	NS	NS	**	NS	**	**	NS	NS
V x N x C	NS	NS	NS	NS	NS	NS	NS	NS	**

*Means in the same treatment group followed by the same letter are not significantly different using DMRT, * = significant at 5 % using DMRT, ** = highly significant at 1% using DMRT, ns = not significant*

Table 3. Effect of nitrogen and cow dung on leaf area per plant (cm^2) of maize (*Zea mays* L.) in 2014 and 2015 rainy seasons and the combined

Factors	3 WAS			6 WAS			At Harvest		
	2014	**2015**	**Combined**	**2014**	**2015**	**Combined**	**2014**	**2015**	**Combined**
Varieties(V)									
EEW	101.79	95.95	98.87	433.19	565.40	499.30	535.61	644.40	590.00
QPM	101.97	90.87	96.42	420.49	423.16	421.83	475.00	608.82	541.91
Level of Significance	NS	NS	NS	NS	**	NS	**	NS	NS
SE±	8.54	4.47	4.82	19.42	25.34	15.96	8.37	54.27	27.45
Nitrogen									
0	96.01	88.63	92.32	335.95	488.21	412.08	478.32	421.38	499.85
60	103.88	99.99	101.94	468.15$_a$	581.52	524.84	509.01	681.10$_a$	595.06
120	105.69	91.61	98.65	476.42	623.11	549.77	528.57	677.34	602.96
Level of Significance	NS	NS	NS	**	**	**	NS	**	**
SE±	4.38	6.24	3.81	20.81	16.48	13.27	16.01	17.29	11.78
Cow dung									
0	93.73	85.85	89.79	381.42	525.27	453.70	485.35	621.86	553.60
1	105.18	102.52	103.85	462.38	575.44	518.91	524.95	650.25	587.60
2	106.73	91.86	92.29	436.71	531.44	484.08	502.62	607.70	556.66
Level of Significance	NS	NS	**	**	NS	**	NS	NS	NS
SE±	4.38	6.24	3.81	20.81	16.48	13.27	16.01	17.29	11.78
Interaction									
V x N	NS	NS	NS	NS	NS	NS	NS	NS	NS
V x C	NS	NS	NS	*	NS	NS	NS	NS	NS
N x C	NS	NS	NS	**	NS	NS	*	NS	NS
V x N x C	NS	NS	NS	NS	NS	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*

3.4 Grain Yield

The effect of nitrogen and cow dung on grain yield of maize in 2014 and 2015 rainy seasons and the combined is presented in Table 5. 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 (4100.00 kg, 5658.30 kg and 4878.20 kg), respectively and was statistically similar to 60 kg N ha^{-1}. The smallest grain yield was with 0 kg N ha^{-1}. There was 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 and cow dung except in 2014 rainy season, where highly significant interaction between varieties with nitrogen was recorded.

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 nutrient and promote growth and yield. The findings collaborate with that of Jama et al. [26] 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. This has resulted in greater improvement of the physical and chemical properties of the soil, likewise growth and yield of the maize plant. Udom et al. [27] also reported an increase in the yield of maize due to organic fertilization and related it to enhancement of soil properties such as decreased bulk density, improved moisture storage, increased organic matter contents and enhanced cation

Table 4. Effect of nitrogen and cow dung on leaf area index (cm) of maize in 2014 and 2015 rainy seasons and the combined

Factors	3 WAS			6 WAS			At harvest		
	2014	2015	Combined	2014	2015	Combined	2014	2015	Combined
Varieties (V)									
EEW	0.08	0.05	0.06	0.32	0.29	0.31	0.40a	0.34	0.37
QPM	0.08	0.04	0.07	0.30	0.28	0.29	0.36	0.32	0.34
Level of Significance	NS	NS	NS	NS	NS	NS	**	NS	**
SE±	0.06	0.02	0.03	0.09	0.01	0.08	0.04	0.03	0.05
Nitrogen (N)									
0	0.07	0.05	0.06	0.25	0.23	0.27	0.37	0.28	0.33
60	0.07	0.05	0.06	0.34	0.31a	0.32	0.39	0.36	0.38
120	0.08	0.05	0.07	0.36	032	0.34	0.37	0.36	0.37
Level of Significance	NS	NS	NS	**	**	**	**	**	**
SE±	0.04	0.03	0.02	0.02	0.01	0.01	0.09	0.09	0.06
Cow dung (C)									
0	0.07	0.05	0.06	0.29	0.28	0.29	0.37	0.33	0.35
1	0.08	0.05	0.07	0.32a	0.29	0.31	0.39	0.35	0.37
2	0.08	0.05	0.07	0.33	0.28	0.31	0.39	0.32	0.36
Level of Significance	NS	NS	**	NS	NS	NS	NS	NS	**
SE±	0.04	0.03	0.01	0.02	0.1	0.1	0.09	0.09	0.06
Interaction									
V x N	NS	NS	NS	NS	NS	NS	NS	NS	NS
V x C	NS	NS	NS	NS	NS	NS	NS	NS	NS
N x C	NS	NS	NS	**	NS	NS	**	NS	NS
V x N x C	**	NS	NS	NS	NS	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*

Table 5. Effects of Nitrogen and cow dung on grain yield of maize ($KgHa^{-1}$) in 2014 and 2015 rainy seasons and the combined

Factors	2014	2015	Combined
Varieties (V)			
Extra Early White (EEW)	3960.90	4240.80	4100.90
Quality Protein Maize (QPM)	3706.80	4533.10	4119.90
Level of Significance	NS	NS	NS
SE±	146.29	174.50	113.85
Nitrogen (N)			
0	3454.60	2662.50	3058.60
60	3946.90	4902.60	4424.80
120	4100.00	5658.30	4879.20
Level of Significance	**	**	**
SE±	155.99	223.45	135.89
Cow dung (C)			
0	3773.50	4366.00	4069.80
1	4084.70	4164.80	4123.80
2	3643.20	4609.60	4126.40
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* concentration. Earlier, Lekasi et al. [28] reported 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 [29]. 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 like plant height and leaf area per plant [30].

4. 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), even though some parameters like plant height, leaf area per plant, leaf area index and plant yield were significantly affected by cow dung. There was combined effect of nitrogen with cow dung on plant height, leaf area per plant and leave area index and grain yield of maize.

5. RECOMMENDATIONS

Based on the result of this study and for higher yield and protein content, the 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

Authors have declared that no competing interests exist.

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