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RESEARCH PAPER

Varietal differences in nitrogen-use efficiency in maize (*Zea mays* L.)

***Abu S. Owoicho[1], Yeye Mary[2], Chinwe Akubuike[3] and Ebiloma Habila Musa[4]**

[1,2,3,4] Department of Plant Science, Institute for Agricultural Research Ahmadu Bello University, P.M.B. 1044 Samaru, Zaria Nigeria

*Corresponding Author

* Abu S. Owoicho

Department of Plant Science, Institute for Agricultural Research Ahmadu Bello University, P.M.B. 1044 Samaru, Zaria Nigeria

*Corresponding Author Email: asosol72@yahoo.com[1]

Abstract

Seven levels of N in form of urea (46%) at the rate of 0, 20, 40, 60, 80, 100 and 120kgN/ha respectively were applied to three maize genotypes to determine their Nitrogen-use efficiency. The factorial combination of the treatments was laid out in a Randomized Complete Block Design (RCBD) and replicated three times during the 2017 and 2018 wet seasons. The N was applied in two split doses at 3WAS and 6WAS respectively in 5cm deep holes and buried between stands. Five plants per plot were harvested at physiological maturity and samples were dried and analysed for percent N using the two primary components of N-use efficiency such as the efficiency with which the N is absorbed (Uptake efficiency) and the efficiency with which the absorbed N is utilized (Utilization efficiency). The three genotypes (LNTP-Y5, LNTP-WC2 and Oba-98) responded positively to all the rates N. Oba-98 produced the highest leaf area at 120kgN/ha while genotypes LNTP-WC2 and LNTP-Y5 had significantly ($p<0.05$) lower leaf area. Application of N from 20kgN/ha and beyond increased the heights of LNTP-WC2 and LNTP-Y5. The heaviest grains were observed at 120kgN/ha in 2018 trials.

Keywords: Maize, Varietal, Nitrogen, Use, Efficiency, Differences

Introduction

Maize (*Zea mays* L.) is an important cereal crop that plays a significant role in diets of the people of Nigeria and Africa as a whole. It is the third most important cereal after wheat and rice (Zeidan *et al* 2006). Major constraints to maize production in Nigeria among others include; rapid loss of soil fertility due to leaching of minerals, degradation of organic matter at a faster pace due to lack of attention to maintenance of soil health coupled with practices of exhaustive cropping pattern without returning adequate nutrients to the soil (Sanni, 2001)

Meanwhile, nitrogen is one of the most limiting factors in maize production in Nigeria because most of the savannah soils are sandy- loam and nitrogen being a mobile nutrient can easily be leached out of the root zone. Despite considerable work done on the response of maize to nitrogen, there is still paucity of information on maize genotypes that is productive under low soil nitrogen. Laffitte and Edmeades, (2004) have reported that higher utilization of available N can be enhanced by selection of genotypes that possess high N-uptake capacity or a more efficient use of absorbed N in production. This work therefore, was to determine Varietal differences in N- use efficiency in maize.

Materials and Methods

The field experiments were conducted at Research field of Institute for Agricultural Research, Samaru Zaria during the 2017 and 2018 wet seasons respectively. Samaru lies in the Northern Guinea Savannah Zone of Nigeria.

Field Experiment and Techniques

The composite soil sample across the experimental field was analyzed in the laboratory for physio- chemical properties such as P^H, organic carbon, total N, available P, exchangeable cat ion (CEC) and particle size for both the first and second year of the experiment.

Treatments consisted of seven levels of N in form of urea (46% N) applied at the rate of 0, 20, 40, 60, 80, 100 and 120kg N/ha and three maize genotypes (LNTP-WC2, LNTP-Y5 and Oba-98). The factorial combination of the treatments were laid out in a Randomized Complete Block Design (RCBD) and replicated three times. The application of N was in two split doses. The first half was applied 3 WAS, while the second half was at 6WAS. This was applied in 5cm deep holes and buried between stands. P and K were uniformly applied in the form of single superphosphate 18%(P_2O_5), Muriate of potash 60% (K_2O) at 19.8kg P/ha and 37.4kg K/ha respectively.

