

COMPARATIVE STUDY OF MAIZE AGRONOMICS PERFORMANCE UNDER LOW NITROGEN SOIL AVAILABILITY, IN SOUTHERN SAVANNA OF DR CONGO

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To determine the growing and yield performance of low nitrogen tolerant maize varieties under fertilized and unfertilized conditions, a study was conducted at the Mvuazi Research Center. Nine varieties were tested with and without fertilizer using the micro-dosing method, following the randomized complete block design with two factors. The results showed a difference among varieties in both crop conditions. The average yield with fertilizer was higher than the yield without fertilizer. The varieties LNTP-W C4 and LNTP-Y C7 registered 5.9 t/ha and 3.6 t/ha respectively under fertilized crop conditions and 7.14t/ha and 7.12t/ha under unfertilized crop conditions. Thus, using Low-N can minimize production costs by improving the productivity of soils low in Nitrogen typical of conditions of the southwestern savanna.

KEY WORDS: LOW NITROGEN SOIL, LNTP, MAIZE PRODUCTION, FERTILIZER, SAVANNA, INERA-DRC

Introduction

Maize is one of the main cereal crops in tropical Africa. It is grown mainly by resource-poor farmers in rainforest and savanna areas (Iken and Amusa, 2004; Tshiabukole *et al.*, 2017). In Africa, maize yields in peasant fields range from 1 to 2 t/ha, unlike higher yields in the order of 5 to 7 t/ha reported at breeding stations or about 8.6 t/ha feasible in the areas of developed countries (FAO, 2001, Fakorede *and al.*, 2003). Low yields are due to poor soil fertility and limited nutrient availability (Azeez and Adetunji 2007).

The use of nitrogen (N) fertilizers has been shown to result in increases in crop yields (Presterl *et al.*, 2002; Coque and Gallais, 2007; Bukan *et al.* 2011). Its deficiency in the soil is caused by imbalanced crop uptake and losses from the soil through erosion, volatilization or leaching vs. supply via fertilizers, N-fixation and organic amendments.

The combined use of organic manure and inorganic fertilizer is a very favorable option for maize production. Several studies have shown that 30 to 50 kg/ha of N fertilizer when

combined with 5 t/ha of organic manure approach grain yields of 100-120 kg of mineral N alone (Crasky and Iwuofor, 1999). However, it is often the case that manure is not available in sufficient quantities. A desirable alternative to the use of organic manure is the planting of nitrogen-fixing cover crops such as Mucuna, cowpea or soybeans in rotation with maize crops.

The high cost of fertilizer poses a major challenge to most small scale farmers (CSO, 2012) making the utilization of varieties tolerant to low soil N an attractive option (Hirel et al., 2001; Davis, 2013). Reports from several studies have indicated that there are genetic potentials for maize genotypes to improve the effective use of nitrogen (Oikeh et al., 2007, Gondwe et al., 2014). This has led to the development of line, open-pollinated (OP) lines and hybrid varieties able to utilise available nitrogen in the soil. Improved varieties could boost the productivity of N-poor soils and reduce reliance on inorganic nitrogen fertilizers.

The objective of this study was to evaluate the performance of low soil nitrogen tolerant maize varieties in terms of their gain and production costs, in order to consider the possibility of minimizing the use of fertilizer on peasant farms.

Materials and method

Experimental site, soil analysis and characterization

The experiment was conducted at the National Institute of agronomics study and research (INERA) Mvuazi center. This site is located at 14°54’ east longitude and 5°21’ south latitude. Rainfall varies between 800 and 1200mm, and temperatures range between 20 and 28°C with an elevation of more than 450 m above sea level. Most Mvuazi’s soils have low organic matter content, low cation exchange capacities (CEC) and depleted plant nutrients resulting in poor crop yields (Fakorede and al., 2001).

Parameters (unit)	Soil pH	P1 (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Mn (ppm)	S (ppm)	Cu (ppm)	B (ppm)	Zn (ppm)	Na (ppm)	Fe (ppm)	CEC (meq/100g)
Results	5.7	14	105	1505	229	55	23	12.3	0.21	7.98	47	194	13.76
Guide Low	6.0	30	268	1651	165	100	20	2.00	1.00	4.00	0	150	15.00
Guide high	7.0	100	537	2064	264	250	200	10.0	2.00	20.0	158	350	30.00

Parameters (unit)	OC (meq/100g)	Silt (%)	Sand (%)	Clay (%)	N (%)
Results	4.07	13	49	39	0.2
Guide Low	-	30	30	20	0.2
Guide high	-	50	55	55	0.5

Table 1: Selected chemical and physical parameters for soils at experimental site

Planting Materials

Nine varieties (table2) including seven (7) maize varieties selected on the basis of origin, genetic background, nitrogen use efficiency, drought tolerance and ecological adaptation to several agro ecological regions from the International Institute of Tropical Agriculture

(IITA) and two (2) local varieties commonly used in the peasant farms were evaluated in this study. A spacing pattern of 0.75 m between and 0.50 m within the rows was followed and two seeds were planted per hill to give a plant population of approximately 53,333 per hectare. The varieties were planted during the growing season in October, 2014.

