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Full Length Research Paper

Evaluation of Genotypic stability of maize populations under two different natural soil nitrogen conditions

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Five maize populations (TZE 5012, TZE 9030, TZE 9450, SWAN 1 and SWAN 4), were evaluated on performance stability under two natural soil nitrogen conditions viz: 1.57gkg^{-1} and 1.74gkg^{-1}. Data were collected on the productivity potential viz; germination and survival percentage and crop performance including; plant height, leaf area, anthesis-silking interval and total seed weight. Results showed that lines SWAN 1, SWAN 4 and TZE 9030 had relatively stable productivity and crop performance, above TZE 5012 and TZE 9450. Kernenberg grouping analysis on yield stability and line variability showed that SWAN 1, TZE 9030 and TZE 9450 had relatively stable yield, above TZE 5012 and SWAN 4. While SWAN 1, SWAN 4 and TZE 5012 showed relatively high stability, above TZE 9030 and TZE 9450. Overall performance and stability assessment revealed that SWAN 1 had better responses in both the environment studied; hence it has good genetic traits for adaptation under varying soil nitrogen conditions.

Keywords: Productivity potential, soil nitrogen, crop performance, genetic traits.

INTRODUCTION

Maize (Zea mays L.) is the third most popular cereal crop worldwide (FAO, 2010) after wheat and rice. It is one of the cereals that have to meet increasing demand for food and feed in the developing world (Cassman *et al*., 2002). The demand for maize in developing countries is expected to exceed rice and wheat demand by year 2020 (Pinstrup-Andersen et al., 1999). It is a major food source in many developing countries of Latin America, Sub-Saharan Africa and Asia, and accounts for 15 % of proteins and 20 % of calorie intake globally (Sofi *et al*., 2009). In Nigeria, maize is an important cereal crop where it serves as a major component of their diet. It serves as a source of dietary carbohydrate for humans (Onwueme and Sinha, 1999). Fresh ripe maize could be boiled and eaten as food, and when dry, maize grains are used for brewing and distillation of alcoholic drinks.

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Increased maize production is therefore needed in the Sub-Saharan Africa to meet its demand within the limits of available land and environmental conditions (Pingali and Pandey, 2001). Maize is compatible with common agronomic practices with great production potential in the moist savanna of West and Central Africa (WCA) where annual rainfall and solar radiation are favorable. Characterization of maize performance under different environmental conditions is a research strategy that has not been explored, especially in the tropics where the weather elements are erratic. Nigeria has large agro-ecological zones that support maize production on commercial scale. Thus, its productivity is hampered by both abiotic and biotic stress. However, low soil nutrients content especially soil nitrogen pose serious biotic stress on maize yield (Luque *et al*., 2006). Gorman *et al.* (1989) and Biarness-Dumolin *et al*. (1996) reported that low N nutrient is one of the most important environmental constraints to yield stability in maize after drought. Borojevic (1990) also noted that yield stability is influenced by the capacity of a genotype to react to environmental conditions, which is determined by the genotype genetic composition. Duvick (1992, 1997) and Tollenaar and Lee (2002) ascribed yield improvement and stability in maize genotypes to increased tolerance to low nitrogen and drought. This stress is associated with extreme climatic conditions, with a characteristic average temperature range between 18.450C to 38.90C in the northern part of Nigeria and 24.30C to 28.20C in the southern part of Nigeria; average rainfall ranges between 1,500mm in the north and 3,500mm in the southern part of Nigeria.

Crop performance is enhanced through developing varieties that possess stable survival, performance and productivity under different range of environmental conditions. Demand increase in maize production, coupled with upsurge in population trend makes improving upon tonnes of maize harvest inevitable, not compromising the safety of the consumers and the environment. Therefore, this study is focused on genotypic stability assessment of some maize population under different natural soil nitrogen conditions, to determine genotypic productivity potentials, observe lines performance and identify genotypes with good grain yield.

MATERIALS AND METHODS

The research field experiment was carried out on experimental field of Plant Science and Biotechnology, Adekunle Ajasin University, Akungba-Akoko (Lat. 7027' North, 5044'10' East; average max temp. 33^0C and min temp. 28^0C; relative humidity 74%; annual rainfall ranges between 1480 and 2500 mm). The maize populations used for this research were obtained from Federal University of Technology, Akure (FUTA), Ondo State, Nigeria. Soil samples were collected from the two experimental plots, at surface and subsurface layers, and analyzed for nitrogen content using Kjedahl laboratory principle. The populations as shown in Table 1 were planted out in four replicates in a randomized complete block design; each line was considered treatment on their genetic variability. Appropriate agronomic management practices were observed in both natural soil nitrogen conditions, from April to July, 2014. Plants were evaluated on productivity potential as germination and survival percentage, two weeks after sowing and at harvest respectively. These were determined as follows:
Percentage germination was calculated as:
GEM (%) = L_e/L_t* 100
Le is line emergence
Lt is total line emergence