Determination of Plant Nitrogen

Five plants per plot were harvested at physiological maturity when the leaves turned yellowish brown and began to fall and the net plants were then harvested. Samples were divided into leaves, stem, cob and tassel. The samples were dried and analyzed for percent N at the nitrogen laboratory of IAR, Samaru-Zaria. After the determination of total percent N in various plant parts, the two primary components of N use efficiency, namely;

(a) The efficiency with which the N is absorbed (uptake efficiency); and

(b) The efficiency with which the absorbed N is utilized to produce grain (N utilization efficiency) were calculated using the procedure described by Moll *et al* (1982) as follows;

N uptake efficiency = N_t/N_s

N utilization efficiency = G_W/N_t

N use efficiency (NUE) calculated as $G_w/N_S = (N_t/N_s)(G_w/N_t)$

Where, N_t =total ground plant nitrogen, N_s = nitrogen applied, G_w = grain yield per plant

Statistical Analysis

The data collected were subjected to analysis of variance (ANOVA) described by Snedecor and Cochran (1962). The linear additive model used is as follows;

$Y_{ijk} = \mu + N_i + G_K + R_J + (NG)_{IK} + e_{ijk}$ where,

Y_{IJK} =Observation of the K^{th} genotype and J^{th} Nitrogen in the J^{th} replication (R) within the Y^{th} year (Y)

μ = Overall population mean

N_i = Effect of the i^{th} nitrogen

R_j = Observation in the J^{th} replication

G_k = Effect of K^{th} genotype, 1,2,3

$(NG)_{ik}$ = Effect of nitrogen within each genotype (Interaction)

e_{ijk} = residual error due to sampling

Means that differ significantly were compared using Duncan's Multiple Range Test (Duncan1955).

Results and Discussion

The effect of N and genotype interaction on leaf area at 9WAS in 2017 and 2018 is presented in Table1.

Table 1: Effect of Nitrogen and genotype on Leaf area (cm^2) of maize during the 2017 and 2018 wet season in Samaru

(A) N (kgN/ha)	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean
0	102.3^e	187.9^e	145.2^e	204.0^e	227.0^g	215.5^g	217.4^g	219.2^b	199.4^f
20	110.5^e	200.7^{de}	155.6^e	218.2^e	246.2^f	232.2^f	280.7^f	271.6^b	257.2^e
40	134.8^d	206.6^{de}	170.7^d	254.9^d	254.3^e	254.6^e	309.2^e	304.5^a	298.3^d
60	144.9^{cd}	216.3^{bdc}	180.6^{cd}	316.4^c	275.3^d	295.9^d	378.2^d	375.4^a	358.2^c
80	165.6^c	222.3^{bc}	194.0^c	357.6^b	318.2^c	333.9^c	421.2^c	390.9^a	388.5^{bc}
100	200.2^b	235.3^b	217.8^b	357.1^b	393.9^b	375.5^b	468.2^b	383.0^a	417.6^b
120	235.3^a	281.2^a	258.3^a	389.1^a	435.9^a	412.5^a	533.2^a	389.8^a	464.4^a
SE(±)	7.28	6.43	6.90	9.62	1.14	4.80	13.31	19.73	1.98
(B) Genotype									
LNTP-WC2	154.4^e	221.7^b	188.0^b	264.9^c	335.7^b	302.5^a	419.3^a	324.9^a	344.8^a
LNTP-Y5	180.3^a	219.6^c	199.9^a	326.9^a	227.9^c	303.9^a	340.3^b	342.1^a	328.2^a
OBA-98	134.0^c	223.2^a	178.6^c	306.8^b	358.6^a	303.9^a	358.2^b	258.4^b	348.2^a
SE(±)	4.77	4.21	3.20	6.30	0.75	3.14	8.71	12.92	7.84
Interaction									
AxB	NS	NS	NS	**	**	**	**	NS	**

