GENETIC VARIABILITY IN MINERAL COMPOSITION AMONG DIFFERENT STRESS TOLERANT MAIZE (*Zea mays* L.) GENOTYPES IN KEFFI, NASARAWA STATE

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Abstract: Genetic variability in mineral composition among different stress tolerant maize genotypes was carried out. Thirteen genotypes and two local checks (control) were evaluated in randomized complete block design (RCBD) with three replications. The twelve agronomic characters studied were plant height, ear per plant, anthesissilking interval, days to pollen, days to silking, days to maturity, number of cob per plant, leave length, Zinc, Magnesium, iron and grain yield. The result obtained from the analysis of variance for all the agronomic traits studied showed significant differences among all the genotypes at ($P < 0.01$). The highest mean value for zinc was seen in SAM 15 (3.39 mg/kg), followed by SAM 24 (3.26 mg/kg) and L2 (control) (3.16 mg/kg). The least mean value for zinc was found in SAM 37 (2.25 mg/kg). The highest mean values for magnesium was found in L1 (control) (6.53 mg/kg), followed by SAM 38 (6.48 mg/kg) and SAM 15 and L2 (control) (6.45 mg/kg). The least mean value was found in SAM 46 and SAM 37 (5.98 mg/kg). The mean performance for Iron showed there was significant difference between the genotypes. SAM 48 had the highest mean value (8.35 mg/kg) for iron, followed by SAM 26 (4.05 mg/kg) and SAM 46 (3.83 mg/kg). SAM 24 had the least mean value (2.09 mg/kg). Correlation studies revealed Magnesium to be positive and significantly correlated zinc ($r = 0.52$). Number of cub per plant was positively correlated to ear per plant ($r = 1.00$) while ear per plant was significant and negatively correlated to zinc ($r = -0.381$) and magnesium ($r = -0.341$). The results from this research have shown that high genetic variability exist with regards to mineral composition and this warrant effective selection for further improvement. The results from the broad sense heritability estimates for the 12 characters studied showed that all the characters are heritable with values range from 69.11 for leaf length to 100.00 for zinc, magnesium and iron. The information presented in this research should be of value to nutritionists. This paper thus recommend that SAM 48 be giving to children because of its iron content.

Keywords: Anthesissilking, genetic variability, mineral composition, maize, stress tolerant

Introduction

Maize (*Zea mays* L.) belongs to the family Poaceae. It is also known as corn, and first domesticated by indigenous peoples in Mexico (Wikipedia, 2016) about 10,000 years ago. The six major types of corn are dent corn, flint corn, pod corn, popcorn, flour corn, and sweet corn (Linda, 2013). Cereals are the most widely cultivated and consumed crops globally. In Nigeria, specifically in the Northern part of the country, cereal provides a major food resource for man (Enyisi *et al*., 2014). Maize is a multipurpose crop, providing food and fuel for human being and feed for animals (poultry and livestock). Its grain has great nutritional value and can be used as raw material for manufacturing many industrial products (Afzal *et al.*, 2009). Due to nutritional composition of maize, it serves as a good. On the average, the seeds were found to contain 63% carbohydrate, 19% protein and 6.5% oil. Its protein content can be used to fortify our mostly starchy foods like 'ogi', made from maize (Mbata *et al.*, 2007). Mineral elements, such as calcium, copper, magnesium, manganese, phosphorus, and potassium, are known to be essential for human health (MacDowel, 2003; O'Dell & Sunde, 1997). These minerals are critical for the growth and formation of strong bones, teeth, hair, blood, nerves and skin, synthesis of vitamins, enzymes and hormones, as well as for healthy functioning of the nervous system, blood circulation, fluid regulation, cellular integrity, energy production and muscle contraction (MacDowel, 2003; O'Dell & Sunde, 1997). However, the average prevalence of iron deficiency among children in 37 African countries has been estimated at 67% (UNICEF, 2004).

Zinc intake has been considered to be inadequate for an estimated 30% of the populations in 46 African countries (Hotz & Brown, 2004). Malnutrition is thus associated with more than half of all deaths of children worldwide (Sobo & Oguntona, 2006). According to Onyezili (1999), malnutrition contributed to more than half a million death of babies born in Nigeria in 1999. These nutritional deficiencies are also known to lead to a high death rate, disabling diseases and retardation in physical growth and mental development (Banigo *et al*., 1986). Therefore, this research is aimed to evaluate genetic variability in mineral composition among different stress tolerant maize genotypes.

