Influence of Low Urea Fertilizer Rates on 1000-Seeds Weight of Maize *(Zea mays* L.) Varieties in a Tropical Humid Ecology

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Abstract
A field experiment was conducted from 2015 to 2018 at the Teaching and Research Farm of Federal College of Education (Technical), Omoku - Rivers State, Nigeria; to determine the influence of low urea fertilizer rates on 1000-seed weight of five maize (Zea mays L.) varieties. The experiment was laid-out in a RCBD with three replications. Treatment rates were 0, 30 and 60 kg N ha^{-1}. The maize varieties were Bende white, DMR-ESRY, Mangu white, Oba super II and Oba super 4. Soil and yield component data of 1000-seeds weights were collected and analyzed. Treatment means were separated using LSD at 5% ($P \leq 0.05$) probability level. The site had sandy soil texture with slightly acidic pH. Cations, organic C and total N were low except for Ca and Mg. Micronutrients were sufficient. The analyses presented in the seasons, showed that there was variation in seeds weights in accordance with the rates of urea applied. The minimum seed weight values were obtained in the control while the maximum weights were recorded at plots treated with 60kg N ha^{-1}. The 1000-seeds weight of Mangu white (208.03 g) was significantly different amongst the other varieties. All the maize varieties attained maximum weight gain at 60 kg N/ha. 60 kg/ha is preferable for Mangu white variety on the sandy soil of Omoku for low input maize production.

Key words: *Maize, cultivars, yield, seed weight.*

INTRODUCTION:

Maize *(Zea mays* L.) is an important cereal crop grown in parts of the world, including Nigeria. Maize (or corn) is cultivated primarily for its energy-rich grains. The grain is competitively demanded for human consumption, livestock feed production and as industrial raw material. In Nigeria, its consumption is prevalent among households. Maize is the most important cereal crop in Nigeria in terms of production and consumption (Olaiyo *et al.* 2020). The production of maize in Nigeria in 2016/2017 stood at 10.5 million metric tons (FAO, 2017); this was the highest in Africa after South Africa with a production capacity of about 10.79 million metric tons in 2014 (FAOSTAT, 2014). Awfully, the average grain yield per hectare is very low estimated at about 1.8 metric tons per hectare when compared to other maize producing countries in Africa such as Egypt and South Africa having an average yield of 7.7 and 5.3 metric tons per hectare, respectively (FAOSTAT, 2014). The low yield is attributed to high cost of farming inputs like fertilizer, poor technical know-how of the farmers, amongst other challenges. Maize cultivation is dominated by resource-poor farmers who apply less quantity of mineral fertilizers to the crop. Nutrient management has remained a challenge because of high cost of mineral fertilizers, the resource-poor farmers applying sub-optimal N fertilizer (8kg of N/ha) due to high price ratios between fertilizer and grain, limited availability of fertilizer, and low purchasing power of farmers (Abe *et al.,* 2013). Hence, the need to select cultivars with superior grain yields under low soil N conditions. Adequate supply of the primary nutrients [nitrogen (N), phosphorus (P) and potassium (K)] is needed for optimum grain yield. But ample quantity and proper timing of fertilizer N boasts its growth and yield the most. In most soils, poor yield components of maize is attributed to low soil N. The maize yield component of 1000-seeds weight is often considered as a major yield determining factor of N rates. Though, influenced by a number of factors including genetic traits, humidity, sprouting rate, storage quality and seed health; N application appears to be the most critical factor. Increase in N dose increases the 1000-seeds weight of maize (Ahmad *et al.,* 2018). Low test weights tend to result from poor grain fill and environmental conditions in the field before harvest (Deivasigamani and Swaminathan, 2018). The weight of the seed is as a result of the size of the embryo and nutrient reserved during grain filling. Maize plants having sufficient N tends to have increased size of embryo and other nutrients reserved during grain filling.

This study sought to examine the influence of low N rates on the yield component of 1000-seeds weight of selected maize varieties. 1000-seeds weight of maize is one of the factors that culminate into grain yield. It is a major grain yield factor. Other factors include number of ear per plant, grains per cob, cob length and cob circumference. The grain weight of 1000-seeds is a measure of the seed bulk density as well as an indicator of the general grain quality. It influences the best market price for maize grain and quality of livestock feed production. It is on these premises that the study was carried out.