Means followed by the same letters within a column are not significantly different 5% level of probability using DMRT. NS = Not significant

LNTP-Y5 responded positively to all the rates of N, while genotypes LNTP-WC and OBA-98 only responded to N application as from 60kgN/ha and beyond. However, OBA-98 produced the highest leaf area values with the application of 120kgN/ha, while genotypes LNTP-WC2 and LNTP-Y5 had significantly (P< 0.05) lower leaf area compared to OBA-98 with N application. Genotypes LNTP-WC2 and LNTP-Y5 had statistically similar leafs area up to addition of 100kg N/ha (EL-Gizawy, 2009). Interaction between N and genotypes significantly influenced plant height at 6 WAS in 2008 (Table 2).

Table 2: Effect of Nitrogen and genotype on plant height (cm) of maize during the 2017 and 2018 wet season at Samaru

Treatment		6WAS			9WAS			12WAS	
(A) N (kgN/ha)	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean
0	32.4^{g}	42.6^{f}	37.5^{g}	91.6^{g}	111.5^{g}	101.5^{g}	113.9^{f}	110.9^{f}	112.4^{g}
20	40.8^{f}	50.9^{e}	45.9^{f}	100.2^{f}	125.0^{f}	112.6^{f}	134.7^{e}	114.8^{e}	126.4^{f}
40	45.3^{e}	53.9^{de}	49.6^{e}	104.7^{e}	135.0^{e}	119.9^{e}	147.4^{e}	127.3^{d}	137.6^{e}
60	52.4^{d}	56.5^{cd}	54.4^{d}	113.8^{d}	140.9^{d}	127.4^{d}	154.2^{d}	132.8^{cd}	144.4^{d}
80	56.8^{c}	59.0^{bc}	57.9^{c}	126.5^{c}	318.2^{c}	138.9^{c}	158.6^{c}	137.4^{bc}	148.8^{c}
100	62.1^{b}	61.0^{b}	61.6^{b}	139.8^{b}	393.9^{b}	145.1^{b}	169.0^{b}	141.8^{b}	156.6^{b}
120	73.6^{a}	64.7^{a}	69.1^{a}	149.9^{a}	435.9^{a}	161.9^{a}	177.1^{a}	149.8^{a}	165.6^{a}
SE(±)	1.02	1.18	1.10	1.21	1.14	0.91	1.77	1.60	1.20
(B) Genotype									
LNTP-WC2	52.8^{a}	53.7^{b}	53.3^{b}	98.3^{c}	145.4^{b}	121.9^{c}	147.7^{b}	125.4^{b}	136.5^{a}
LNTP-Y5	49.3^{b}	56.5^{a}	52.9^{b}	124.3^{b}	154.4^{a}	139.4^{a}	152.5^{a}	135.7^{a}	144.1^{a}
OBA-98	53.7^{c}	56.2^{a}	55.0^{a}	128.2^{a}	127.0^{b}	127.6^{b}	152.1^{a}	136.6^{a}	144.3^{a}
SE(±)	0.67	0.77	0.51	0.79	0.88	0.65	1.16	1.005	1.04
Interaction									
AxB	NS	**	**	**	**	**	**	NS	NS

Means followed by the same letters within a column are not significantly different 5% level of probability using DMRT. NS = Not significant

Plant height at 0 kg N/ha, 0ba-98 had significantly (P< 0.05) taller plants compared to LNTP-Y5 (EL-sheikh, 2008). But when various rates of N were added, all the 3 genotypes had statistically similar heights. In each genotype, application of N from 20kg N/ ha and beyond increased the heights of LNTP-WC2 and LNTP-Y5, while only the application of N from 80kgN/ ha increased the heights of Oba-98. Application of 120kgN/ha to LNTP-Y5 produced the tallest plants. At 12 WAS, all genotypes in the combined analysis had statistically same heights in plots which received no N treatments. Subsequently, LNTP-Y5 and Oba-98 recorded statistically similar heights up to the highest rate of N (120kg/ha). The addition of 80kgN/ha and beyond also resulted in statistically similar heights except in Oba-98 following the application of 120kgN/ha which resulted in the tallest plants. The number of 1000- grain weight was significantly increased with N application in the year 2018 than 2017(Table 3).

