Adamawa State University Journal of Scientific Research
Volume 10 Issue 2, 2022; Article no. ADSUJSR-1001007
ISSN: 2705-1900 (Online); ISSN: 2251-0702 (Print)
http://www.adsujsr.com

Genetic Variability and Heritability Studies of some Genotypes of Maize (*Zea mays* L.) in Mubi, Adamawa state.

B. Kwada[1] and P.M. Jonah[2]
[1]Goverment Secondary School P.M.B. 17 Mubi North Adamawa State, Nigeria
[2]Department of Crop Science, Adamawa State University Mubi, Nigeria.
Contact: *buluskwada86@gmail.com*; +2347035953845

(Received in July 2022; Accepted in September 2022)

Abstract
Agronomic and morphological techniques were used to evaluate the genetic variability of 25 genotypes of maize obtained from International Institute of Tropical Agriculture, Ibadan, Oyo State; Michika and Mubi, Adamawa State, Nigeria during 2018 and 2019 rainy season at the Food and Agricultural Organization/Tree Crop Production Research Farm, Adamawa State University, Mubi. The objectives of the study were: to determine the genetic variation among 25 genotypes of maize and to identify and select the most promising genotype(s) with respect to yield and yield related traits. Twenty - five genotypes of maize were evaluated in a Randomized Complete Block Design replicated three times. Twenty agronomic traits were collected: plant height, plant diameter, leaf width, leaves/plant, number of ears/plant, days to first and 50% tasseling, days to first and 50% silking, days to first and 50% maturity, cob length and diameter, kernel rows/cob and kernels/row. Other parameters collected include seed thickness, length and width, 100 grain weight and grain yield/hectare. The results revealed highly significant differences ($P \leq 0.01$) among the genotypes for all the agronomic characters studied. These indicated the presence of sufficient variation among the twenty – five genotypes of maize studied. From the mean performance, genotypes ADSUM/013 (TZM1121), ADSUM/014 (TZM1163) and ADSUM/015 (TZM1180) showed earliness attributes with respect to tasseling and maturity traits including cob diameter and number of kernels/row. ADSUM/018 (TZM1124) recorded highest grain yield (3.59 kg/ha), followed by ADSUM/022 (Michika – 2) with 3.56 kg/ha grain yield. The highest genotypic and phenotypic coefficients of variation were recorded for seed thickness (79.01 and140.60 respectively). Furthermore, high heritability coupled with high genetic advance were recorded for days to 50% maturity (98.92 and 68.41 respectively) and days to 50% silking of maize plants (96.95% and 70.62% respectively).

Keywords: Genotypes, Genetic parameters, Genotypic and Phenotypic variances, Heritability and Variability.

Introduction

Maize (*Zea mays* L.) is an annual cross-pollinated crop, which is the only monoecious among cereal crops that has the male and female inflorescences on separate branches of the same plant. It belongs to grass family called Poaceae (gramineae) which is leading in importance in the order Poales (Bremer *et al*., 2003). It has a variation in height of about 2.5 – 3 meters (Stevenson and Goodman, 1972). The stem has the appearance of a bamboo cane and is commonly composed of 20 internodes each of 18 cm length (Brown and David, 2009). A leaf grows from each node, which is generally 9 cm in width and 120 cm in length and the ears (18 cm long) develop above a few of the leaves in the midsection of the plant, between the stem and the leaf sheath (Roney and John, 2009). FAOSTAT (2021) reported that just four individual crops account for half the global production of primary crops in 2019: sugar cane (21% of the total with 1.9 billion tonnes), maize (12%, with 1.1 billion tonnes), rice and wheat each having 8% with 0.8 billion tonnes, respectively. Maize is the most-produced cereal worldwide and FAOSTAT (2016) revealed that in 2014, more than 1,022 million tons of maize was produced in more than 170 Countries on about 181 million hectares of land. The top producers were United States of America with 361 million tons, China with 216 million tons, Brazil with 80 million tons, and Argentina and Ukraine with 33 and 28 million tons respectively. Furthermore, FAOSTAT, (2016) reported that Nigeria is the second top ten maize producers in Africa with a grain yield of 10.8 million tons.

Martin *et al*. (1976) reported that maize seed contains 72.1% carbohydrate, 13.2% water, 10% protein, 4% oil, 0.41% phosphorus, 0.14% magnesium and 0.25% sulphur. Maize is used in many ways than any other cereals. It is used as human food and widely used in poultry farms, fisheries and animal feeding (Elfadil, 2005) and the yellow maize kernel contains carotene, which is a precursor of vitamin A. The crop is also useful for fermentation and for industrial purposes (Elfadil, 2005).

There has not been any extensive breeding work on selected maize genotypes in the Northern Guinea Savannah of Nigeria and many farmers cultivate local varieties, characteristically low yielding which are susceptible to pests and diseases. In order to overcome these challenges, the development of high yielding maize genotypes through evaluation and selection of accessions including multi-location trials to overcome these challenges cannot be over emphasized. Therefore, there is need to study genetic variation among twenty – five maize genotypes in Mubi for yield and yield related components. Das and Kumar (2012) stated that the progress to any plant breeding programme(s) depends on the nature and degree of variability present in the germplasms used for that particular study. Furthermore, genetic variability enables the breeder(s) to have a wide range of traits that can be used to select parents for any crop improvement (Dube *et al*., 2019).

The study was aimed at investigating the variation in agronomic characters of maize accessions with the specific aim of unveiling the available genetic variability present among 25 maize genotypes and to identify superior genotypes exhibiting desirable traits. Therefore, the objectives of the research are to:

i. determine the amount of genetic variation that exist among 25 genotypes of maize.
ii. identify and select high yielding genotypes among the accessions.

Materials and Methods

Genetic variability trial in some genotypes of maize trial was carried out at the Food and Agricultural Organization/Tree Crop Programme (FAO/TCP) Research Farm, Faculty of Agriculture, Adamawa State University, Mubi, during 2018 and 2019 cropping seasons. Mubi is geographically located within latitude $10^o 05^1$ N and longititude$13^o 16^1$ E at altitude 696 m^2 above the sea level as reported by Adebayo *et al*. (2020). The climate is characterized by alternating dry and wet seasons. The rains usually begin from the month of May and attain its peak between July and August and subsequently decline in September and at times ends in October. The vegetation is typically Sudan Savannah, which comprises of grass land interpose by shrubs and few trees mostly acasia, locust bean and eucalyptus among others (Adebayo *et al*., 2020).

