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PERFORMANCE OF MAIZE (*ZEA MAYS*) CULTIVARS AS INFLUENCED BY GRADE AND APPLICATION RATE OF ORGANO-MINERAL FERTILISER IN A TRANSITORY RAIN FOREST

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ABSTRACT

Field trials were conducted in a transitory humid rain forest, Abeokuta, Nigeria (Latitudes 7◦ 15'N, 3◦ 25'E, altitude 144 above sea level) in early wet cropping seasons of 2014 (site A) and 2015 (site B). The trials were aimed at investigating the effects of application rates of grades of organo-mineral fertiliser on maize (Zea mays)cultivars. The trials were in split-split plot arrangement fitted into randomised complete block design and replicated three times. In the main plot was variety {Oba super 2 (hybrid) and Suwan 1[open pollinated variety (OPV)]}, sub-plot consisted of grade of organo-mineral fertiliser (A, B, C), while the sub-sub plot was made of application rate (0, 2.5 and 5.0 t ha^{-1}). Oba super 2 had significantly (P< 0.05) more assimilatory surface, with more 100 grain (7.13 g) and ear weight (0.08 kg), harvest index (37.60 %) than OPV maize cultivar (Suwan 1) in 2015. Maize cultivars sown with grade B organo-mineral fertiliser had delayed tasselling (57.50 days) and silking (66.33 days) compared to when sown with other organo-mineral grades. Increasing application rates of organo-mineral fertiliser resulted in increased assimilatory surface and a higher grain yield and its attributes in both years.

Keywords: Hybrid, Open Pollinated Maize, Transitory Rain Forest, Silking, Tasselling

INTRODUCTION

In North America there has been a steady rise in the yield potential of hybrid maize compared to the open pollinated varieties (OPV) (Tollenaar and Lee, 2006). Genetic improvement in conjunction with good management practise have played a fundamental role on this increase (Tollenaar and Lee, 2006). The physiological basis that underpins this genetic improvement has been attributed to both canopy and root architecture, especially under high population density (Hammer *et al*., 2009). The hybrids have been characterised to have high yield potentials (Tollenaar and Lee, 2006) due mainly to higher assimilatory surfaces and high leaf angle that could facilitate diffusion of light into the lower portion of the canopy (Duncan *et al*., 1967). Other physiological basis has been reported to be linked to stay green leaf at the most critical stage of maize growth and increased duration of grain filling period (Tollenaar and Lee, 2006). Abayomi *et al*., (2006) reported that the yield advantage observed in the hybrid maize could be linked to their higher leaf growth, leaf area duration and effective leaf area than the OPV. However, among resource challenged farmers in the tropical region of Africa purchase of hybrid maize cultivar is beyond their financial means. Most have thus resolved to the use of OPV.

Humid rainforest is characterised by high precipitation and temperature. With climate change, it is expected that there would be variation in rainfall and temperature pattern. The variation in these environmental variables could be as a result of increased atmospheric carbon dioxide that accompanies climate change (Ainsworth, 2008). Under elevated carbon dioxide (CO_2) increased temperature could lead to increased evapotranspiration and a disruption in plant water balance, which will consequently affect the growth of maize at the most critical period. Maize has been reported to have low remobilisation efficiency and reduced plasticity of seed weight to assimilate availability especially under the influence of abiotic stress (Borrás *et al*., 2004), with the negative implication on its performance. Soils in humid rain forest are highly susceptible to leaching of macronutrients and are low in nutrient content due to intense weathering (Lathwell and Grove, 1986). Together this could compromise the growth and development of maize crop. The application of inorganic fertiliser is expensive and has the potential to negatively impact environment if not properly used. The low usage of inorganic fertiliser in some parts of the country was also ascribed to the educational status of farmers, farm size and contact with extension workers (Adenuga *et al*., 2012). Organic fertiliser can be used as an alternative solution to this problem, but their bulkiness and slow releasing property could pose a challenge. Reports have indicated that the use of organo-mineral fertiliser in maize and melon gave high relative agronomic efficiency, phosphorus recovery efficiency and added benefit than inorganic fertiliser in medium axicpaleustalf and weakly acid typicpaleudalf soil types (Akinrinde *et al*., 2005). Similar pattern was also observed on cucumber in the rainforest agroecology of Nigeria, where it was observed that they had the added benefit of retaining moisture in the soil (Olaniyi *et al*., 2009).