Table 3: Effect of N and genotype on 1000-grain weight of maize during the 2017 and 2018 wet season

(A) N (kgN/ha)	2017	2018	Mean
0	180.00[a]	174.83[d]	182.78[a]
20	297.00[a]	225.33[e]	264.28[a]
40	300.11[a]	219.67[c]	268.78[a]
60	333.78[a]	258.00[abc]	289.56[a]
80	289.56[a]	268.50[ab]	272.17[a]
100	300.67[a]	242.17[bc]	273.87[a]
120	295.78[a]	383.17[a]	280.39[a]
SE(±)	28.81	10.41	15.56
(B) Genotype			
LNTP-WC2	286.33[a]	287.7[a]	287.02[a]
LNTP-Y5	285.43[a]	248.81[a]	267.12[a]
OBA-98	284.05[a]	228.81[b]	260.38[a]
SE(±)	18.86	6.82	10.19
Interaction			
(C) AxB	NS	**	NS

Means followed by the same letters within a column are not significantly different 5% level of probability using DMRT. NS = Not significant

The heaviest grain was observed at 120kg N/ha in 2018 trials. The heaviest grain weight could be due to the differences in grain ear weight as a result of assimilate production and its portioning (Akmal *et a*l 2010), who also reported that the highest 1000 grain weight (192g) was observed for 150kg N/ha nitrogen application and lowest (172g) for 90kg N/ha. Among the genotypes evaluated LNTP-WC2 recorded the heaviest 1000- grain weight.

The working hypothesis here is that a genotypes with high NUE possesses the mechanism for N uptake and utilization of both forms of N (No_3^- , NH_4^+) in the soil either at low or high N levels. Genotypic differences among maize genotypes in respect to NUE have been reported by several researchers (Lafitte and Edmeades, 2004b), and the use of the ratio G_W/N_S as a selection criterion for NUE is widely accepted. Similar results have been reported byn Moll *et al* (1982), Akintoye *et al* (2001) and Omogui *et al* (2006). Variations I NUE in terms of its component appear to differ between levels of N supply and among genotypes (Table1). Under low N, lower utilization efficiency and NUE were observed which is the reverse to high N. LNTP-WC2 genotype is relatively higher in N utilization compared to LNTP-Y5 and Oba 98 at higher rates of N. This result is in agreement with the findings of Mol *et al* (1987) and Reel *et al* (1980). The result also showed that LNTP-WC2 is likely to be preferred or recommended for cultivation in areas where N is limited. LNTP-WC2 under high N had higher N-utilization efficiency and NUE values than LNTP-Y5 and Oba98 and this will help to maintain growth and productivity under low soil N.

Conclusion

Seven levels of N in form of urea (46%) at the rate of 0, 20, 40, 60, 80, 100 and 120kgN/ha respectively were applied to three maize genotypes (LNTP-WC2, LNTP-Y5 and Oba 98) to determine their Nitrogen-use efficiency during the 2017 and 2018 cropping season at the Institute for Agriculture research, Samaru, Zaria. There were variations in NUE in terms of its component which appeared to differ between levels of N supplied and among genotypes. Under low N, lower utilization efficiency and NUE were observed which is the reverse to high N. LNTP-WC2 genotype is relatively higher in N utilization compared to LNTP-Y5 and Oba 98 at higher rates of N which also indicated that LNTP-WC2 is likely to be preferred or recommended for cultivation in areas where N is limited and this will help to maintain growth and productivity under low soil N.

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