Cultural Practices and Experimental Design

The land was cleared using cutlass and hoe, the field was then ploughed and harrowed to obtain fine soil tilt for easy emergence of maize seeds. For each genotype of maize, two to three seeds were sown on a plot size of 3 m x 2 m (i.e 6 m^2) with inter – row spacing of 75 cm and intra – row spacing of 25 cm. The gross plot size of 6 m^2 and a net plot size of 3 m^2 (1.5 m x 2 m) were used. At 2 Weeks After Sowing (WAS) thinning was done to one plant per stand to obtain 32 plant population per plot. Hand hoe was used manually for weeding at 3 and 6 WAS to minimize weed competition for space and nutrients with the maize crop plants. A compound fertilizer 426.67 kg of (NPK 15:15:15) per ha was applied in two split doses. The first application was done at 2 WAS and the second application at 4 WAS and later urea 213.33 kg/ha was applied during tasseling of maize plants at 8 WAS. The treatments consisted of 25 genotypes of maize (Table 1) assigned to each experimental plot. These treatments were laid out in a Randomized Complete Block Design replicated three times which gave a total of 75 plots. Harvesting was done at 120 days after sowing, from the net plot (3 m^2) when each maize genotypes had reached physiological maturity. Harvesting was done manually by cutting the maize stalks and leaning them against each other into a tee-pee-like structure to enhance drying of the maize cobs and to help make peeling away the husks easier. After one week of the drying, the cobs were plucked, dehusked and further sundried. Furthermore, the cobs were then threshed and winnowed to obtain clean grains as described by Sharifai *et al*. (2012).

Table 1: Twenty five Genotypes Collected with their Source Codes and Source

S/ No	Genotypes code	Genotypes Number	Source
1	ADSUM/001	TZMI -1117	IITA
2	ADSUM/002	TZMI-1159	IITA
3	ADSUM/003	TZMI – 1123	IITA
4	ADSUM/004	TZMI – 1148	IITA
5	ADSUM/005	TZMI – 1147	IITA
6	ADSUM/006	TZMI – 1110	IITA
7	ADSUM/007	TZMI – 1200	IITA
8	ADSUM/008	TZMI – 1199	IITA
9	ADSUM/009	TZMI – 1135	IITA
10	ADSUM/010	TZMI – 1103	IITA
11	ADSUM/011	TZMI – 1125	IITA
12	ADSUM/012	TZMI – 1202	IITA
13	ADSUM/013	TZMI – 1121	IITA
14	ADSUM/014	TZMI – 1163	IITA
15	ADSUM/015	TZMI – 1180	IITA
16	ADSUM/016	TZMI – 1116	IITA
17	ADSUM/017	TZMI – 1118	IITA
18	ADSUM/018	TZMI – 1124	IITA
19	ADSUM/019	TZMI – 1096	IITA
20	ADSUM/020	TZMI – 1128	IITA
21	ADSUM/021	Michika-1	Michika local cultivar
22	ADSUM/022	Michika-2	Michika local cultivar
23	ADSUM/023	Mubi-1	Mubi local cultivar
24	ADSUM/024	Mubi-2	Mubi local cultivar
25	ADSUM/025	OBA-98	AADP Mubi

IITA = International Institute of Tropical Agriculture, Ibadan
AADP = Adamawa Agricultural Development Program

Data Collection

The following agronomic (quantitative) data were measured:

Plant height (cm), plant diameter (mm), leaf width (cm), number of leaves per plant, days to first tasseling, days to 50 percent tasseling, days to first silking, days to 50 percent silking, number of ears per plant, days to first maturity. Other parameters include: days to 50% maturity, cob length (cm), cob diameter (mm), number of kernel rows per cob, number of kernels per row, seed thickness (mm) seed width (mm), seed length (mm), 1000 - grain weight (g), and grain yield per hectare (t/ha).

Data Analysis

To estimate the magnitude of variation among these genotypes, the data collected was subjected to analysis of variance for each year based on plot means, followed by a combined analysis of the data across the two years of evaluation as described by Singh and Chaudhary (1985). Mean separation was carried out according to Duncan's Multiple range Test described by Duncan (1955). Components of variance (σ^2_p, σ^2_e and σ^2_g) were used for the estimation of (Phenotypic and genotypic coefficients of variation) as described by Singh and Chaudhary (1985).

Estimates of Genetic Parameters

The genetic parameters were calculated using Burton and Dave (1953) with Singh and Chaudhary (1985) method:

Genotypic variance ($\sigma^2 g$) = $\frac{MSg-MSe}{r}$

Phenotypic variance $\sigma^2 p = \sigma^2 g + \sigma^2 e$

Where:

MS_g and MS_e are genotype and error mean square and r = number of replications.

The phenotypic Coefficient of Variation (PCV) were calculated as follows:

PCV = $\sqrt{\frac{\sigma^2 p}{\bar{X}} x\ 100}$ and the

$\bar{X}$= Mean value

Genotypic Coefficient of Variance (GCV):

GCV = $\sqrt{\frac{\sigma^2 p}{\bar{x}} x\ 100}$

Broad sense heritability for each of the twenty traits studied were computed by the formula:

$h^2 = \frac{\sigma^2 g}{\sigma^2 p}$ x $\frac{100}{1}$

The genetic Advance (GA) was calculated using percentage of the grand mean

GA = $\frac{h^2 \text{ x K } \sigma^2 P}{\text{grand mean}(\bar{x})}$ x 100

Where:

h^2 = heritability

K = selection differential = 2.06

$\sigma^2 p$ = standard deviation of phenotypic variance.

Results

Analysis of Variance for Agronomic Characters of Maize

The mean square values for the combined analysis is presented in Table 2. From the table, the genotype mean squares showed highly significant estimates for all the characters studied. The year effect revealed a highly significant difference for plant height, plant diameter, leaf width, leaves/plant, days to first tasseling, days to 50% tasseling, 50% silking, first days to maturity, days to 50% maturity, and 1000 grain weight. Four characters (days to first silking, number of kernels/row, seed thickness and seed length) recorded a significant difference. For the interaction effect (Genotype x Year) of the accessions within the two years, a highly significant difference (P<0.01) was recorded for most of the characters except for, days to 50% silking, number of ears/plant, number of rows of kernel/cob and seed width. The CV range of 0.80 to19.31 was recorded for cob diameter and grain yield respectively.

Table 2: Combined Mean Square Values for 20 Agronomic Characters of Maize Evaluated During 2018 and 2019 Rainy Season at Mubi.