Entrees	Variety	Origin	Type
1	BR 99 TZL Comp 4 DMSRSR	IITA	Opv
2	BR 9928-DMRSR LN C1	IITA	Opv
3	Local check1	INERA	Opv
4	Local check2	INERA	Opv
5	LA POSTA SEQUIA C6	IITA	Opv
6	LNTP-W C4	IITA	Opv
7	LNTP-Y C7	IITA	Opv
8	TLZ COMP 1 C6 LN C1	IITA	Opv
9	TZPB Prol C4	IITA	Opv

OPV: Open pollinate variety

Table 2: Names, Origin and type of varieties used in the study

Experimental design

The experiment was set up in a Randomized Complete Block Design (RCBD) with two factors and replicated 3 times. The first factor was the maize varieties and the second factor the level of nitrogen (2 levels): without fertilizer (WOF) and with fertilizer (WF) use. Two plots were set up; one in which a reference, unfertilized crop was grown and a second one to which regular urea was applied. The seed variety for this study was sown at 75 cm x 50 cm in two rows (each row was 5m long) in a two factors experiment with three replications. Nitrogen was applied by a compound fertilizer (NPK 12-24-12) at a dose of 18 g/hill. Urea 46% was applied at 18g/hill divided into two halves. The first half was applied 15 days after sowing and the second half 30 days after sowing.

Data collection:

Yield was measured in ton per hectare following the formula below.

$$\text{Yield} = ((\text{FW}/1000) * (100 - \text{FGM}/100 - \text{SGM}) * (\text{GW}/\text{EW}) * (10000/\text{UA}))$$

Where:

FW: Field Weigh

FGM: Field Grain Moisture

SGM: Storage Grain Moisture

GW: Grain Weigh

EW: Ear Weigh

UA: Useful Area

At the flag leaf stage, plant height was measured using a measuring tape as the distance from the ground level to the flag leaf. Days to 50% tasselling (TS) and silking (SK) were

taken as the date when 50% of the plants in a plot had tasselled and extruded silk, respectively. Anthesis Silking Interval (ASI) which is the difference between Silking date and Anthesis date was also computed. All data was collected from plants in the middle row of each plot.

Statistical analyzes:

The collected data were analyzed using R software to determine difference among varieties with respect to various growing and yield parameters. The means of the varieties that exhibited significant differences were separated using the least significant difference (LSD) post-hoc test.

Results and discussion

Analysis of Variance of study parameters

Table 3 shows the effects of factors and their interaction on characteristics parameters observed during growth and yield.

Factor	TS 50%	SK 50%	ASI	Plant Height	Yield
Fertilizer	p>0.05	p>0.05	p<0.05	p<0.05	p<0.01
Varieties	p<0.0001	p<0.001	p>0.05	p>0.05	p<0.001
Fertilizer:Varieties	p>0.05	p>0.05	p>0.05	p>0.05	p>0.05

Table 3: Analysis of variance

Table 4 shows some growing and yield parameters observed under this study. The means of those parameters are grouped following fertilization (WF and WOF).

Fertilizer	Varieties	TS 50%	SK 50%	ASI	Plant Height	Yield
WF	BR9928-DMRSRLNC1	69.00a	71.25a	2.25abc	196.08abcd	3.81cde
	BR99TZLComp4DMSRSR	67.50abc	70.75ab	3.25abc	201.91abc	6.39ab
	Check1	64.00efgh	66.50cde	2.50abc	138.25s	3.55cdef
	Check2	64.50defgh	66.75cde	2.25abc	187.58abcd	5.67ab
	LAPOSTASEQUIAC6	66.00cde	68.00bcd	2.00bc	212.00a	4.88bcd
	LNTP-WC4	65.00defg	66.25cde	1.25c	210.91a	7.14a
	LNTP-YC7	65.50cdefg	66.75cde	1.25c	211.83a	7.12a
	TLZCOMP1C6LNC1	65.25cdefg	67.25cde	2.00bc	200.33abc	4.97bc
	TZPBProC4	68.50ab	71.50a	3.00abc	207.66ab	5.00bc
WOF	BR9928-DMRSRLNC1	64.75defh	69.00abc	4.25ab	186.25abcd	2.15efg
	BR99TZLComp4DMSRSR	66.00cde	70.25ab	4.25ab	177.33abcde	2.23sfg
	Check1	62.50h	64.75e	2.25abc	129.08f	2.00fg
	Check2	63.25dh	67.25cde	4.00ab	152.25def	2.24sfg
	LAPOSTASEQUIAC6	64.25defgh	66.00de	1.75bc	162.83cdef	3.10defg
	LNTP-WC4	64.50defgh	66.25cde	1.75bc	181.75abcde	5.96ab
	LNTP-YC7	63.50fgh	66.50cde	3.00abc	196.0abcd	3.62cdef
	TLZCOMP1C6LNC1	65.75cdef	70.50ab	4.75a	139.33af	1.47g
	TZPBProC4	66.50bcd	70.50ab	4.00ab	165.25bcdef	2.038efg
Mean		65.34	68.11	2.76	180.92	4.077
CV		2.4	2.9	64.1	16.8	30.1
LSD		2.28	2.84	2.73	44.36	1.788

The numbers with the same letter are not statically different.