In order to address the problem of bulkiness of natural organic manures like poultry droppings and cow dungs, fertiliser companies have started producing organo-mineral fertilisers. However, few literatures exist on how different grades and application rates of organo-mineral fertiliser affect the performance of maize cultivar in a transitory rain forest. The availability of such information would shed more light on sustainable maize production. It would allow farmers to implement the right application rates of this type of organo-mineral fertiliser. It would provide information on the comparative agronomic advantage of hybrid maize and OPV in this zone.

MATERIALS AND METHODS

Characterisation of location and experimental site

Field experiments were conducted at the Teaching and Research Farm of Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State (Latitudes 7◦ 15'N, 3◦ 25'E, altitude 144 above sea level). They were conducted during the wet seasons at site A and B in the year 2014 and 2015 respectively in the same location. The agrometeological data were sourced from the Department of Agrometeorological and Water Management, Federal University of Agriculture, Abeokuta. Soil pH was determined using glass electrode pH-meter as described by McLean, (1982) in soil:water suspension (1:1). Soil organic carbon was determined using the wet oxidation method as described by Walkley and Black (Allison, 1965). Soil total nitrogen was determined using the modified micro Kjeldahl digestion technique (Jackson, 1962).Available phosphorus was determined according to Bray-1 method as described by Landor, (1991).

Experimental Treatments and Design

The treatments had three grades of organo-mineral fertilisers (A, B and C) that were applied at three rates (0, 2.5 and 5.0 t ha^{-1}) on two maize cultivars (Oba super 2 and Suwan 1). Oba super 2 was a hybrid while Suwan 1 was OPV maize. The field trial was a split-split plot arrangement fitted into randomised complete block design and replicated three times. The main plot consisted of cultivar, with grades of the organo-mineral fertiliser in the sub plot, while application rates were in the sub-sub plot. Organo-mineral fertiliser used was sourced from Gateway Fertiliser plant Kotopo, Abeokuta, Ogun State. The percentage of N in the organo-mineral fertiliser grades used was 5 %, 10 % and 15 % for grade A, B and C respectively. Application rate of 2.5 t ha^{-1} of organo-mineral fertiliser was equivalent to N application rates of 62.5 kg N ha^{-1}, 87.5 kg N ha^{-1}, and 110 kg N ha^{-1}for grade A, B and C respectively. While application rate of 5.0 t ha^{-1} of organo-mineral fertiliser was equivalent to N application rates of 125 kg N ha^{-1}, 175 kg N ha^{-1}, 220 kg N ha^{-1} for type A, B and C respectively. The control plot received no fertiliser application. There was variation in the chemical composition of the organo-mineral fertiliser used. The order of chemical composition of the major macro and micro nutrients was organo-mineral fertiliser grade C > B > A except Mg, where the order of nutrient composition was A > B > C. The pH of all the grades of organo-mineral fertilisers used was similar (Table 1).

Table 1: Chemical composition of organo-mineral fertilizer grades (A, B and C)

Variables / Grade	pH	Organic carbon g kg^{-1}	Total N g kg^{-1}	P cmol kg^{-1}	K cmol kg^{-1}	Ca cmol kg^{-1}	Mg cmol kg^{-1}	Na cmol kg^{-1}	Mn cmol kg^{-1}	Zn cmol kg^{-1}	Fe cmol kg^{-1}	Cu cmol kg^{-1}
A	7.8	6.88	2.5	1.73	0.54	0.16	0.19	0.45	0.13	0.03	0.07	0.05
B	7.2	7.03	3.5	2.00	0.56	0.17	0.18	0.44	0.12	0.03	0.07	0.03
C	7.9	7.18	4.4	2.22	0.62	0.18	0.17	0.50	0.13	0.03	0.09	0.04

Table 2: Pre-planting physical and chemical soil properties for 2014 and 2015 experimental site

Year	Clay %	Sand %	Silt %	Textural class	pH	Organic Carbon %	Total N %	P cmol kg^{-1}	K cmol kg^{-1}	Ca cmol kg^{-1}	Mg cmol kg^{-1}	Na cmol kg^{-1}	Mn cmol kg^{-1}	Zn cmol kg^{-1}	Fe cmol kg^{-1}	Cu cmol
2014	9.40	84.40	6.20	Sandy loam	6.4	0.456	0.147	0.64	0.02	0.01	0.01	0.05	0.02	0.01	0.01	0.01
2015	4.70	88.50	6.80	sandy	6.65	1.00	0.08	0.72	0.01	0.21	0.04	0.02	1.57	0.09	0.06	0.01