Characters	Genotype (G)	Year (Y)	G×Y	Rep	Residual	CV
Df	24	1	24	4	48	
PH	5858.01**	79537.79**	2780.47**	1422.32**	219.71	7.47
PD	40.05**	1302.19**	23.47**	13.98*	3.26	8.02
LW	4.31**	67.62**	1.92**	0.16**	0.16	4.68
NOL/P	112.74**	104076.7**	57.76**	0.51^{ns}	2.55	4.09
DFT	222.42**	201.84**	14.40**	2.02^{ns}	3.61	3.53
D50%T	232.03**	493.23**	26.59**	5.23^{ns}	3.76	3.29
DFS	261.19**	64.03*	10.69*	4.87^{ns}	4.72	3.67
D50%S	280.24**	440.33**	10.94^{ns}	4.67^{ns}	8.53	4.56
FDM	345.66**	1574.64**	83.22**	18.98^{ns}	12.44	4.46
D50%M	353.18**	854.43**	37.91**	4.95^{ns}	1.29	1.27
NOE/P	0.31**	0.11^{ns}	0.16^{ns}	0.21^{ns}	0.11	6.43
CD	52.33**	12.60^{ns}	39.64**	27.40*	6.01	0.80
NOKRPC	4.52**	2.43^{ns}	1.68^{ns}	0.34^{ns}	1.89	6.40
NOKPR	71.59**	57.07*	66.42**	80.43*	13.68	10.98
CL	15.24**	9.86^{ns}	10.18**	6.35**	1.37	7.47
ST	0.31**	0.76*	0.25*	0.21^{ns}	0.14	8.52
SL	5.56**	4.54*	2.40**	0.13^{ns}	0.50	7.06
SW	1.79**	0.27^{ns}	0.63^{ns}	0.53^{ns}	0.31	6.40
1000GW	25781.24**	18193.81**	8438.73**	120433.37**	1926.44	11.01
GY	0.93**	0.10^{ns}	0.57**	1.40*	0.30	19.31

* and ** indicate significance of values at P = 0.05 and P = 0.01 highly significance, respectively, NS = Not significant, $\sigma^2 g$ = Genotypic variance, σ^{2p} = Phenotypic variance, H^2 = Heritability, GCV = Genotypic coefficient of variation, PCV = Phenotypic coefficient of variation, GA = Genetic advance, PH = Plant height, PD = Plant diameter, LW = Leaf width, NOL/P = Number of leaves/ plant, DFT = Days to first tasseling, D50%T = Days to 50% tasseling, DFS = Days to first silking, D50% S = Days to 50% silking, FDM = First days to maturity, D50%M = Days to 50% maturity, NOE/P = Number of ears per plant, CD = Cob diameter, NOKRPC = Number row of kernels per cob, NOKPR = Number of kernels per row, CL = Cob length, ST = Seed thickness, SL = Seed length, SW = Seed width, 1000GW = One thousand seed weight, GY = Grain yield.

Mean Performance of 20 Agronomic Characters of Maize Studied

The mean performance of the maize genotypes during two years of evaluation (2018 and 2019 combined) is presented in Table 3. Plant height was highest for genotype 11 (ADSUM/011) with 242.13 cm, followed by genotype 9 (ADSUM/009) 226.16 cm. Although the two genotype were at par. The least plant height was recorded by ADSUM/015 (112.65 cm). For plant diameter, ADSUM/010, had the widest (28.34 mm) and followed by genotype 11 (ADSUM/011) with 28.20 mm. Both genotypes are statistically not different from each other. The least plant diameter was recorded by genotype 15 (ADSUM/015) with 18.78 mm. For leaf width, Michika-1 (ADSUM/021) was the widest (10.08 cm), followed by ADSUM/025 (9.99 cm), while the least estimate was recorded by ADSUM/018 with 7.23 cm. Number of leaves/plant was highest for ADSUM/011 with 46.00 leaves, followed by ADSUM/005 (44.58) and the least number of leaves/plant was ADSUM/015 (27.38). For days to first tasselling, genotype 15 (ADSUM/015) recorded the least estimate (39.17 days), indicating earliness, followed by genotype 14 (ADSUM/014) with 41.33 days to produce its first tassel, but genotype 11 (ADSUM/011) was late to produce its first tassel (67.00 days). Similarly, the lowest days to 50% tasseling (earliness) was produced by ADSUM/015 with 42.50 days, followed by genotype 14 (ADSUM/014) with 45.33 days, while genotype 11 (ADSUM/011) was late to produce days to 50% tasseling (70.67 days). Furthermore, days to first silking was recorded by ADSUM/015 with 42.83 days to produce its first silk, followed by ADSUM/014 having 47.33 days. Although, ADSUM/011 had the highest number of days 74.33 to produce its first maize silk. In a similar vein, ADSUM/015 had the least number of days to 50% silking (46.50 days), followed by genotype 14 (ADSUM/014) with 51.67 days. The highest number of days to 50% silking was recorded by genotype 11 (81.50 days). Furthermore, ADSUM/015 had first days to maturity (65.00 days), while ADSUM/011 recorded 96.33 days to obtain its first days to maturity. Genotype 15 (ADSUM/015) took 71.5 days to days to 50% maturity, followed by accession 14 (ADSUM/014) 73 days; but genotype 11 (ADSUM/011) had the highest number of days to 50% maturity (100.33). For number of ears/plant genotype 17 (ADSUM/017) recorded 6 ears, while all other genotypes recorded 5 ears/plant each.

Harvest Data

Cob diameter was highest for ADSUM/023 with 48.57 mm, followed by ADSUM/025 with 47.95 mm. Although the two genotypes were at par, while the least value was recorded by ADSUM/011with 37.49 mm. For kernel rows/cob ADSUM/014 had the highest estimate of (16.13), followed by ADSUM/018 with 15.88, and the least value was recorded ADSUM/016 (12.87). Highest kernels/row was recorded by genotype 22 (ADSUM/022) with 40.57, followed by ADSUM/010 (38.95) and these two genotypes were statistically similar. The least value was recorded by ADSUM/015 with 25.67. The longest maize cob length of (18.47 cm) was recorded by ADSUM/008, followed by ADSUM/021 with 18.03 cm. Although these two genotypes are at par, while the least value was recorded by ADSUM/018 with 12.47 cm.

For seed thickness of maize was highest for ADSUM/011 with 4.73 mm, followed by ADSUM/009 (4.71 mm). Although the two genotypess were not statistically different. ADSUM/016 was the least (3.92 mm) for seed thickness. The longest seed length was recorded by Oba 98 (Genotype 25) with 12.04 mm, followed by genotype 21 (Michika–1) with 11.67 mm, while TZM 1180 (genotype 15) was the least (8.09 mm). For highest seed width trait, genotype 3 (ADSUM/003) recorded 9.88 mm, followed by ADSUM/025 with 9.66 mm. Both genotypes were also not statistically different from each other with respect to seed width. For this trait the least estimate was recorded by ADSUM/007 having 7.94 mm. For 1000 grain weight, genotype 25 (ADSUM/025) had the highest estimate with 551.37 g, followed by ADSUM/023 (518.55 g), while the lowest value was recorded by ADSUM/011 with 303.45 g. The highest grain yield estimate of 3.59 t/ha was recorded by ADSUM/018, followed by ADSUM/022 (3.56 t/ha), but the lowest value was recorded by ADSUM/006 with 2.26 t/ha.