Percentage survival was calculated as:
SUV (%) = L_e - L_s/L_t* 100
L_e is line emergence
L_s is line survival
L_t is total line emergence

Data were collected on crop character, as plant height, leaf area, anthesis-silking interval and total seed weight. These were analyzed using the following statistical formulae:

Means were calculated using the following formula:
$$x = {}^{1}/_{N} \sum xi$$

Standard errors were calculated as:
$$SEx = S/\sqrt{n}$$

Coefficient of variations were calculated using the below formula:

C_V = Standard deviation/ Mean

$$S = \sqrt{1/N\text{-}1} \sum (x_i - x)^2$$

Lines were grouped into four classes on yield and stability of performance using Kernenberg grouping technique. Hence:
Group I represents lines with low yield and high variability
Group II represents lines with high yield and high variability
Group III represents lines with low yield and low variability
Group IV represents lines with high yield and low variability

RESULTS AND DISCUSSION

Results on Table 1 revealed that lines TZE 5012, TZE 9450, SWAN 1 and SWAN 4 have lower plant height mean value in Soil Nitrogen condition 1 (N1) compare to the plant height mean values in Soil Nitrogen condition 2 (N2) while line 9030 have higher plant height mean value in N1compare to the value in N2. This showed that line 9030 performed better in plant height for genetic stability under low nitrogen condition N1 (1.57gkg-1) than in high nitrogen condition N2 (1.74 gkg-1) which may be as a result of the capacity of the genotype 9030 to favorably react to environmental condition in favor of plant height (Borojevic, 1990). However, lower plant height recorded for lines TZE 5012, SW1 and SW4 under N1 compare to the mean values recorded under N2 revealed that the plant height decreased relatively under low nitrogen condition, consistent with Ayodeji et al. (2013). Anthesis-silking interval gave contrast values for lines TZE 9450 and SWAN 1 having low values under N1 with relative to values recorded under N2, and total seed weight gave similar contrast values for lines TZE 9450 and SWAN 1, this indicated that anthesis-silking interval and total seed weight for lines TZE 5012 and SWAN1 relatively decreased under low nitrogen condition as this decreased TZE 9450 and SWAN 1 grain yield, as reported by Eberhart and Russell (1966). Percentage differences obtained from values among the measured parameters under N1 and N2 gave respective values of 18.70 % and 37.85 % for plant height, 41.90 % and 57.90 % for leaf area, 20% and 33.30 % for anthesis-silking interval and 71.50 % and 73.20 % for total seed

Table 1. Crop performance characters observed on plant height, leaf area, anthesis-silking interval and total seed weight for the lines under both soil nitrogen conditions.

Traits	Inbred lines	Nitrogen I Mean +SE	Nitrogen II Mean +SE
Plant height (cm)	TZE 5012	98.2+3.39	104.0+ 4.42
	TZE 9030	98.6+ 3.84	75.0+ 3.78
	TZE 9450	91.2+ 3.44	82.0+ 2.07
	SWAN 1	93.0+ 2.54	103.0+ 4.76
	SWAN 4	112.2+ 5.42	120.6+ 3.58
Leaf area (cm^2)	TZE 5012	441.4+ 12.47	397.2+ 2.97
	TZE 9030	363.2+ 18.04	233.8+ 10.70
	TZE 9450	351.4+ 16.69	288.4+ 14.13
	SWAN 1	560.4+ 18.24	409.4+ 4.73
	SWAN 4	605.2+ 5.40	555.8+ 8.00
Anthesis-silking interval (days)	TZE 5012	13.0+ 1.58	10.0+ 0.70
	TZE 9030	15.0 1.41	13.0+ 1.14
	TZE 9450	12.0+ 1.14	15.0+ 0.94
	SWAN 1	13.0+ 1.64	15.0+ 1.14
	SWAN 4	14.0+ 1.76	12.0+ 0.94
Total seed weight (g)	TZE 5012	64.4+ 2.839	45.2+ 1.68
	TZE 9030	44.4+ 2.619	41.4+ 1.74
	TZE 9450	26.2+ 1.15	20.6+ 1.28
	SWAN 1	72.6+ 3.50	69.6+ 2.22
	SWAN 4	91.8+ 3.91	77.0+ 2.09

Table 2. Regression line equation, for the regression between yield and other attributes based on combined data across two natural soil nitrogen environments.