Materials and Methods

Study Area:

Field experiments were piloted at the Teaching and Research Farm of the Federal College of Education (Technical), Omoku, Rivers State; located on latitude 6^o 40' E and longitude 5^o 21' in the tropical rainforest of Southern Nigeria. Earlier, the soil was classified as typic kandiudult derived from the alluvial plain of the Niger Delta (Sombreiro - Warri morphological region) (Ayolagha and Onuegbu, 2001). The site situated on an elevation of about 18 m above sea level enjoys dry and rainy seasons with an annual rainfall range of about 2040 - 3000 mm. The rainy season stresses between April and October, with a break in August, resulting to a bimodal rainfall pattern. Sunshine is prevalent between the months of November to March with an ambient mean temperature of 28.8^o C (maximum 38.3^o C). The relative humidity range is 68 - 80% with a monthly sunshine of 4.2 hours per day in the rainy season. The site was on a well-drained middle part toposequence with a slope of 0 - 2%.

Land Clearing / Soil Preparation:

The experimental site was ploughed, harrowed and marked into plots of size 8 x 3 m = 24 m^2 and fifteen (15) plots were mapped out for each rate of urea. The experimental arrangement had a total of 45 plots on a land area of 50 x 26 = 1300 m^2.

Experimental Design:

The experiment was laid out in a factorial design fitted into a randomized complete block design (RCBD) with three replicates. Urea fertilizer was applied at the rates of 0, 30 and 60kg N/ha. Each replicate was separated by 2m alley to minimize treatment interaction.

Planting Material:
Five (5) maize varieties used were Oba super II, Oba super 4, DMR-ESRY, Bende white and Mangu white. They were selected from the National Root Crop Research Institute, Umudike, Abia State. Oba super II, Oba Super 4 and DMR-ESRY are hybrids while Bende white and Mangu white are local varieties.

Crop management:
Basal application of phosphorus (P) and potassium (K) were done using single superphosphate (SSP) and muriate of potash (MOP) at the rate of 30kg P_20_5/ha and 15 K_20/ha respectively, before sowing. The first experiment was set up on August 29, 2015. Three (3) maize seeds were sown per stand, later thinned to (2) seedlings to obtain uniform seedlings. Sowing was at a distance of 0.75 x 0.5m giving a total of 124 plants per plot, equivalent to a plant density of 53,333 plants/hectare. Each plot had four (4) rows of plants with length 8.0 m. The two inner rows were used for destructive samples. Urea was applied in split dosage at two (2) and six (6) weeks after planting. Weed control was done by manual hoeing twice. Insect pests control was done using insecticide with the brand lambdashi, applied at 41/ha. The field borders were fenced and kept clean to minimize encroachment of rodents and insects. Subsequent sowings were performed on 29th April 2016, 25th August 2017 and 6th March 2018 respectively; and the cultural details followed strictly.

Climate Data:
The first experimental period from August-November 2015, recorded a mean temperature of 25.34^{o} C with a total rainfall of 1,190 mm. The second experiment from March-June 2016 had a mean temperature of 26.9^{o} C and total rainfall of 641.8 mm. The third experiment from August-November 2017 had an average temperature of 25.36^{o} C and a total rainfall of 1,312 mm. The fourth experimental duration of March-May 2018 had a mean temperature of 27.1^{o} c and a rainfall sum of 347.3 mm.

Soil Sampling/Analysis:
A total of 20 core samples of pre-sowing top soil were collected randomly at a depth of 0 – 15 cm for chemical and physical analysis. The samples were properly mixed in a plastic bowl to obtain composite sample, air dried, crushed and sieved through 2mm sieve to remove larger particles, debris and stones. The sample was analyzed following standard laboratory procedures.

Particle Size Analysis: This was determined using the Bouyoucos hydrometer method using 0.5N sodium hexameta-phosphate as dispersant (Landor, 1991).

Soil pH: Was determined using the glass electrode method in 1:2.5 soil to water (V/V) suspension (Peech, 1965).

Soil Organic Carbon: Was analyzed using the Walkley-Black method (1934) while organic carbon was determined by multiplying organic carbon by the factor of 1.724.

Total N: This was analyzed from soil and plant tissue using the micro-Kjedahl and distillation method of Bremmer and Malvaney (1982).

Available Phosphorus: Was analyzed using the Bray P1 method (Olsen and Sommer, 1982).

Exchangeable cations (Ca, Mg, Na and K): Soil samples were analyzed using ammonium acetate (NH_4O Ac) at 7.0 (Chapman, 1965). Ca and Mg were obtained using the EDTA complex metric titrations, while Na and K were determined using the flame photometric method.

Exchangeable acidity: Was analyzed using the titration method after extracting with 1.0 M K_2O (Page *et al*., 1982).

Base saturation: Was obtained as an expression of the percentage of ECEC (K^+, Na^+, Ca^2+, Mg^{2+}).