Table 3: Combined Mean Performance of 25 Genotypes of Maize with Respect of 20 Characters During 2018 and 2019 Rainy Season

S/N	ACC	PH	PD	LW	NOL/P	DFT	D50%T	DFS	D50%S	FDM	D50%M	N0E/P	CD	NOKRPC	NOKPR	CL	ST	SL	SW	1000GW	GY
1	TZM 1117	217.07^{bc}	23.50^{c-g}	9.01^{cd}	37.67^{gh}	51.50^{g}	58.67^{g-i}	57.67^{hi}	66.17^{c-f}	80.33^{d-f}	89.33^{f-h}	5.33^{bc}	43.74^{d-g}	13.90^{d-j}	32.85^{c-f}	15.61^{d-g}	4.50^{ab}	9.91^{de}	8.80^{c-g}	418.50^{ef}	2.88^{a-f}
2	TZM1159	181.04^{ef}	25.58^{b}	7.53^{i}	39.83^{ef}	60.00^{b}	64.67^{bc}	67.83^{b}	70.83^{b}	84.00^{b-d}	94.83^{d}	5.00^{c}	44.94^{b-g}	13.78^{d-j}	33.83^{c-f}	15.31^{e-h}	4.26^{a-d}	9.92^{de}	8.65^{d-h}	377.68^{f-j}	2.29^{f}
3	TZM1123	210.51^{b-d}	20.71^{h-l}	8.89^{de} 0	42.09^{cd}	55.50^{c-e}	66.00^{b}	60.17^{f-h}	65.17^{d-g}	64.33^{k}	90.33^{e-g}	5.17^{bc}	45.50^{a-f}	13.70^{e-j}	34.71^{b-f}	14.90^{e-h}	4.52^{ab}	10.04^{de}	9.88^{a}	398.66^{f-h}	2.99^{a-f}
4	TZM1148	195.85^{de}	20.52^{i-l}	8.57^{d-g}	38.92^{e-g}	51.83^{g}	56.50^{c}	59.67^{f-h}	62.83^{fg}	74.50^{gh}	88.17^{hi}	5.17^{bc}	42.84^{e-h}	15.60^{a-c}	31.65^{d-f}	14.15^{gh}	4.28^{a-d}	9.84^{de}	8.05^{gh}	383.22^{f-j}	2.85^{a-f}
5	TZM1147	199.35^{cd}	22.17^{d-i}	8.03^{h}	44.58^{ab}	57.67^{b}	63.17^{cd}	63.83^{cd}	69.67^{bc}	87.83^{b}	97.83^{b}	5.00^{c}	41.88^{g-i}	12.97^{h-j}	31.93^{c-f}	16.03c-f	4.54^{ab}	9.53^{d-f}	9.21^{a-d}	415.07^{ef}	2.64^{c-f}
6	TZM1110	199.92^{cd}	18.79^{l}	8.30^{f-h}	37.42^{gh}	52.67^{g}	61.00^{d-h}	60.00^{f-h}	65.17^{d-g}	82.67^{c-e}	90.67^{ef}	5.00^{c}	42.35^{e-i}	13.74^{e-j}	31.45^{d-f}	13.88^{h}	3.96^{cd}	9.57^{d-f}	8.69^{d-h}	339.64^{h-k}	2.26^{f}
7	TZM1200	218.99^{bc}	21.41^{f-j}	8.71^{d-f}	41.97^{cd}	59.50^{b}	64.83^{bc}	66.33^{bc}	71.33^{b}	76.17^{fg}	96.83^{bc}	5.00^{c}	37.98^{j}	14.15^{d-i}	38.88^{ab}	17.82^{ab}	4.37^{a-d}	9.49^{ef}	7.94^{h}	325.79^{jk}	2.49^{d-f}
8	TZM1199	206.91^{b-d}	22.18^{d-i}	8.27^{f-h}	42.75^{b-d}	59.83^{b}	62.67^{c-e}	63.50^{de}	67.83^{b-e}	85.33^{bc}	94.17^{d}	5.17^{bc}	41.81^{g-i}	12.93^{h-j}	35.33^{b-e}	18.47^{a}	4.39^{a-d}	9.59^{d-f}	8.45^{d-h}	408.71^{e-g}	2.81^{b-f}
9	TZM1135	226.16^{ab}	21.69^{e-j}	8.51^{d-h}	42.00^{cd}	53.17^{e-g}	60.83^{d-h}	59.83^{f-h}	66.17^{c-f}	76.67^{fg}	89.17^{gh}	5.00^{c}	44.19^{c-g}	14.10^{b-d}	34.15^{b-f}	16.36^{b-e}	4.71^{a}	9.65^{d-e}	8.69^{d-h}	385.34^{f-i}	3.24^{a-d}
10	TZM1103	221.42^{b}	28.34^{a}	9.42^{bc}	40.75^{de}	52.67^{g}	59.00^{f-i}	59.00^{f-i}	62.33^{fg}	79.33^{ef}	86.83^{i}	5.17^{bc}	45.35^{a-f}	14.43^{d-g}	38.95^{ab}	17.71^{ab}	4.10^{b-d}	10.37^{c-e}	8.84^{c-f}	395.09^{f-h}	3.25^{a-d}
11	TZM1125	242.13^{a}	28.20^{a}	9.02^{cd}	46.00^{a}	67.00^{a}	70.67^{a}	74.33^{a}	81.50^{a}	96.33^{a}	100.33^{a}	5.00^{c}	37.49^{j}	13.22^{g-j}	29.94^{fg}	15.64^{d-g}	4.73^{a}	8.79^{fg}	8.22^{e-h}	303.45^{k}	2.80^{b-f}
12	TZM1102	223.76^{ab}	23.76^{b-f}	8.65^{d-g}	38.79^{e-g}	47.67^{h}	53.00^{j}	53.00^{j}	57.50^{h}	71.67^{hi}	84.17^{j}	5.00^{c}	42.34^{e-i}	13.10^{d-j}	34.65^{b-f}	15.12^{e-h}	4.14^{b-d}	10.16^{c-e}	8.64^{d-h}	390.29^{f-i}	2.89^{a-f}
13	TZM1121	140.21^{h}	22.64^{d-i}	7.39^{i}	33.50^{i}	44.17^{i}	49.67^{k}	47.50^{k}	53.17^{i}	69.67^{ij}	74.00^{k}	5.33^{bc}	40.08^{h-j}	14.87^{b-e}	31.88^{c-f}	14.29^{gh}	4.18^{b-d}	9.42^{ef}	8.17^{e-h}	324.96^{jk}	2.57^{c-f}
14	TZM1163	146.18^{h}	18.99^{kl}	8.13^{gh}	29.25^{j}	41.33^{j}	45.33^{l}	47.33^{k}	51.67^{i}	66.50^{jk}	73.00^{k}	5.00^{c}	47.15a-c	16.13^{a}	30.50^{ef}	14.17^{gh}	4.61^{ab}	9.48^{ef}	8.17^{e-h}	353.13^{g-k}	2.45^{ef}
15	TZM1180	112.65^{i}	18.78^{l}	7.09^{i}	27.38^{k}	39.17^{j}	42.50^{m}	42.83^{l}	46.50^{j}	65.00^{k}	71.50^{l}	5.33^{bc}	39.23^{ij}	13.56^{f-j}	25.67^{g}	14.09^{gh}	4.61^{ab}	8.09^{g}	8.54^{d-h}	346.76^{h-k}	2.29^{f}
16	TZM1116	155.79^{gh}	21.19^{g-k}	7.44^{c}	36.00^{h}	59.50^{b}	61.50^{d-f}	64.50^{cd}	64.17^{e-g}	84.33^{b-d}	90.83e	5.00^{c}	41.81^{g-i}	12.87^{j}	31.17^{d-f}	14.67^{f-h}	3.92^{d}	8.47^{g}	8.55^{d-h}	312.80^{k}	2.62^{c-f}
17	TZM1117	210.63^{b-d}	24.47^{b-c}	8.87^{de}	38.50^{fg}	51.83^{g}	56.67^{i}	58.00^{hi}	63.50^{fg}	78.33e-g	90.00^{e-g}	6.00^{a}	43.57^{d-g}	14.50^{b-e}	32.30^{c-f}	15.16^{f-h}	4.11^{b-d}	9.70^{d-f}	8.43^{e-h}	416.36^{ef}	3.10^{a-e}
18	TZM1124	166.67^{fg}	20.91^{h-l}	7.23^{i}	36.92^{gh}	52.50^{g}	56.50^{i}	58.17^{g-i}	63.00^{fg}	76.50^{fg}	84.50^{j}	5.00^{c}	42.21f-i	15.88^{ab}	29.67^{fg}	12.47^{i}	4.46^{a-c}	9.57^{d-f}	8.08^{f-h}	335.28^{i-k}	3.59^{a}
19	TZM1096	216.83^{bc}	23.10^{c-g}	7.45^{i}	37.50^{gh}	55.33^{c-f}	58.50^{hi}	59.17^{f-i}	63.83^{fg}	78.83^{e-g}	86.83^{i}	5.17bc	42.92^{e-h}	13.20^{g-j}	33.35c-f	14.51^{f-h}	4.23^{a-d}	10.36^{c-e}	8.76^{f-g}	435.83^{d-f}	3.32a-c
20	TZM1128	206.36^{b-d}	19.39^{j-l}	8.46^{e-h}	37.67^{gh}	53.33^{d-g}	56.67^{i}	56.67^{i}	61.83^{g}	78.33^{e-g}	84.67^{j}	5.00^{c}	43.02^{e-h}	13.72^{e-j}	31.50^{d-f}	13.87^{h}	4.45^{a-c}	10.11^{c-e}	8.78c-g	381.33^{f-j}	3.29^{a-c}
21	MCH-1	224.63^{ab}	21.31^{f-k}	10.08^{a}	43.25^{bc}	53.00^{fg}	59.00^{f-i}	58.67^{g-i}	63.50^{fg}	80.00d-f	89.67^{e-g}	5.00^{c}	46.83^{a-d}	14.13^{d-i}	36.85^{a-c}	18.03^{a}	4.36^{a-d}	11.67^{ab}	9.59^{ab}	500.99^{a-c}	3.34^{a-c}
22	MCH-2	200.00^{cd}	23.16^{c-h}	9.41^{bc}	42.25^{cd}	57.50^{bc}	63.17^{cd}	63.00^{de}	68.50^{b-d}	86.67^{bc}	94.17^{d}	5.17bc	$45.64.^{a-e}$	13.90^{d-j}	40.57^{a}	17.19^{a-c}	4.09^{b-d}	12.10^{a}	9.48^{a-c}	487.88^{b-d}	3.56^{ab}
23	MB-1	209.08^{b-d}	22.51^{d-i}	9.63^{ab}	38.50^{fg}	57.67^{bc}	61.17^{d-g}	61.83^{d-f}	66.33^{c-f}	85.83^{bc}	96.33^{c}	5.00^{c}	48.57^{a}	13.70^{e-j}	35.95^{a-d}	16.96^{a-d}	4.47^{a-c}	10.49^{cd}	9.58^{ab}	518.55^{ab}	3.10a-e
24	MB-2	211.59^{b-d}	25.88^{b}	8.99^{cd}	38.00^{f-h}	56.00^{c}	60.83^{d-h}	61.00^{d-f}	65.00^{d-g}	82.83^{c-e}	96.67^{bc}	5.50^{b}	47.33^{a-c}	14.20^{d-h}	38.90^{ab}	17.09^{a-d}	4.15^{b-d}	11.00^{bc}	8.95^{b-e}	460.75^{c-e}	2.78^{c-f}
25	OBA98	219.74^{bc}	24.08^{b-e}	9.99^{a}	42.67^{b-d}	55.67^{cd}	60.17^{e-h}	59.83^{f-h}	64.67^{d-g}	84.00^{b-d}	97.83^{b}	5.17bc	47.95^{ab}	13.90^{d-j}	35.45^{b-e}	17.38^{a-c}	4.58^{ab}	12.04^{a}	9.66^{ab}	551.37^{a}	2.50^{d-f}