Table 4: Comparative study of growing and yield parameters

Days to 50 % tasselling and 50 % Silking

The average number of days to 50 % silking and 50% tasseling ranged from 65.3-68.11 days after sowing (Table 4). Significant differences were observed ($p < 0.001$) among varieties for both characteristics. The number of days to 50% tasseling and 50% silking were within the normal ranges observed in maize development (Banziger and Daillo, 2002).

Anthesis -Silking Interval (ASI)

Based on the Days to 50% silking and tasseling discussed above, the anthesis-silking interval ranged from 1.25 to 4.75 days among the varieties as shown in Table 4. The smal-

ler numbers indicate that the pollen had enough time to pollinate the silk (Banzinger and Daillo, (2002), Hema *et al.*, (2001)) and increase the number of kernels on the cobs which is better for grain yield and Nitrogen use efficiency.

Plant height

Plant height at the flag leaf stage (72 DAP) ranged from 129 cm to 196 cm without fertilizer and from 138 cm to 212 cm with fertilizer (Table 4) and was statistically different ($p < 0.05$) among the fertilization groups. The average height of all the varieties was 180.9 cm; variety Check1 was the shortest under both fertilization groups (Table 4).

In summary, varieties LNTP-WC4 and LNTP-YC7 were taller, had longer leaf length and broader leaves compared to others without fertilizer (Table 4). The traits mentioned translated to higher biomass yields in varieties LNTP-WC4, LNTP-YC7 and LAPTASE-QUIAC6.

Table 3 shows the effect of fertilizer application on maize growth. The result shows that there is a clear difference between the control and fertilized groups. In general, applying fertilizer increased the yields for all varieties, but keeping the significant differences ($p < 0.001$) between them. Under fertilizer additional (WF), the highest yields were recorded for the varieties LNTP-W C4 and LNTP-Y C7 with 7.14kg/ha and 7.12kg/ha, respectively. The results obtained from unfertilized plots shows that the highest yield was recorded for LNTP-WC4 (5.96 kg/ha).

Several studies detailing breeding for improved performance under low soil nitrogen levels have reported on tropical maize (Lafitte and Edmeades, 1994; Banzinger and Lafitte 1997; Banzinger *and al.*, 1999a). In general, the selection for grain yield in combination with other desirable secondary characteristics should be effective in improving performance under low nitrogen conditions. The results of our study indicate that the application of the seed in the required fertilized plots significantly increases the yield of grain maize of both varieties evaluated. Banzinger *and al.*, (1999b) noted that improved yield under conditions of low nitrogen availability was not a result of increased soil N uptake, but earlier improvements in efficient use. Bertin and Gallias (2000) argued that the difference in maize lineages in the use of nitrogen was largely due to the ability to take up this nitrogen efficiently.

The results of this study are similar to those obtained by Ogunniyan and Olakojo (2014) in the genetic variability of agronomic traits of plant-tolerant varieties to low levels of nitrogen. Varieties such as LNTP-WC4, LNTP-Y C7 and LA POSTA SEQUIA C6 showed higher yield performance under low and high nitrogen conditions. These results are consistent with the results obtained by Menkir *et al.*, (2006) and Ajala *et al.*, (2007).

Statistics provided by FAO, (2001) and Fakorede *et al.*, (2003) report that maize production on peasant farms remains around one ton per hectare. However, the results obtained with improved so-called low-N varieties in conditions similar to that of farm peasants increase the yield from 1 or 2 t/ha to more than 3 t/ha.

Conclusion

The study was conducted to evaluate the agronomic performance of different maize varieties growing in fertilized and unfertilized plots. The evaluation of growing and yield parameters showed differences among the 9 varieties. The results of this study show that among the 9 varieties evaluated, 3 lines (LNTP-W C4, LNTP-Y C7 and LAPOSTA SEQUIA C6) produced values slightly higher than the reference genotype and the recorded world average, of 5.9; 3.6 and 3.1 t/ha of grain respectively, in unfertilized plots. Varieties LNTP-W C4 and LNTP-Y C7 were better than other varieties in fertilized plots. They each recorded more than 7 t/ha. For each kg of N applied these varieties produced more grain than the rest of the varieties.

Based on the Nitrogen Use Efficiency –Agronomics Efficiency, the varieties LNTP-W C4, LNTP-Y C7 and LAPOSTA SEQUIA C6 can be included in the next stage of the breeding program for tolerance to low N in the savanna of the south western of the DR Congo.

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