Cultural Practices

The field was ploughed twice and harrowed once. Planting was conducted on the 24th and 27th of June in the years 2014 and 2015 respectively. Planting materials were sourced from Ogun State Ministry of Agriculture, Asero, Abeokuta. Three seeds were sown per hole at a depth of 2 cm with a spacing of 75 × 50 cm. The seedlings were later thinned to 2 plants per stand 3 weeks after planting (WAP). Missing stands were supplied at this period. The organo-mineral fertiliser was applied 2 WAP. The gross plot size was 3 × 4 m, while the net plot size was 2 × 2 m. The plots were separated from each other by 0.5 m pathway while each block was separated by 1m. Weeding was done manually at 3 and 6 WAP.

Sampling and data collection

A composite soil sample was randomly collected at 0- 20 cm depth across the field to determine pre-planting physical and chemical properties of the soil at the experimental sites. All growth parameters were taken at 4, 8 and 12 WAP. Yield and its attributes were taken at physiological and harvest maturity. Five plants were randomly sampled from each net plot to determine growth, development, grain yield and its attributes. The growth parameters determined were leaf area, leaf area index and stover weight. Leaf area was determined according to the protocol proposed byDwyer and Stewart, (1986). Days to 50 % anthesis, days to 50 % silking, Anthesis-Silking Interval (ASI), cob length, cob girth, 100 grain weight, shelling percentage, harvest index and grain weight were determined according to standard agronomic practises.

Statistical analysis

Data collected were subjected to Mixed Model Analysis of Variance (ANOVA) for each year. Significant means were separated using Least Significant Difference (LSD) at 5 % probability level. Data collected were checked for the violation of ANOVA assumption visually by plotting residual against fitted values. Discrete data were transformed using square root transformation prior to analysis. The statistical package used for the analysis was GENSTAT 12th Edition (Payne *et al*., 2009).

RESULTS

Both years had similar temperature pattern during the cropping seasons (Fig.1). The mean temperature during the cropping season was in the range 27.5 ^{0}C (Nov)-25.6 ^{0}C (Aug). The cropping seasons at both years experienced bimodal rainfall pattern (Fig.2). Increase in the total rainfall experienced at the beginning of the cropping season (June) resulted in decrease in the intensity of rainfall at August (August break), with a subsequent increase in the amount rainfall which eventually declined in November in both years. During the 2014 cropping season, the highest amount of rainfall (205.9 mm) was observed in October (Fig.2). In the next cropping season the highest amount of rainfall (165.1 mm) was observed in September (Fig.2). Both years had the least amount of rainfall in November. The soil physical and chemical characteristics of the two sites used were slightly different (Table 2). Soil pH for both sites was similar (slightly acidic). The texture of site A used in 2014 was sandy loam, while that of site B used in 2015 was sandy. The amount of N present in the soil was 0.147 % and 0.08 % for the site A (2014) and B (2015) respectively. Conversely percentage organic carbon was more in B (1.00 %) than the site A (0.356 %). Similar pattern was observed on the amount of available P, Ca and Mg. More sodium (0.05cmol kg^{-1}) was observed in the site A than site B (0.02 cmol kg^{-1}). The amount of K present in the soil was 0.02 cmol kg^{-1} and 0.01 cmol kg^{-1} in site A and B respectively.