Materials and Methods

Study area

Genetic variability in mineral composition among different stress tolerant maize genotypes was carried out in the Department of Plant Science and Biotechnology Research Garden of Nasarawa State University Keffi. Keffi Local Government Area is located between Latitude 8.847°N and longitude 7.905°E about 68KM from Abuja the Federal Capital and 128 km from Lafia the state capital (Awka *et al*., 2007).

Experimental materials

The experimental materials for this study was thirteen (13) maize genotypes representing a range of resistance and or tolerant to different stresses which was obtained from the Institute for Agricultural Research (I.A.R), Ahmadu Bello University, Samaru, Zaria and two (2) local checks. The maize genotypes used for this research include Sam 37, Sam 33, Sam 24, Sam 15, Sam 16, Sam 17, Sam 48, Sam 26, Sam 39, Sam 46, Sam 45, Sam 38 and Sam 32.

Experimental design/field layout

The genotypes obtained was planted in the botanical garden of the department in a randomized complete block design (RCBD) in three replications, with 2-row-plots each at a spacing of 75 cm by 25 cm. Foliar diseases were controlled by spraying Laraforce at the rate of 1 ml/litre. Other cultural operations including plant protection measures were followed as recommended practices for maize ensuring uniform and healthy crop. Observations on the agronomic traits were recorded on 5 individual plants, randomly selected from each plot.

Data collection

Data on the following characters was recorded from five randomly selected plants and used for analysis;

1. Ears per plant: Number of ear (s) each plant had were counted, summed up and the mean recorded.
2. Anthesis-silking interval (ASI): The number of days between day of pollen to the day of silking was recorded.
3. Plant height (cm): Height of each selected plant were measured from ground level to the top with the aid of a ruler and the mean recorded.
4. Leaf length (cm): The leaf length of every selected plant was taken and the mean recorded.
5. Days to pollen: The number of days it took for every selected plant to pollen was taken and the mean recorded.
6. Days to silking: The number of days it took for every selected plant to silk was taken and the mean recorded.
7. Days to maturity: Days after sowing to Harvest (maturity). When leaves start losing their greenness.
8. Number of cubs per plant: The number of Cub(s) per selected plant was taken and the mean recorded.
9. Representative grain samples were drawn in triplicate by quartering method and the individual samples were ground into fine powder using iron free Cyclotech Sample Mill. Biochemical analysis for kernel Fe and Zn concentration was carried out by digestion with 9:4 diacid mixture (HNO_3: $HClO_4$) followed by observation by the atomic absorption spectrometry (AAS) method, using protocol as described by Zarcinas *et al.* (1987) with some modifications suggested by Singh *et al.* (2005). The individual datasets were analyzed for analysis of variance (ANOVA) and comparison of means using PROC GLM of SAS Version 9.1 (SAS Institute, 2005). The data set of the 15 genotypes evaluated, was analyzed for stability analysis using Windostat Version 8.0.
10. Grain yield (Kg/hectare): Grain yield, measured as kilograms per hectare of harvested land. This was calculated using the formula: $GY = \frac{GW\,(100-MC)}{85 \times Area} \times 10000$. Where GW is the grain weight, MC is the Moisture content of the grain and Area is the Area of the experimental plot.

Statistical analysis

The data obtained were subjected to a standard statistical procedure to estimate the concentration of minerals and associations among the traits. Significant means will be separated using least significant difference (LSD) at 5%. The statistical tools to be used are: Analysis of Variance (ANOVA), Estimation of coefficient of variance, Heritability Estimate. The experimental design was arranged in randomized complete block design (RCBD) in three replications. For the statistical processing, data was analysed us SAS computer software.

Estimation of heritability

Heritability in broad sense (h_b^2) was calculated for each trait as the ratio of genotypic variance to the phynotypic variance (Falconer, 1989);

$$h_b^2 = \sigma g^2 / \sigma Ph^2$$

Where; h_b^2 = broad sense heritability estimate; σ_g^2 = genotypic variance; σ_{ph}^2 = phenotypic variance

And was categorised according to Singh (2001) as follows: values greater than 80% are very high, value from 60 to 79% are moderately high, values from 40 to 59% are medium and values less than 40% are low.

Results and Discussion

The mean square from the analysis of variance of different agronomic traits of stress tolerant maize genotypes is presented in Table 1. The result obtained from the analysis of variance for the agronomic traits of this plant showed significant differences among all the genotypes at ($P < 0.05$) for plant of height, ear per plant, anthesissilking interval, days to pollen, days to silking, days to maturity, number of cub per plant, leave length, Zinc, Magnesium, iron and grain yield. The mean performance of the maize genotypes for various agronomic traits that include plant height, ear per plant, anthesissilking interval, days to pollen, days to silking, days to maturity, number of cob per plant and leaf length are presented in Table 2.