Means with the same letter (s) are not significant at 5% level of probability using Duncan Multiple Range Test. , PH = Plant height, PD = Plant diameter, LW = Leaf width, NOL/P = Number of leaves/ plant, DFT = Days to first tasseling, D50%T = Days to 50% tasseling, DFS = Days to first silking, D50% S = Days to 50% silking, FDM = First days to maturity, D50%M = Days to 50% maturity, NOE/P = Number of ears per plant, CD = Cob diameter, NOKRPC = Number row of kernels per cob, NOKPR = Number of kernels per row, CL = Cob length, ST = Seed thickness, SL = Seed length, SW = Seed width, 1000GW = One thousand seed weight, GY = Grain yield.

Estimate of Coefficient of Variance for 20 Traits of Maize Evaluated

Estimates of genetic parameters for the 20 traits of maize for the combined years of evaluation (Table 4) showed high estimates of genotypic and phenotypic variance by 1000 grain weight (7952.60 and 9878.03) and plant height (1879.43 and 2099.13) values, respectively. Low estimate of genotypic and phenotypic variances were recorded for seed thickness (0.06 and 0.19, respectively). Generally the Phenotypic Coefficients of Variation (PCV) estimates were higher than their corresponding Genotypic Coefficients of Variation (GCV) for all the traits evaluated. The GCV range from (0.34) for 1000 grain weight to (85.34) for number of ears/plant. In a similar vein the PCV ranged from 0.38 to 133.00 for 1000 grain weight and number of ears/plant. High GCV and PCV estimates were recorded for seed thickness (79.01 and 140.60, respectively), ears/plant (85.34 and 133 respectively) and grain yield (48.61 and 76.85 respectively), while the lowest estimate of GCV and PCV was recorded by 1000 grain weight (0.34 and 0.38, respectively).

Table 4: Combined Genetic Parameters of 20 Agronomic Characters in Maize During 2018 and 2019 Rainy Season.