Attributes	Reg. co. for N1	Slope	Reg. co. for N2	Slope
Percentage survival	16.4085+0.6612x	0.6612	10.7460+0.8611x	0.8611
Plant height	84.4483+0.2370x	0.2370	61.8771+0.7108x	0.7108
Leaf area	208.9048+4.2655x	4.2655	136.5436+4.8750x	4.8750
Anthesis-silking interval	12.5945+0.0135x	0.0135	14.2545-0.0254x	0.0254

weight, this revealed that there was a wide gap between genotypes response under the two environment of soil nitrogen, which the observed differences in environment N2 were much above environment N1. Figure 1 showed productivity potential and yield parameters under two soil nitrogen conditions, the line 9450 gave relative lowest values, followed by 9030 for the parameters, lines 5012 and SW4 gave similar values for percentage germination, but different values for percentage survival and total seed weight, with SW4 having higher value above 5012, this revealed that 9450 and 9030 were low performing genotypes, and that line 5012 and SW4 had close viability potentials, but SW4 gave better survival and total seed yield above line 5012 . SW1 gave highest values for percentage germination and survival compare to values recorded for total seed weight. Regression analysis (Table 2) showed strong and positive coefficient values between grain yield and percentage survival, plant height and leaf area, this revealed that the traits had high contribution to grain yield under varied soil nitrogen conditions, only for anthesis-silking interval that showed same positive trend in environment N1, but gave negative coefficient in environment N2, this expressed that anthesis-silking interval is not a viable dependent attributes for grain yield determination in maize plants. Regression slope obtained for the attributes revealed a wide gap differences between yield and plant height and leaf area recorded across the two soil nitrogen conditions, therefore level of nitrogen content within a particular agro-ecology greatly has effects on plant height and leaf area in maize. Fig 2 and Fig 3 revealed stability of performance of lines under two soil nitrogen conditions, 9030 and 9450 gave low yield, while SWI and SW4 gave high yield in both environments; 5012 gave low

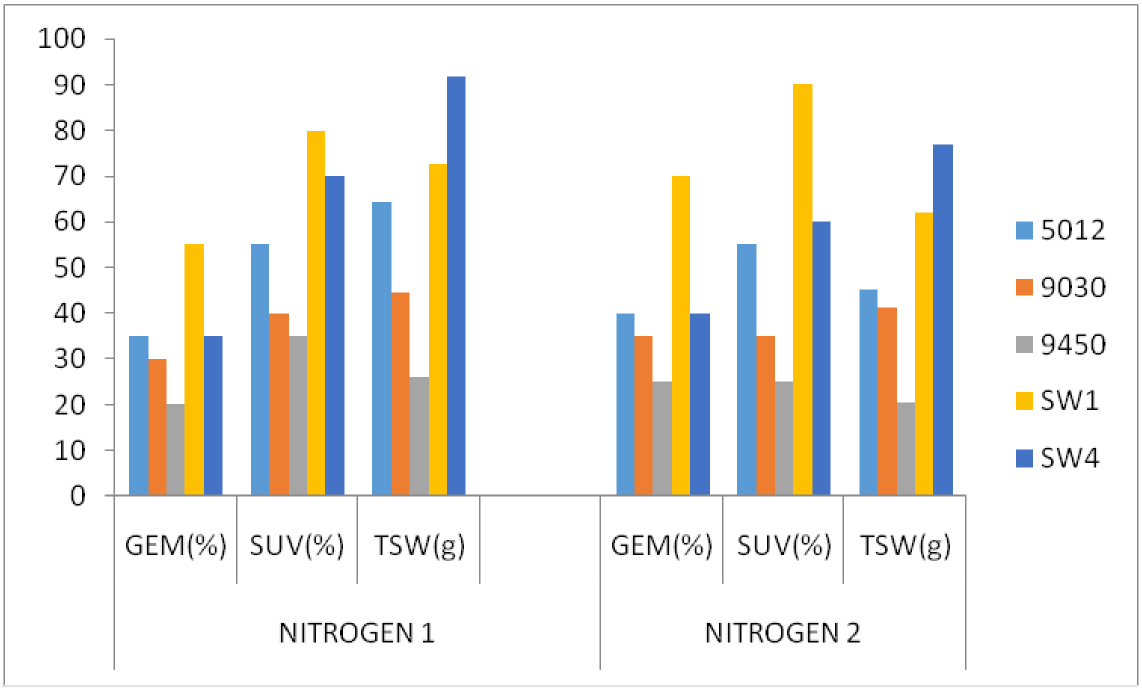

Figure 1. Percentage germination, percentage survival and grain yield parameters obtained from the lines under two soil nitrogen conditions.