Data Collection: Mature maize cobs were harvested, bundled separately according to each plot, tagged and brought to clean threshing floor. They were de-husk, dried, shelled and weighed. The 1000-seeds were counted from each plot after oven drying at 12% moisture and weighed on electrical balance.

Data Analysis: Statistical analysis was performed using the analysis of variance (ANOVA) on all the parameters described using GenStat 3rd edition software (2007) and treatment means were separated using the least significant difference (LSD) at $P \leq 0.05$ probability.

RESULTS AND DISCUSSION

Result of the initial soil analysis as presented in the table 1 shows that the soil textural class was sandy with very slightly acidic pH. The cation exchange cation (CEC) and effective cation exchange capacity (ECEC), total N and organic C were low. Available P was moderate; percentage base saturation was very high while micronutrients were sufficient. The low fertility indices indicate that the crop will respond to the applied fertilizer.

Table 1: Pre-planting soil analysis of the experimental site

Soil parameters	Value
Particle size distribution (g kg^{-1}):	
Sand	910.0
Clay	56.0
Silt	34.0
Textural class	Sandy soil
Chemical parameters:	
pH (1:2.5 H_2O)	6.10
Exchangeable cations:	
Ca (cmol kg^{-1})	5.50
Mg (cmol kg^{-1})	2.08
Na (cmol kg^{-1})	0.21
K (cmol kg^{-1})	0.11
Exchangeable acidity (cmol kg^{-1})	0.11
Effective CEC (cmol kg^{-1})	7.90
Cation exchange capacity (cmol kg^{-1})	8.01
Based saturation (%)	98.63
Org. C (g kg^{-1})	0.23
Total N (g kg^{-1})	0.023
Avail. P (mg kg^{-1})	3.12
Micronutrients (mg kg^{-1}):	
Cu	1.10
Mn	83.5
Fe	250.00
Zn	45.5

The result of the influence of N-rates on 1000-seeds weight of maize varieties at late cropping season of 2015 is presented in Table 2. The result shows significant differences in the 1000-seeds weights of the maize varieties across the different rates at $p \leq 0.05$. Across the rows, DMR-ESRY was significantly different at the rates of N application. The application rate of 60kg N ha^{-1} was significantly higher than 30kg N ha^{-1}, and 30kg N ha^{-1} was significantly higher than the control. Similar results were obtained in Bende white and Mangu white, as the 1000-seeds weight at 60kg N ha^{-1} was significantly higher than 30kg N ha^{-1} and control. However, the analysis obtained in Oba super II and Oba super 4 were different. In both varieties, 1000-seeds weights at the rate of 60kg N ha^{-1} were significantly different from

30kg N ha^{-1} and the control, but there were no significant differences between 30kg N ha^{-1} and controls. This implies that at lower rates of urea application the maize varieties could not extra sufficient N for optimum growth and development. This finding agrees with the report of Bashir *et al. (2012)* who posited that genotypic differences at lower level of urea application was not very apparent, from which it can also be concluded that the maize varieties were unable to extract sufficient N from low urea level.

At the control column, Oba super II and Oba super 4 were significantly higher than DMR-ESRY, Bende white and Mangu white respectively. However, the 1000-seeds weights of the different varieties at the column of 30kg N ha^{-1} were not significantly different. A similar result was obtained at the rate of 60 kg N ha^{-1}. The 1000-seeds weights amongst the maize varieties at 60kg N ha^{-1} were not statistically different. This implies that increasing the rate of urea application from 30 to 60kg N ha^{-1} increased the weight gain of the maize seeds across the varieties. This finding is in tandem with the report of Amado *et al.* (2017) that the most evident economic and environmental benefits related to nitrogen fertilization are linked to the application of average dose ranging from 40 to 60 kg ha^{-1}. This finding also agrees with the report of Hokmalipour and Darbandi (2011) that increasing N rates from 30 to 60 and or 90 kg per acre produced greater response on the N uptake and yield, followed by a limited response at 120 kg N per acre. The finding is also in agreement with Sapkota *et al.* (2017) who reported that addition of increasing rate of nitrogen increases the yield and yield attributing characters of maize.