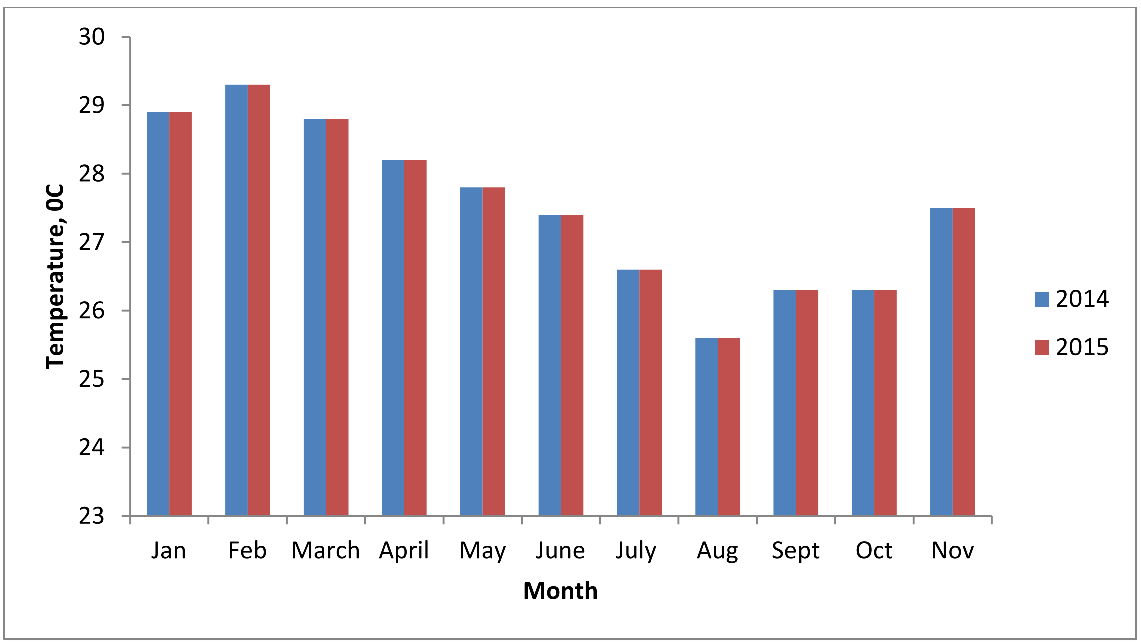

Figure 1: Temperature distribution for the years 2014 and 2015 cropping seasons

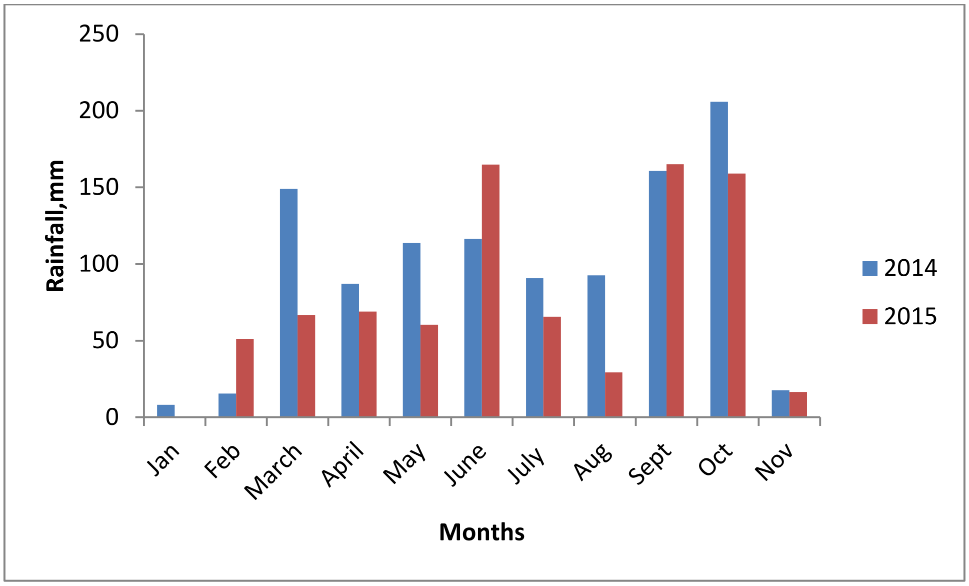

Figure 2: Rainfall distribution for the years 2014 and 2015 cropping seasons

There were no significant differences among the varieties on the leaf area at all sampling period in the year 2014 (Table 3). Similar pattern was observed on other vegetative (Table 4), phenological (Table 5) and reproductive growth (Tables 6 and 7) variables at all sampling period in the same year. The hybrid maize Oba super 2 had significantly (P< 0.05) higher leaf area (272.80 cm^2) than the OPV (186.10 cm^2) (Suwan 1) maize cultivar at 4 WAP in the year 2015 (Table 3). In the same year similar pattern was observed on harvest index (37.60 %) (Table 6), 100 grain weight (7.13 g), cob weight (0.08 kg) and grain yield (1655 kg ha^{-1}) (Table 7).

Fertiliser grades had significant effect on leaf area at 12 WAP (2014) in the order A > B > C (Table 3). In the same year maize cultivars sown with fertiliser grade B attained days to 50 % tasseling (57.50 days) and 50 % silking (66.33 days) later than those cultivars sown with other grades of organo-mineral fertilisers (Table 5). Maize cultivars sown with organo-mineral fertilisers grade A and C attained days to 50 % tasseling and days to 50 % silking respectively earlier than other maize cultivars sown with other grade of organo-mineral fertiliser (Table 5). Grades of organo-mineral fertilisers had no significant effect on grain yield and its components in both years (Tables 6 and 7).