Table 1: Mean squares from analysis of variance for different agronomic traits of Maize

Source	DF	PLHT	EPP	ASI	DP	DS	DM	NCPP	LL	ZN	MG	FE	GY
Genotype	14	1533.11	0.28	3.47	44.74	40.18	12.01	0.28	118.92	0.40	0.10	6.36	0.00002
Rep	2	829.27	0.16	0.96	5.49	10.40	40.47	0.16	37.37	0.00	0.00	0.00	0.00002
Error	28	1046.83	0.18	3.24	30.68	27.85	11.99	0.18	159.43	0.00	0.00	0.00	0.00002
CV		13.68	32.86	51.28	9.61	9.75	4.01	32.86	13.30	0.00	0.00	0.00	51.05234

PLHT: Plant height; EPP: Ear per plant; ASI: Anthesissilking interval; DP: Days to pollen; DS: Days to silking; DM: Days to Maturity; NCPP: Number of cob per plant; LL: Leave length; ZN: Zinc; MG: Magnesium; FE: Iron; GY: Grain yield

Table 2: Mean performance of different agronomic traits in *Zea mays*

Genotype	PLHT	EPP	ASI	DP	DS	DM	NCPP	LL	GY
SAM 37	198.17	1.67	4.67	53.33	48.67	88.00	1.67	85.50	0.01
SAM 33	215.33	1.00	2.33	60.67	58.33	86.67	1.00	92.33	0.01
SAM 24	223.17	1.00	3.00	62.67	59.67	87.00	1.00	96.17	0.01
SAM 15	226.83	1.00	3.33	58.00	54.67	88.33	1.00	99.67	0.00
SAM 16	221.17	1.00	4.00	54.67	50.67	85.00	1.00	86.83	0.01
SAM 17	250.50	1.67	5.00	54.67	49.67	84.67	1.67	102.17	0.01
SAM 48	233.33	1.33	3.33	59.00	55.67	85.33	1.33	103.00	0.01
SAM 26	217.17	1.33	3.00	57.67	54.67	85.67	1.33	88.33	0.02
L1	254.67	1.00	6.00	68.00	62.00	92.00	1.00	98.67	0.01
SAM 39	252.83	1.00	2.67	55.67	53.00	85.00	1.00	89.67	0.01
SAM 46	238.00	2.00	3.67	57.67	54.00	85.33	2.00	88.00	0.01
SAM 45	258.67	1.33	4.00	58.00	54.00	84.67	1.33	105.67	0.01
L2	238.00	1.33	3.00	54.67	51.67	86.67	1.33	95.33	0.01
SAM 38	258.67	1.33	2.67	56.00	53.33	84.33	1.33	96.00	0.01
SAM 32	253.67	1.33	2.00	54.00	52.00	85.33	1.33	96.50	0.01
LSD	**54.11**	**0.71**	**3.01**	**9.26**	**8.83**	**5.79**	**0.71**	**21.12**	**0.008**
MEAN	**236.47**	**1.29**	**3.51**	**57.64**	**54.13**	**86.27**	**1.29**	**94.92**	**0.01**

The result from the mineral analysis of the harvested kernels is presented in Table 3. The zinc value of the kernels ranges from 2.25 to 3.39, while Magnesium level ranges from 5.98 to 6.53 and the Iron level ranges from 2.28 to 8.35. SAM 15 had the highest Zinc level of 3.39, followed by SAM 24 with a zinc level of 3.26 and L2 with a zinc level of 3.16. L1 had the highest magnesium level of 6.53, followed by SAM 38 with magnesium level of 6.48 and SAM 15 and L2 with magnesium level of 6.45. SAM 37 and SAM 46 had the least magnesium level of 5.98. SAM 48 had the highest Iron level of 8.35, followed by SAM 26 with an iron level of 4.05 and L1 with an iron level of 3.66. SAM 24 had the least iron level of 2.09.

Correlation of mineral composition and grain yield are shown in Table 4. The estimate of correlation coefficient between all combinations of the 12 pairs of agronomic traits among the studied traits showed Magnesium to be positive and significantly correlated zinc (r = 0.52). It also showed Number of cub per plant to be positively correlated to ear per plant (r = 1.00). Grain yield was also positive and significantly correlated with ear per (r = 0.628). It was also found that ear per plant was significant and negatively correlated to zinc (r = -0.381) and magnesium (r = -0.341). The broad sense heritability estimates for the 12 characters of maize are presented in Table 5. Heritability values range from 69.11 for leaf length to 100.00 for zinc, magnesium and iron. Leaf length, days to pollen and anthesissilking interval had the least heritability values (69.11 to 76.26). All traits had very high heritability estimates (80-100) except for leaf length, days to maturity, anthesissilking interval and grain yield with moderately high heritability.