Table 2: Influence of N-rates on 1000-seeds weight (g) of the maize varieties @ late cropping season of 2015 (August-November)

Varieties	Control	N-rates 30kg N ha^{-1}	60kg N ha^{-1}	$LSD_{(0.05)}$
DMR-ESRY	179.09±10.48	216.83±9.56	235.07±5.84	17.705
Bende White	181.4±12.23	209.07±16.77	233.97±8.89	26.046
Mangu White	187.7±5.18	217.73±7.22	254.57±7.74	13.59
Oba Super II	171.79±3.92	208.66±19.72	232.16±4.65	23.806
Oba Super 4	161.51±6.91	205.18±6.79	217.5±10.99	16.908

The influence of urea rates on 1000-seeds weight of the maize varieties at the early cropping season of 2016 is presented in table 3. The analysis shows significant differences across the maize varieties and the rates. Across the rows are the maize varieties and across the columns are the rates of urea application. In the column of the DMR-ESRY variety there was no significant difference between the 1000-seeds weights of 30 and 60kg N ha^{-1}. However, the seed weights at both rates were significantly different from the control. The 1000-seeds weight at 60kg N ha^{-1} of Bende white was significantly different from 30kg N ha^{-1}, which was different from the control. The 1000-seeds weight of Mangu white at 60kg N ha^{-1} was significantly different from 30kg N ha^{-1} and the control. But, there was no significant difference between the 1000-seeds weights at 30kg N ha^{-1} and the control. The 1000-seeds weights of Oba super II and Oba super 4 were statistically the same. The 1000-seeds weights of both varieties were significantly different at 60kg N ha^{-1}.

Across the columns, DMR-ESRY, Mangu white, Oba super II and Oba super 4 were significantly different from Bende white. The 1000-seeds weights of DMR-ESRY, Oba super II and Oba super 4 at 30kg N ha^{-1} were significantly higher than the other varieties of Bende white and Mangu white. The 1000-seeds weights of the maize varieties 60kg N ha^{-1} were not significantly different from each other. The implication of the result is that the 1000-seeds weights of the maize varieties were better off at the rate of 60kg N ha^{-1} than the other rates.

This finding is also in tandem with the report of Amado *et al.* (2017) who asserted that the most evident economic and environmental benefits related to nitrogen fertilization are linked to the application of average dose ranging from 40 to 60 kg ha^{-1}. The finding is also in agreement with Anjorin (2013) that maize grain yield and other agronomical traits were significantly reduced in the low N soil compared with the N fertilized plots.

Table 3: Influence of N-rates on 1000-seeds weight (g) of the maize varieties @ early cropping season April-July, 2016.

Varieties	Control	N-rates 30kg N ha^{-1}	60kg N ha^{-1}	$LSD_{(0.05)}$
DMR-ESRY	179.50±3.70	226.90±8.21	234.85±6.41	13.37
Bende White	178.57±11.05	202.18±9.05	232.83±11.51	21.16
Mangu White	192.07±3.56	206.87±7.68	267.03±46.54	54.57
Oba Super II	170.93±12.53	202.30±19.36	219.53±5.07	20.36
Oba Super 4	175.50±10.44	205.87±8.59	218.83±8.32	18.32

The influence of urea rates on 1000-seeds weight of the maize varieties at the early cropping season of 2017 is presented in table 4. The analysis shows significant difference in the 1000-seeds weight of the maize varieties and rates. The DMR-ESRY variety was significantly different at the three rates of urea application. The application of 60kg N ha^{-1} was significantly higher than 30kg N ha^{-1} and the control. Bende white was somewhat different in its response to the rate of urea application, as it was significant at only 60kg N ha^{-1}. There was no significant difference between 30kg N ha^{-1} and the control. For Mangu white, there was no clear statistical difference between the rates 60 and 30kg N ha^{-1}. However, there was significant difference between 60kg N ha^{-1} and the control. The observation in Oba super II was that there was no significant difference in the 1000-seeds weights of the variety at the rates of urea application. However, the 1000-seeds weights of Oba super 4 were significantly different. The seeds weight obtained a 60kg N ha^{-1} was significantly different from that of 30kg N ha^{-1} and the control. The seeds weight obtained at 30kg N ha^{-1} was significantly higher than the control. The implication is that the seed weights are influenced by the rates of urea application. This finding is in line with the report of Ayeni (2011) that maize yield increased with increasing N availability.

Table 4: Influence of N-rates on 1000-seeds weight (g) of maize @ late cropping season (August-November, 2017).