In the year 2014 increasing application rates of organo-mineral fertiliser resulted in a significant increase in leaf area of maize cultivars at all periods of investigation (Table 3). Similar pattern was repeated in the following year except at 4 WAP where it was observed that applying organo-mineral fertiliser beyond 2.5 t ha^{-1} resulted in a significant decrease in leaf area (Table 3). Leaf area index in both years at all periods of investigation responded in a similar pattern to increasing application rates of organo-mineral fertiliser as leaf area (Table 4). It was observed that with increasing application rates of organo-mineral fertiliser maize cultivars attained days to 50 % tasseling earlier (both years). Similar pattern was observed on days to 50 % silking (2015). Maize cultivars had similar duration of anthesis-silking interval in year 2014, however no significant effect was observed on this variable in the following year with increasing application rates of organo-mineral fertiliser (Table 5). Increasing application rates of organo-mineral fertiliser resulted in an increased stover weight (2014 and 2015) and shelling percentage (2014). However, it was observed that at application rates of 2.5 t ha^{-1} and 5.0 t ha^{-1} maize cultivars displayed similar stover weights (2014 and 2015) and shelling percentage (2014) (Table 6). Cob weight, 100 grain weight and grain yield in both years increased with increasing application rates of organo-mineral fertiliser (Table 7).

Table 3: Effect of organo-mineral fertiliser grade and application rate on leaf area of maize cultivars at 4, 8, 12 WAP (2014 and 2015)

	2014			2015		
Treatments	Leaf area 4 WAP (cm^2)	Leaf area 8 WAP (cm^2)	Leaf area 12 WAP (cm^2)	Leaf area 4 WAP (cm^2)	Leaf area 8 WAP (cm^2)	Leaf area 12 WAP (cm^2)
Variety (V)						
Oba super 2	244.00	552.70	578.50	272.80	719.00	674.00
Suwan 1	203.50	515.90	522.40	186.10	681.00	633.00
LSD	NS	NS	NS	76.43*	NS	NS
Grades (G)						
A	248.80	564.70	595.10	220.00	694.00	660.00
B	220.30	541.10	530.20	233.60	732.00	662.00
C	202.20	497.20	526.10	234.70	674.00	638.00
LSD	NS	NS	55.07*	NS	NS	NS
Rates (R) (t ha^{-1})						
0	190.10	489.60	494.30	163.90	612.00	544.00
2.5	235.60	561.60	571.80	290.30	735.00	690.00
5	245.50	551.80	585.30	234.10	753.00	727.00
LSD	22.62**	27.46**	33.65**	33.27**	72.90**	50.80**
V × G	NS	NS	NS	NS	NS	NS
V × R	NS	NS	NS	NS	108.50*	84.20**
G × R	NS	NS	NS	58.74**	144.60*	109.70*
V × G × R	NS	NS	NS	NS	NS	146.80**

LSD-Least Significant Difference, NS-Not significant, WAP- Weeks after Planting, * $P < 0.05$, ** $P < 0.01$

Table 4: Effect of organo-mineral fertiliser grade and application rate on leaf area index of maize cultivars at 4, 8, 12 WAP (2014 and 2015)

	2014			2015		
Treatments	Leaf area index 4 WAP	Leaf area index 8 WAP	Leaf area index 12 WAP	Leaf area index 4 WAP	Leaf area index 8 WAP	Leaf area index 12 WAP
Variety (V)						
Oba super 2	0.58	1.84	0.15	0.62	2.32	2.01
Suwan 1	0.46	1.65	0.14	0.40	2.16	1.80
LSD	NS	NS	NS	NS	NS	NS
Grades (G)						
A	0.60	1.85	0.16	0.48	2.26	1.91
B	0.50	1.77	0.14	0.52	2.38	1.89
C	0.46	1.63	0.14	0.54	2.08	1.92
LSD	NS	NS	NS	NS	NS	NS
Rates (R)(t ha^{-1})						
0	0.40	1.52	0.13	0.37	1.90	1.58
2.5	0.56	1.85	0.15	0.63	2.42	2.07
5	0.59	1.88	0.16	0.54	2.41	2.07
LSD	0.07**	0.10**	0.01**	0.01**	0.31**	18.00**
V × G	NS	NS	NS	0.19**	NS	9.00**
V × R	NS	NS	NS	NS	0.43**	0.41**
G × R	NS	NS	NS	0.16**	NS	0.31**
V × G × R	NS	NS	NS	NS	NS	0.49**