Characters	σ^2g	σ^2p	GCV	PCV	H^2 (%)	GA
PH	1879.43	2099.13	0.74	0.78	89.53	67.54
PD	12.26	15.52	8.74	9.83	79.99	63.07
LW	1.38	1.53	27.31	28.76	90.19	66.10
NOL/P	36.73	39.27	5.38	5.56	93.53	67.11
DFT	72.93	76.54	3.83	3.93	95.28	67.54
D50%T	76.09	79.85	3.76	3.86	95.29	67.55
DFS	85.49	90.21	3.53	3.63	94.76	67.42
D50%S	90.57	99.09	5.88	5.97	96.95	70.62
FDM	110.40	122.83	3.03	3.20	89.88	65.79
D50%M	117.29	118.57	3.06	3.08	98.92	68.41
NOE/P	0.07	0.17	85.34	133.00	41.17	19.15
CD	15.43	21.44	7.50	8.85	71.96	60.74
NOKRPC	1.23	2.04	24.53	31.59	60.29	56.05
NOKPR	19.30	32.97	6.13	8.02	58.53	55.52
CL	4.62	5.98	14.11	16.05	77.25	62.48
ST	0.06	0.19	79.01	140.60	31.57	39.60
SL	1.68	49.22	23.35	126.40	3.41	62.29
SW	0.49	0.80	39.32	50.24	61.25	56.70
1000GW	7951.60	9878.03	0.34	0.38	80.49	63.52
GY	0.20	0.50	48.61	76.85	40.00	72.29

σ^2g = Genotypic variance, σ^{2p} = Phenotypic variance, H^2 = Heritability, GCV = Genotypic coefficient of variation, PCV = Phenotypic coefficient of variation, GA = Genetic advance, , PH = Plant height, PD = Plant diameter, LW = Leaf width, NOL/P = Number of leaves/ plant, DFT = Days to first tasseling, D50%T = Days to 50% tasseling,, DFS = Days to first silking, D50% S = Days to 50% silking, FDM = First days to maturity, D50%M = Days to 50% maturity, NOE/P = Number of ears per plant, CD = Cob diameter, NOKRPC = Numberof rows of kernel/ cob, NOKPR = Number of kernels per row, CL = Cob length, ST = Seed thickness, SL = Seed length, SW = Seed width, 1000GW = One thousand seed weight, GY = Grain yield.

Heritability Estimates

Most of the characters had high broad sense heritability estimates with days to 50% maturity (98.92%), days to 50% silking (96.95%) and days to 50% tasseling (95.29%). Seed length recorded the least heritability estimates (3.41%). High heritability coupled with high genetic advance was recorded by days to 50% maturity (98.92% and 68.41%, respectively) and days to 50% silking (96.95% and 70.62%, respectively) and the least estimates was recorded by seed thickness (31.57% and 39.60% respectively.

Discussion

Analysis of Variance for Agronomic Characters of Maize

The results of the combined analysis of variance across years (2018-2019) for all traits studied indicated that the genotypes showed highly significant difference (P<0.01) for all the traits studied (plant height, plant diameter, leaf width, number of leaves/plant, days to first tasseling, days to 50% tasseling, days to first silking, days to 50% silking, first days to maturity, days to 50% maturity, number of ears/plant, cob diameter, number rows of kernel/cob, number of kernels/row, cob length, seed thickness, seed length, seed width, 1000 grain weight and grain yield). This suggests that these genotypes can respond to selection procedure. These results are similar to the findings of the following maize researchers (Maruthi 2009; Nagabhushan *et al.,* 2012; Reddy *et al.,* 2013; Ogunniyan and Olakojo, 2015; Zakariya *et al*., 2018 and Nusrat *et al*., 2020). All these researchers reported existence of significant genetic variability among maize genotypes for all the quantitative characters studied. Highly significant genotype x year interaction effect observed for days to 50% silking, number of ears/plant, kernel rows/cob and seed width showed that the genotypes performed differently within the two years of evaluation. Similarly, genetic variability studies in Bambara groundnut by Kadams and Sajo (1998) revealed significant genotype x year interaction for pod yield/plant and pod number/plant. Furthermore, Jonah (2008) also reported significant results (genotype x year) for plant height, pods/plant, pod yield/plant, 100 grain weight, seed width and length in Bambara groundnut.

Mean Performance of Twenty Agronomic Characters of Maize

The comparative performance of twenty five genotypes of maize cultivated during the two years of evaluation revealed a clear agronomic superiority of some of the genotypes. Great potential for improvement exist for three genotypes (ADSUM/013, ADSUM/014 and ADSUM/015) that tasseled earlier than the other genotypes and also flowered earlier (days to first and 50% tasseling, days to first and 50% silking, first days to maturity and 50% maturity). Genotype 21 (ADSUM/021) and ADSUM/018, although late maturing genotypes, but excelled in most of the agronomic characters (cob diameter, number of kernels/row, cob length including grain yield). Depending on the breeding objectives, there is a wide range of accessions to choose. For instance, if the breeding objective is to produce high yielding varieties then genotype 21, genotype 22 and 18 could be used for hybridization to improve the early maturing genotypes that are low yielding. Earliness in growth is an important trait to select for, especially in areas with low seasonal rainfalls. Furthermore, results of days to 50% silking, plant height, number of kernel rows/plant and 1000 kernel weight obtained in the study agrees with the findings of Selvi *et al.* (2013).

Estimate of Genetic Parameters of Maize

In this study, the estimates of phenotypic and genotypic variances observed for the combined years (2018-2019) for 1000 grain weight and plant height are in consonance with the findings of Ogunniyan and Olakojo (2015), Rahman *et al*. (2015), Bhiusal *et al*. (2017), Dar *et al*. (2018), Ahmed *et al*. (2018) and Rathod *et al*. (2021). They earlier reported high estimates of genotypic and phenotypic variances in maize. Furthermore, the combined years of maize evaluation recorded the highest estimates of genotypic and phenotypic coefficient of variation for ears/plant, seed thickness and grain yield. This result corroborates with the findings of Bello *et al.* (2012) in grain yield, grains/ear, ear weight, ear height and plant height in maize; Sharma *et al.* (2018) in number of ears/plot and grain yield, Bartaula *et al.* (2019) in grain yield, kernels/cob and anthesis silking interval traits in maize. Hence, these characters are under the influence of genetic control. High coefficient of variation provides great scope for phenotypic selection of desirable types. Generally the PCV values were higher than their corresponding GCV values for all the traits studied, which reflect the influence of environment on the expression of all the traits. The low GCV and PCV recorded for 1000 grain weight, was in contrast with the finding of Hassan *et al*. (2018) in maize. Furthermore, high heritability indicates the scope of genetic improvement of any character through selection. The knowledge of heritability enables the plant breeder(s) to decide the course of selection procedure to be followed under a given situation (Li and Yang, 1985). In this study, estimates of broad sense heritability were highest for the combined years of evaluation for days to 50% maturity, days to 50% tasseling and most of the traits studied. This suggested the greater effectiveness of selection and improvement to be expected for these characters in future breeding programme as the genetic variance is mostly due to the additive gene action (Manjunatha *et al*., 2019). Similar results were observed by several researchers (Debnat and Sarkar 1981; Umakanth and Sunil 2000; Singh *et al*., 2003; Aboyi *et al*; 2004; Zahid *et al*., 2004; Sofi and Rather 2007). High heritability values in this study indicated that these characters are less influenced by environment in their expression. The characters that exhibit high heritability and high genetic advance are needful during selection procedure. High heritability coupled with high genetic advance in this study were observed for days to 50% maturity and days to 50% silking. Other traits with high estimates of heritability and genetic advance include: plant height, plant diameter, leaf width, cob diameter, cob length and 1000 grain weight. These traits with high heritability and high genetic advance indicated that they are controlled by additive gene action and selection can safely be done on the bases of phenotypic expression by adopting mass or pure line selection method. Similar results on high heritability and high genetic advance in maize variability studies were reported by several researchers (Bhalla and Khehra 1977; Reddy and Agarwal, 1992; Bisne *et al.*, 2009; Rahman *et al.*, 2015; Jakhar *et al.*, 2017 and Rathod *et al.*, 2021).