Varieties	Control	N-rates 30kg N ha^{-1}	60kg N ha^{-1}	$LSD_{(0.05)}$
DMR-ESRY	162.83±7.00	178.7±7.43	202.37±6.57	14.007
Bende White	170.83±6.53	183.33±4.25	213.33±15.54	20.054
Mangu White	178.03±2.30	195.83±8.13	266.67±72.1	83.843
Oba Super II	171.33±9.54	190.337±6.83	276.4±44.19	52.73
Oba Super 4	179.37±2.35	190.17±4.54	200.4±2.29	6.46

The analysis of response of 1000-seeds weights of the maize varieties to the rates of urea application in the early cropping season of 2018 is presented in table 5. The influence of the N rates on 1000-seeds weights are arranged in the rows while the influence of the rates on the varieties appears in the columns. In the season under review, the 1000-seeds weights of DMR-ESRY were not significantly different at 30 and 60kg N ha^{-1}, except at the control. A similar trend was observed in Oba super II. However, the 1000-seeds weights of Bende white, Mangu white and Oba super 4 were significantly different at the different rates of urea application. That is, 60kg N ha^{-1} were significantly different from 30kg N ha^{-1}, which were significantly different from the control. At 60kg N ha^{-1}, it was observed at the control that DMR-ESRY and Oba super II were significantly higher than the other three varieties of Bende white, Mangu white and Oba super 4. A similar trend was observed at the rate of 30kg N ha^{-1}. However, there was no significant difference between the varieties at the rates of 60kg N ha^{-1}.

Table 5: Influence of N-rates on 1000-seeds weight (g) of maize @ early cropping season (March-May, 2018).

Varieties	Control	N-rates 30kg N ha^{-1}	60kg N ha^{-1}	$LSD_{(0.05)}$
DMR-ESRY	174.14±6.00	210.08±6.4	220.09±0.44	10.147
Bende White	176.6±7.50	198.35±5.83	226.33±9.32	15.352
Mangu White	186.07±1.80	214.98±20.93	249.5±6.77	25.462
Oba Super II	171.37±8.62	200.43±12.5	217.33±4.15	18.167
Oba Super 4	172.17±0.07	200.73±2.85	215.27±5.66	8.123

The cumulative analysis of the 1000-Seeds weight of the maize varieties is presented in Table 6. The analysis shows that the 1000-seeds weight of Mangu white was significantly higher than other varieties, followed by DMR-ESRY and Bende white. Nonetheless, there was no significant difference between the values of Bende white and Oba super II. Values of 1000-seeds weight of Oba super 4 had the least significant weight difference at $p \leq 0.05$ probability. The weight gain of 1000-seeds weight presents a linear relationship with the N-rates. This observation is consistent with the report of Gul *et al.* (2015) that maize grain yield was linearly influenced by nitrogen levels applied. The differences in the grain weight of the maize varieties could be attributed to the variation in nutrition level.

Table 6: 1000-Seeds weight of different maize varieties

Variety	1000-seeds Weight (g)
Bende white	199.18
DMR-ESRY	201.29
Mangu white	208.03
Oba super 4	195.21
Oba super 2	196.88
$LSD_{(0.05)}$	4.79

The general observation was that there was significant difference in the 1000-seeds weights at the different rates of urea application. The least seed weights were recorded in the control while the highest were recorded in 60kg N ha^{-1} (table 7). In most varieties there were significant differences between 30 and 60kg N ha^{-1}. This could be attributed to the availability of $N0_3^-$ in plots treated with 60kg N ha^{-1}. Hence, the maize plants absorbed more nitrates for their growth and development than in other plots. This finding is in tandem with Azeez *et al.* (2006) who reported that the amount of nitrogen taken by maize increased with increase in fertilizer rates; application of 30 and 90kg N/ha to soil increased grain N concentration and total N uptake. The interaction between the season and the varieties was positive. This result agree with the findings of Ahmad *et al.* (2018) who reported that by the increase in N dose the 1000-seeds weight of maize showed increase.

Table 7: 1000-Seeds weight of maize at different fertilizer levels

Urea	1000-seed Weight (g)
0	176.04
30	202.19
60	222.12
$LSD_{(0.05)}$	3.39

Conclusion:

The findings of this study confirm that there is positive co-relation between the rates of urea fertilizer application and maize yield component of 1000-seeds weight. The least 1000-seeds weights were recorded in the control plots while the highest weights were obtain plots treated with 60kg N ha^{-1}. This significant variation in seed weight could be attributed to differences in the availability and subsequent uptake of nitrates for the maize Plant growth and grain yield. The maize variety of Mangu white was most outstanding in the seeds weight. In most case, the 1000-seeds weights of Oba super II and Oba super 4 were similar. This could be attributed to similarity in their genotypic inheritance. The alleged fear of applying an optimum nitrogen rate of 90kg N ha^{-1} has been overcome by the results of this study, as the suboptimum rate of 60kg N ha^{-1} could suffice on the sandy soil of Omoku.

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