LSD-Least Significant Difference, NS-Not significant, WAP- Weeks after Planting, * $P< 0.05$, ** $P< 0.01$

Table 5: Effect of organo-mineral fertiliser grade and application rate on days to 50 % tasseling, silking and Anthesis-silking interval of maize cultivars (2014 and 2015)

	2014			2015		
Treatments	Days to 50 % Tasseling (days)	Days to 50 % Silking (days)	Anthesis - silking interval (days)	Days to 50 % Tasseling (days)	Days to 50 % silking (days)	Anthesis-silking interval (days)
Variety (V)						
Oba super 2	56.00	62.44	6.44	59.52	69.74	10.22
Suwan 1	57.30	64.78	7.48	60.33	72.52	12.19
LSD	NS	NS	NS	NS	NS	NS
Grade (G)						
A	56.06	63.22	7.17	59.22	70.83	11.61
B	57.50	66.33	8.83	60.50	72.39	11.89
C	56.39	61.28	4.89	60.06	70.17	10.11
LSD	18.00*	2.83**	NS	NS	NS	NS
Rate (R) (t ha^{-1})						
0	57.33	64.89	7.56	61.61	74.33	12.72
2.5	56.33	62.61	6.28	58.72	70.28	11.56
5	56.28	63.33	7.06	59.44	68.78	9.33
LSD	18.00*	NS	2.07**	1.90**	2.13**	NS
V × G	NS	NS	NS	NS	NS	NS
V × R	NS	NS	NS	NS	NS	NS
G × R	NS	NS	NS	NS	NS	NS
V × G × R	NS	NS	NS	NS	8.40*	NS

LSD-Least Significant Difference, NS-Not significant, * *P*< 0.05, ** *P*< 0.01

Table 6: Effect of organo-mineral fertiliser grade and application rate on stover weight, shelling percentage and harvest index of maize cultivars (2014 and 2015)

	2014			2015		
Treatments	Harvest index (%)	Stover weight (kg ha^{-1})	Shelling percentage (%)	Harvest index (%)	Stover weight (kgha^{-1})	Shelling percentage (%)
Variety (V)						
Oba super 2	31.19	4452.00	72.73	37.60	3844.00	82.90
Suwan 1	32.90	3900.00	73.92	24.20	3887.00	66.70
LSD	NS	NS	NS	5.96**	NS	NS
Grade (G)						
A	30.97	4587.00	72.18	34.50	3756.00	72.10
B	31.00	4056.00	74.10	26.10	3868.00	85.70
C	34.16	3884.00	73.71	32.10	3972.00	66.60
LSD	NS	NS	NS	NS	NS	NS
Rate (R) (t ha^{-1})						
0	29.28	3209.00	70.64	25.60	3356.00	65.90
2.5	31.84	4870.00	74.59	35.90	4409.00	94.00
5	35.02	4449.00	74.76	31.20	3831.00	64.60
LSD	NS	443.10**	3.56*	NS	825.20*	NS
V × G	NS	NS	NS	9.11**	NS	NS
V × R	NS	NS	NS	NS	NS	NS
G × R	NS	NS	NS	NS	NS	NS
V × G × R	NS	NS	NS	NS	NS	NS

LSD-Least Significant Difference, NS-Not significant, * $P< 0.05$, ** $P< 0.01$

Table 7: Effect of organo-mineral fertiliser grade and application rate on 100 grain weight, cob weight and grain yield of maize cultivars (2014 and 2015)

	2014			2015		
Treatments	100 grain yield (g)	Cob weight (kg)	Grain yield (kg ha^{-1})	100 grain yield (g)	Cob weight (kg)	Grain yield (kg ha^{-1})
Variety (V)						
Oba super 2	11.53	1.02	2417.00	7.13	0.08	1655.00
Suwan 1	10.32	0.88	2076.00	5.09	0.05	1056.00
LSD	NS	NS	NS	1.32**	0.01**	267.00**
Grade (G)						
A	11.51	1.04	2466.00	6.38	0.06	1378.00
B	10.11	0.90	2129.00	5.42	0.05	1205.00
C	11.16	0.91	2144.00	6.52	0.07	1483.00
LSD	NS	NS	NS	NS	NS	NS
Rate (R) (t ha^{-1})						
0	8.13	0.59	1368.00	4.96	0.05	908.00
2.5	12.50	1.10	2615.00	6.68	0.08	1770.00
5	12.14	1.16	2757.00	6.69	0.07	1388.00
LSD	1.62*	0.15**	366.10**	0.93**	0.01**	332.40**
V × G	NS	NS	NS	NS	NS	NS
V × R	NS	NS	NS	NS	NS	NS
G × R	NS	NS	NS	NS	NS	NS
V × G × R	NS	NS	NS	NS	NS	NS