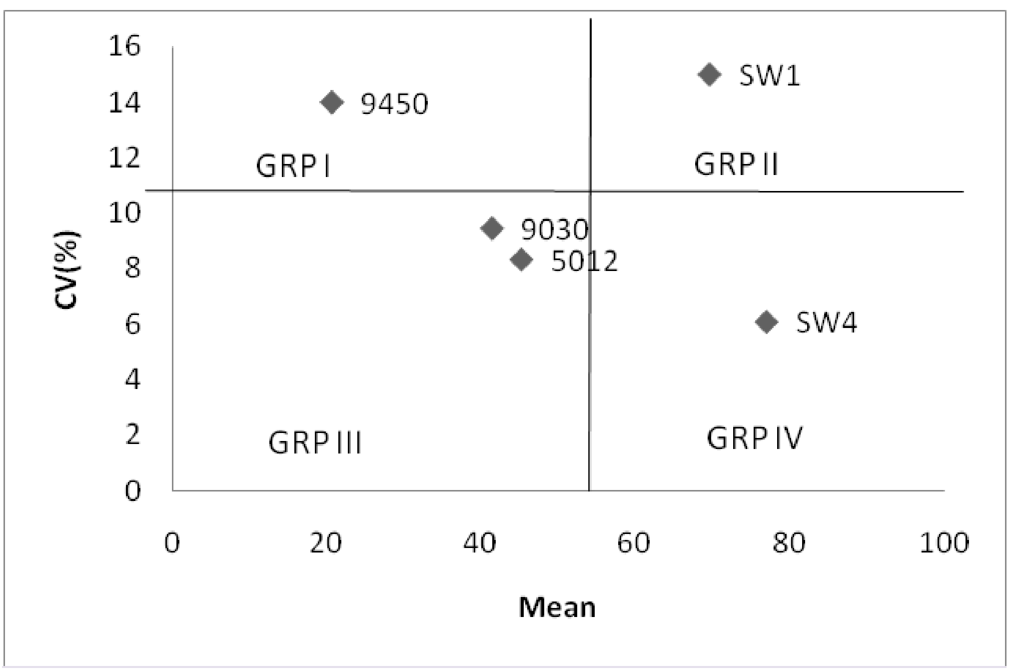

Figure 2. Average yield and line variability graph obtained from plant under soil nitrogen condition 1.74 gkg-1 for the lines.

yield under N1 and high yield under N2. This implied that lines 5012, SW1 and SW4 had relative high stability in both environments, while 9450 showed high variability under environment 1 and low variability under environment 2, and line 9030 showed low variability under environment 1 and high variability under environment 2.

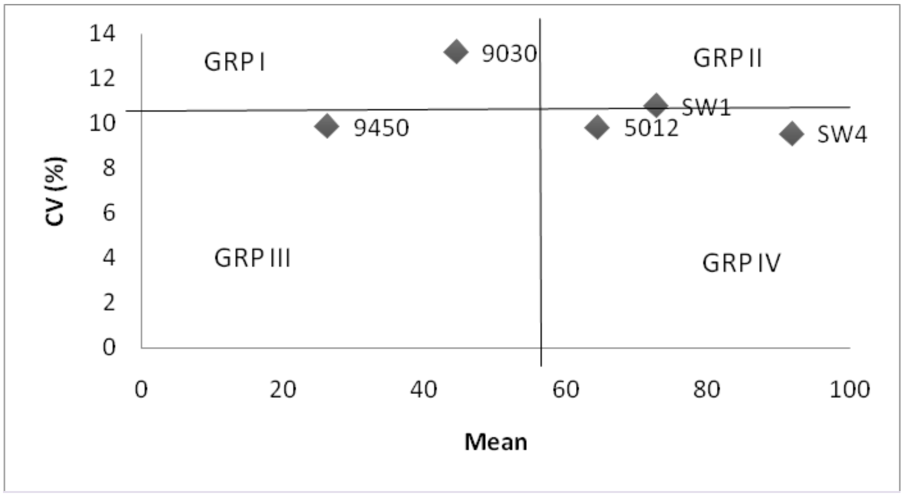

Figure 3. Average yield and line variability graph obtained from plant under soil nitro- gen condition 1.57gkg-1 for the lines.

CONCLUSION

This study revealed that maize genotypes respond in different manner based on their gene composition, hence with relative to their environmental conditions. Therefore genotype SWAN 1 was identified to have better response under both soil nitrogen conditions studied.

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