Conclusion

This study revealed that sufficient genetic variability exists among the 25 genotypes of maize with respect to the 20 agronomic traits evaluated. The results revealed clearly that high yielding genotypes such as ADSUM/018 and ADSUM/022 could serve as suitable genotypes for hybrid production in order to improve lower yielding genotypes like ADSUM/002 and ADSUM/015.

Recommendations

1. From this study, ADSUM/018 (TZM1124) and ADSUM/022 (Michika-2) maize genotypes showed superiority in grain yield estimates and could be recommended for farmers in Mubi environs.
2. ADSUM/0013 (TZM1121), ADSUM/014 (TZM1163) and ADSUM/015 (TZM 1180) which exhibited earliness characters could be adopted in Mubi/other environs that has low rainfalls.
3. To ascertain the results obtained, multi-locational trials over several years should be carried out.

References

Aboyi, I. K., Ojo, A. A., Kalu, B. A and Adeyemo, M. O. (2004). Genetic variability heritability and genetic advance in S1 progenies of extra-early and early maize *(Zea mays* L.) populations. *Journal of Sustainable Agriculture and the Environmen,* 6: 179-184.

Adebayo, A. A.; Tukur, A. L. and Zemba, A. A. (2020). Adamawa State in Maps, 2nd Edition, Paraclete Publishers, Yola – Nigeria. Pp. 1 – 203.

Ahmed, H. O., Oyekunle, M., Hassan, I. B., Abdumalik, R. D., Sami, R. O. and Lawan, Z. M. (2018).Genetic Variability and Correlation Studies of Grain Yield and Related Agronomic Traits in Maize Genotypes, Proceedings of Genetic Society of Nigeria 42ND Annual Conference, Nigeria Defence Academy Kaduna Pp 133-139.

Bartaula, S., Panthi, U., Timilsena, K. , Sharma, S.A. and Shrestha, J. (2019). Variability and Genetic Advance of Maize (*Zea mays* L.) genotypes. *Journal of Agricultural, Livestock and Fisheries*, 6, (2): 163-169.

Bello, O. B., Ige, S. A., Azeez, M. A., Afolabi, M. S., Abdulmaliq, S. Y. and Mahamood, J. (2012). Heritability and Genetic Advance for Grain Yield and its Component Characters in Maize (*Zea mays* L.), *International Journal of Plant Research*, 2 (5): 138 – 145.

Bhalla, S. K. and Khehra, A. S. (1977). Analysis of Combining Ability in Maize at Varying Plant Densities. *Maydica*, 22 : 19-26.

Bhiusal, T.N. LAL, G.M., Marker, S. and Synrem, G.J. (2017). Genetic Variability and Traits Association in Maize (*Zea mays* L.) Genotypes. *Annals of Plant and Soil Research* 19 (1): 59 – 65

Bisne, R., Sarawgi, A. K. and Verulkar, S. B. (2009). Study of Heritability, Genetic Advance and Variability for Yield Contributing Characters in Rice. *Bangladesh Journal of Agicultural Resources*, 34 (2): 175 – 179.

Bremer, K., Bremer, B. and Thulin, M . (2003). Introduction of Phylogeny and Systematic of Flowering Plants. *Symbolae Botanicae Up salienses*, 33 (2): 64-73.

Brown, A. and David, J. (2009). “Scientist have High Hopes for Corn Germs” Washington Post.

Burton, G.W. and Dave, E. M, (1953). Estimating Heritability in Fall Feschele (*Festuca arunelianaceia)* From Replicated Clonal Material. *Agronomy Journal*, (45): 478-481.

Dar, I. A., Dar, Z. A., Kamaluddin, A. A. L., Sofi, P. A., Hussan, S., Dar, M. S. and Alie, W. (2018). Genetic Variability Studies involving Drought Tolerance Related Traits in Maize Genotypes, *Journal of Agriculture and Ecology Research International*, 14 (2): 1-13.

Das, A. and Kumar. D. (2012). Genetic Evaluation and Characterization of Jute (*Corchorus Spp* L.) Genotypes using DUS Parameters. *SAARC Journal of Agriculture*, 10: 147-153.

Debnath, S. C. and Sankar, K. R. (1981). Diallel Analysisof Plant and Ear Height in Maize. *Acta Agronomica Hungarica,* 36:77-87.

Dube, S. P., Marais, D. Mavengahama, S. Jaarsveld, C. M.V. and Gerrano, A. S. (2019). Characterisation of Agro – Morphological Traits of Corchorus Accesioons, *Acter Agriculturae Scandinavica*, *Section B – Soil and Plant Science*, 69 *(2): 126-134.*

Duncan, D. B (1955). Multiple Range and Multiple F-Test, *Biometrics*, 11, 1-5.

Elfadil, M .A . (2005). Genetic Variability for Yield and Yield Components of Some Maize (*Zea mays* L.) Genotypes Determined Under Drought at different Growth Stages; unpublished M.Sc Thesis, Department of Agronomy, Faculty of Agriculture, University of Khartoum, Pp 1-114.

FAOSTAT, (2016). Food and Agricultural Commodities Production, Available On www.faostat.fao.org (retrieved 20 September, 2019).

FAOSTAT (2021). Statistical year book, World Food and Agriculture Organization, Rome. https://doi.org/10.4060/cb4477on.

Hassan, A. A., Abdikadir, M., Hasan, M., Abdulkalam Azad, M. D. and Hasanuzzaman, M. D. (2018). Genetic variability and Diversity Studies in Maize (*Zea mays* L) Inbred Lines, *Journal of Agriculture and Veterinary Science*, 11(11):69-76.