LSD-Least Significant Difference, NS-Not significant, * $P< 0.05$, ** $P< 0.01$

DISCUSSION

The result of the trial showed that in both years it was observed that the hybrid maize cultivar (Oba super 2) outperformed OPV in growth, yield attributes and grain yield. The significantly higher assimilatory surface as indicated by high leaf area at 4 WAP in the hybrid cultivar compared to the OPV could have increased its capability of intercepting more radiant energy. This capability could have positively affected carbon assimilatory process. This observation is consistent with Tollenaar and Lee, (2006), who observed that higher assimilatory surface at pre-silking period could support accumulation of dry matter in hybrid maize cultivars. Duncan *et al*., (1967) suggested that the higher assimilatory surface observed in hybrid maize was accompanied by changes in leaf orientation (erectophile orientation) that could aid even distribution of light into the lower strata of the canopy, thus reducing shade induced senescence (Massignam, 2003). Other physiological implication of this observation could be to increase radiation use efficiency as reported by Lindquist *et al*., (2005). A significantly higher grain yield observed in the hybrid maize than the OPV could be attributed to the significantly higher 100 grain weight, cob weight and harvest index. Otegui and Bonhomme, (1998) attributed increased ear growth observed in hybrid maize to increased dry matter accumulation and photosynthesis at grain filling period and its eventual partitioning to the ear. Partitioning of assimilates to the ear suggested that there could be an increased kernel set in the hybrid than OPV maize cultivars. This was reflected in reduced ASI (Otegui and Bonhomme, 1998; Vega *et al*., 2001). A non-significant reduction in ASI was equally observed in our trials, which is consistent with earlier made observation. Though not replicated in 2014 a significantly higher harvest index observed in hybrid maize than OPV in 2015 could have suggested the effect of environmental variability on this yield component. Similar opinion on the effect of harvest index on the yield increase of maize was also reported by Tollenaar and Lee, (2006). In addition they opined that genetic contributions to yield improvement of maize accounted for 75 %. They observed that these hybrid maize cultivars had a higher yield potential, resource use efficiency and tolerance to stress than OPV in the corn belt of United States. Chiduza *et al*., (1996) also reported that hybrid maize had significantly higher yield than OPV by 19 % and 16 % without and with fertiliser application respectively. The better performance of Oba super 2 than Suwan 1 in the site B (2015) than site A (2014) could be attributed to the differences in physical and chemical properties of the sites where the experiments were established. The fertility status of site B (2015) indicated that it had higher soil organic matter with more available P, Ca, Mg and lower Na than site A in 2014 to support growth and development of hybrid maize.

The significantly larger leaf area observed in 2014 at 12 WAP when organo-mineral fertiliser grade A was applied compared to other grades could have indicated that despite its comparatively lower nutrient concentration than other grades of organo-mineral fertiliser, soil N and K in that site A (2014) could have complimented this observed nutrient shortfall and supported the growth and development of maize cultivars. The high concentration of these nutrients in site A in that year could have reduced the uptake of Cu and Mg through antagonistic relationship of mineral nutrients. However, the high concentration of Cu and Mg in grade Aorgano-mineral fertiliser suggested a more balanced nutrition for maize cultivars. Balanced nutrition could also have been augmented by the available P in that grade of organo-mineral fertiliser which is comparable to other grades to compliment the inherently low soil P observed. The prevailing textural class of the soil in site A in that year that could predispose the soil to retain more nutrient, make nutrient and water readily available and increased soil microbial activity. It could be suggested that the high concentration of soil nitrogen contained in site A (2014) could have resulted in significantly higher assimilatory surface observed. Nitrogen deficiency had been implicated in leaf growth, activity of Ribulosebiphosphate carboxylase/oxygenase and the rate of hormone synthesis (Andrade *et al*., 2002; Jones and Setter, 2000). Potassium had also been implicated in reduced stalk lodging, increased stomatal conductance, increased photosynthetic capacity, protein uptake of K/NO_3 ion and turgor pressure (Pettigrew, 2008). Increased turgor and reduced lodging could facilitate increased assimilatory surface and increased diffusion of radiant energy into the canopy of maize cultivar. A delayed reproductive development (tasselling and silking) observed in maize cultivars when sown with grade B organo-mineral fertiliser in the site A (2014) could have compromised the reproductive growth of these maize cultivars, .which resulted to an increase in vegetative growth at the expense of the reproductive growth. One of such factor that could predispose maize cultivars to increased vegetative growth in site A (2014) could be attributed to the availability of nutrients from this grade of organo-mineral fertiliser and that of the soil. Observed leaf area response at 12 WAP in site A (2014) could have suggested that grade B organo-mineral fertiliser occupying intermediate position in the composition of macronutrients, with comparatively high concentration of N and K in the soil in site A (2014) could have explained the observed growth and development responses of maize cultivars. Jones *et al*., (1996) attributed delayed silking to nitrogen deficiency; however luxury consumption of N could equally facilitate increased vegetative growth at the expense of reproductive growth.