Table 3: Mean performance of 15 genotypes for kernel Zn, Mg and Fe content (mg/kg)

Genotype	ZN	MG	FE
SAM 37	2.25	5.98	2.78
SAM 33	2.83	6.17	3.24
SAM 24	3.26	5.99	2.09
SAM 15	3.39	6.45	3.35
SAM 16	2.62	6.23	2.70
SAM 17	2.48	6.07	2.28
SAM 48	2.29	6.24	8.35
SA M 26	2.67	6.21	4.05
L1	2.93	6.53	3.66
SAM 39	2.57	6.35	2.96
SAM 46	2.36	5.98	3.83
SAM 45	2.42	6.21	3.00
L2	3.16	6.45	3.50
SAM 38	3.03	6.48	3.42
SAM 32	2.52	6.20	2.83
MEAN	**2.72**	**6.24**	**3.47**

ZN: Zinc; MG: Magnesium; FE: Iron

Table 4: Spearman's rank correlation coefficients for different agronomic traits in *Zea mays*

Traits	PLHT	EPP	ASI	DP	DS	DM	NCPP	LL	ZN	MG	FE	GY
PLHT	1	0.014	0.204	0.203	0.147	-0.095	0.014	0.459	0.047	0.25	0.035	-0.033
EPP		1	-0.101	-0.267	-0.247	-0.156	1**	-0.056	-0.381**	-0.341**	0.058	0.628**
ASI			1	0.298**	-0.009	0.229	-0.101	0.389**	-0.12	-0.01	-0.037	-0.104
DP				1	0.952**	0.479**	-0.267	0.347**	0.232	0.141	0.106	-0.12
DS					1	0.428**	-0.247	0.238	0.281	0.151	0.123	-0.092
DM						1	-0.156	0.002	0.206	0.159	-0.023	-0.222
NCPP							1	-0.056	-0.381**	-0.341	0.058	0.628**
LL								1	0.082	0.147	0.132	-0.145
ZN									1	0.52**	-0.274	-0.186
MG										1	0.177	-0.233
FE											1	0.028
GY												1

Table 5: Estimates of variance components of stress resistant genotypes evaluated for genetic variability

Traits	GV	EV	PV	HB
PLHT	1533.11	1046.83	1882.05	81.46
EPP	0.28	0.18	0.34	82.37
ASI	3.47	3.24	4.55	76.26
DP	44.74	30.68	54.96	81.39
DS	40.18	27.85	49.47	81.23
DM	12.01	11.99	16.01	75.03
NCPP	0.28	0.18	0.34	82.37
LL	118.92	159.43	172.06	69.11
ZN	0.40	0.00	0.40	100.00
MG	0.10	0.00	0.10	100.00
FE	6.36	0.00	6.36	100.00
GY	0.00	0.00	0.00	77.97

GV= Genetic Variance; EV= Environmental Variance; PV= Phenotypic Variance; HB= Broad Sense Heritability

The research genetic variability in mineral composition among different stress tolerant maize genotypes was carried out. Analysis of variance revealed high significant differences for all the traits studied, which indicated the existence of sufficient genetic variability among the tested genotypes. These findings showed the presence of large variation among the tested maize genotypes. These results agree with finding of Agrawal *et al*. (2012), whom reported significant differences among genotypes for plant height, ear per plant, anthesissilking interval, days to pollen, days to silking, days to maturity, number of cub per plant, leaf length, zinc, magnesium, iron and grain yield. This might be as a result of considerable amount of genetic disparity among the genotypes. Analysis of variance indicated significant variation for both Fe and Zn concentration in all the genotypes (Table 3), suggestingthe availability of wider genetic variation.

Presence of similar variation have been reported in earlier study (Prasanna *et al*., 2011), indicating that the genetic behavior of the genes influencing the micronutrient concentration gives enough opportunity for the micronutrient enhancement in maize by following conventional plant breeding methods.

The genetic behaviour of the kernel Fe Zn and Mg provided enough evidence that separate groups of genes control micronutrient concentration in these genotypes. Besides, it was also revealed that kernel Fe and Zn were more affected by environmental fluctuation than kernel Mg, which showed more stable nature across genotypes. The development of an efficient breeding program to increase minerals concentration in maize depends on the presence of genetic variability in this species (Menkir, 2008).

Conclusion

Based on obtained results it could be concluded that investigated maize lines showed high variability in concentration of important mineral elements (Fe, Zn and Mg). The information presented should be of value to nutritionists.

Conflict of Interest

Authors declare that there is no conflict of interest related to this study.

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