Jakhar, D.S.S., Rajesh, S., Virek, K.O., Chandan, K. and Aneesh, K.C. (2017). Estimation of Genetic Variability, Heritability and Genetic Advance in Genotypes of Maize (*Zea mays* L.) *An International Quarterly Journal of Life Sciences*, 12 (2): 1161-1164.

Jonah, P. M. (2008). Genetic Variability and Correlation Studies in Some Cultivars of Bambara Groundnut (Vigna subteranea (L) Verde.) at Mubi, Adamawa State. unpublished M.Sc Thesis.

Juliet Hepziba, S. Gecthaand, K. and Ibrahim, S. M. (2013). Evaluation of Genetic Diversity, Variability, Character Association ad Path Analysis in Diverse Inbreeds of Maize (*Zea mays* L.). *Electronic Journal of Plant Breeding,* 4(1): 1067 – 1072.

Kadams, M. A. and Sajo, A. A. (1998). Variability and Correlation Studies in Yield and Yield Components in Bambara Groundnut (*Vigna subterranean* L.Verdc), *Journal of Applied Science and Management*, (2): 66-70.

Li, C. M and Yang, K. C. (1985). Studies on Inheritance of Quantitative Characters for Plant Type in Some Inbred Lines of Maize. *Scientia Agriculture Sinical*, 9: 28-36.

Manjunatha, B., Niranjana, B. K., Sannathimmappa, H. G. and Maruthesha, M. A. (2019). Varibility Analysis for Various Quantitative Traits In Maize (*Zea mays* L.) Hybrids. *International journal of Current and Microbiology Applied Sciences*, 8(9): 365-368.

Martin, J.H., Leonard, W.H. and Stamp, D.L. (1976). *Principles of Field Crop Production.* Macmillan Publishers New York.

Maruthi, R .T. (2009). Studies on Genetic Diversity in Maize (*Zea mays* L.) Thesis submitted to The Department of Genetics and Plant Breeding, College of Agriculture Acharya N.G.Ranga Agricultural University Rajendranagar, Hyderabad For The Award Of Master Degree in Genetics and Plant Breeding, Pp 149 – 154.

Nagabhushan, N. M., Mallikarjuna, C. H., Shashibhaskar, M. S. and Prahalada, G.D. (2012). Genetic Variability and Correlation Studies for Yield and Related Characters in Single Cross Hybrids of Maize (Zea mays L.). *Current Biotica*, 5 (2): 157-163.

Nusrat Ul, I., Ali, G., Dar Za, M.S., Baghel, S and Bhat, A. (2020). Genetic Variability Studies Involving Draught Tolerant

Related Traits in Maize (*Zea mays* L.) Inbreds. *International Journal of Chemical Studies*, 8 (1): 414 - 419.

Ogunniyan, D.J and Olakojo, S.A. (2015). Genetic Variation, Heritability, Genetic Advance and Agronomic Characters Association of Yellow Elite Inbred Lines of Maize (*Zea mays* L.), *Nigerian Journal of Genetics* 29: 111-119.

Rahman, S., Mukul Mia, M. D. Tamanna, Q. Lutful, H. and AshrafulHaque, M. D. (2015). Assessing Genetic Diversity of Maize (*Zea mays* L.) Genotypes for Agronomic Traits. *Research Agriculture, Animal and Fisheries*, 2 (1): 53 – 61.

Rathod, S.D., Shinde, G.C. and Shinde, S.D. (2021). Genetic Variability and Path Coefficient Analysis Studies in Forage Maize Genotypes (Zea mays L.). *Journal of Pharmacognosy and Phytochemistry* 10 (1): 2764-2768.

Reddy, V. N., Sadaiah, K., and Sudhear Kumar, S. (2013). Correlation Studies for yield and Contributing Characters in Sweet Corn (*Zea mays* L.(Saccharata). *International journal of Agriculture Innovation and Research*, 2 (2): 145-148

Reddy, K. H. P. and Agarwal, B. D. (1992). Estimation of Genetic Variation in an Improved Population of Maize (*Zea mays* L.). *Madras Agricultural Journal*, 79: 714-719.

Roney, H.C. and John, O.O. (2009). The Beginning of Maize Agriculture: *Archeology Southwest*, 23 (1): 4.

Selvi, D. T., Srimathi, N.S. and Ganesan, K. N. (2013). Distinctness, Uniformity and Stability (DUS) Characterization on Phenological Traits and Assessing The Diversity of Inbreds in Maize (Zea mays L), *African Journal of Agricultural Research*, 8(48): 6086-6092.

Sharma, B. K., Sharma, S., Kandel, B. P. and Shrestha, J. (2018). Varietal Evaluation of Promising Maize Genotypes, *Azarian Journal of Agriculture*, 5 (4): 120-124.

Sharifai, A. I. Mahmud, M. Mahadi, M. A. Kura. N. H., Isah, A. S. Babaji, B. A., Muhammad, A. A. Arunah, U. L. Mohammad, H. I. and Hussaini, Y (2012). Performance Of Extra Early Maize (*Zea mays* L.) As Influenced By Intra-Row Spacing, Nitrogen And Poultry Manure Rates, *Proceedings Of The 46th Annual Conference Of The Agricultural Society Of Nigeria.*

Singh, B.B and Chaudhary, B.D. (1985). Biometical Methods in Quantitative Genetical Analysis, Kalyanti Publishers, Ludhiana, New Delhi, Pp 54-214.

Singh, P., Dass, S., Kumar, Y., Yagya, D. and Dutty, Y. (2003) Variability studies for grain yield and component traits in maize *(Zea mays* L.*). Annals of Agricultural Biology Research* 8: 29-31.

Sofi, P. and Rather, A. G. (2007). Studies on genetic variability, correlation and path analysis in maize *(Zea mays* L.*).* University of Agriculture Sciences and Technology of Kashmir, Shalimar.

Stevenson, A. A and Goodman J. J. (1972). The Maximum Leaf Number of the Maize Subspecies; The "Leafy Mutation Placed into the Tallest Strain", Edition of Crop Science, Pp. 864.

Umakanth, A .V and Sunil, N. (2000). Character association and heritability studies in Harsha maize composite. *Bioved* 11: 43-45.

Zahid, M., Malik, S. R., Raheel, A. and Tariq, R. (2004). Heritability and genetic advance estimates from maize genotypes in Shishi Lusht a valley of Krakurm. *International Journal of Agriculture and Biology* 6: 790-791.

Zakariya, S., Oyekunle, M., Aba, D.A. and Bugaje, S.M. (2018). Analysis of Genetic Variability for Grain Yield and other Traits of Early and Extra – Early Maize (*Zea mays* L) Inbred Lines Under Drought, *Proceedings of 42nd Genetic Society of Nigeria* GSN, Annual Conference Held on 9th- 13th December 2018 at Nigeria Defense Academic, Kaduna Pp. 119-132.