Increased application rates of organo-mineral fertiliser resulted in increased assimilatory surface in both years (site A and B). This could have aided interception of more radiant energy and photosynthetic capacity of maize cultivars sown at higher application rates. A higher application rate of organo-mineral fertiliser could have resulted in the availability of more nutrients for the growth and development of maize cultivars. Sangoi *et al*., (2001) posited that increased availability of nitrogen to maize plants would aid their photosynthetic capacity. Improved availability of nitrogen could also have been implicated in the early flowering observed at increased application rate of organo-mineral fertiliser. Tollenaar *et al*., (1994) reported that nitrogen deficiency in maize crop is capable of delaying silking. It was suggested that this could have resulted from the protandrous development observed when there was nitrogen deficiency in maize (Earl and Tollenaar, 1997; Jones *et al*., 1996). Apical dominance had also been implicated under this condition, resulting in tassel development, increased ASI and a delayed silking. By extension there is the possibility of barrenness and reduced grain yield in maize. However in this investigation, increased application rates of organo-mineral fertiliser resulted in a converse pattern on growth, development and grain yield of maize. This was evidenced in increased cob weight, 100 grain weight and grain yield observed in both years. This pattern was consistent with the observation made by Onasanya *et al*., (2009), where optimum growth of maize was observed at 120 kg N ha^{-1} + 40 kg P ha^{-1} that gave the highest grain yield in the humid tropics of Nigeria. In cucumber Olaniyi *et al*., (2009) observed that application rates of organo-mineral fertiliser in the range 2-4 t ha^{-1} resulted in a significant increase in the growth, yield and nutrient uptake of cucumber. This was equally corroborated by Arunah and Ibrahim, (2004), where it was observed that combined application of inorganic and organic fertiliser gave the highest performance in sorghum grown in the Guinea savanna zone of Nigeria. Other nutrients that could be made available at a higher application rates like P and K could also be implicated in the pattern of growth, development and grain yield observed. Plénet *et al*., (2000) had observed the effect of P on growth of maize through increased assimilatory surface, radiation use efficiency and biomass accumulation. Pettigrew, (2008) also reported the implication of K on photosynthetic capacity of maize, leaf growth and transportation of assimilates.

CONCLUSION

There was a significant varietal variation on growth, yield attributes and grain yield of maize at site B in 2015. In that year maize hybrid Oba super 2 had significantly more assimilatory surfaces than OPV maize cultivar (Suwan 1). This observation could have suggested interception of more radiant energy to facilitate canopy photosynthesis. This was reflected in 100 grain weight, ear weight and harvest index that could have contributed to the better performance of this hybrid variety in site B (2015) than OPV. The better performance of Oba super 2 than Suwan 1 in site B (2015) than site A (2014) could be attributed to the differences in physical and chemical properties of the sites where the trials were established. Maize cultivars in which grade B organo-mineral fertiliser was applied but had delayed tasselling and silking compared to other grades in the year 2014 (site A). A comparatively high availability of macro and micronutrients from this grade of organo-mineral fertiliser could have increased vegetative growth (leaf area at 12 WAP) at the expense of reproductive growth which could have resulted in a delayed flowering. Increasing application rates of organo-mineral fertiliser resulted in increased assimilatory surface that could have aided the availability of assimilates for the growth of reproductive organs (100 grain weight and cob weight) and improved grain yield ha^{-1} in both years (sites A and B). Faster rate of development observed in both years with increasing application rates of organo-mineral fertiliser could have suggested increased availability of assimilates for the reproductive growth.

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