PHENOTYPIC DIVERSITY AND CORRELATION COEFFICIENT ANALYSIS OF OPEN POLLINATED MAIZE VARIETIES IN UGANDA

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Global Journal of Agricultural Research
Vol.9, No.1, pp.36-47, 2021
Print ISSN: ISSN 2053-5805(Print),
Online ISSN: ISSN 2053-5813(Online)

PHENOTYPIC DIVERSITY AND CORRELATION COEFFICIENT ANALYSIS OF OPEN POLLINATED MAIZE VARIETIES IN UGANDA

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ABSTRACT: *Maize (Zea mays L.) is among the most important cereal crops grown and consumed in East Africa. Improved open pollinated maize varieties prevail popular among resource-poor farmers due to their low cost of production. Despite the advantages of OPVs in Uganda current trends show that open pollinated varieties are being continuously replaced by hybrids, and maize production is constrained by foliar diseases and abiotic (drought) factors. Therefore, it has become important to broaden the genetic pool of OPVs by characterising them using agronomic and diseases related traits. In this study, nineteen OPVs and five checks were phenotypically characterised at the National Crop Resources Research Center in α-lattice design. The results showed highly significant (P < 0.001) variations among the local and introduced OPVs in most of agronomic traits, except plant aspect, grey leaf spot and stem borer. An OPV SUWAN showed the highest grain yield (10.22 t ha^{-1}) performance. The least number of days to anthesis, silking and stem lodging was observed on OPV SITUKA MI. Regarding correlation coefficient analysis, the result showed that positive significant (P < 0.001) correlations were observed between days to anthesis and silking (r = 0.99). The highest negative and significant (P < 0.001) correlation was observed between percentage of fuzarium ear rot and number of kennels per row (r = -0.67).*

KEY WORDS: OPV, agronomic and disease related traits, *grain yield, correlation coefficient.*

INTRODUCTION

Maize (Zea mays L.) is the most important cereal crop grown in East African. Open pollinated varieties (OPVs) are popular among resource-poor farmers due to their low or no seed cost (Correjado and Magulama, 2008). Plant breeders continue to improve open-pollinated varieties due to increasing demand for low-cost seed, better nutritional quality, wider adaptability and both larger genetic and phenotypic diversity, as compared with maize hybrids (Warburton *et al.*, 2008; Correjado and Magulama, 2008a). However, open pollinated varieties have been continuously replaced by modern crop varieties, which are bred with a limited number of germplasm in their pedigree. Hybrids and modern crop varieties contain less genetic diversity compared to the OPVs (DTMA, 2013; MacRobert, 2013).

The decrease in genetic diversity may have consequences on the vulnerability of crops to disease, and on their ability to respond to changes in climate or agricultural practices (Kansiime *et al*.,2013); besides the response to selection for the development of varieties in the long run. To counter balance loss in genetic diversity, plant breeders should continuously enrich their breeding material with new germplasms. It was, therefore found necessary to broaden the genetic pool of the OPVs. To carry out this, germplasms introduced into Uganda from East African Countries. The introduced OPVs germplasm was developed from populations with wide genetic pool, (with different genetic back grounds and hence, they are relatively stable across generations (Prasanna, 2012).

In Uganda's context, there is little information available on the phenotypic/agronomic characteristics of the existing OPVs, local germplasm and introductions. Information related to maturity period, pest and disease resistance and crop yield is crutial for crop improvement. The objective of this study was to determine the phenotypic diversity of local and introduced OPVs in Uganda so as to develop inbred lines.

MATERIALS AND METHODS

This study was conducted at National Crops Resources Research Institute (NaCRRI) Namulonge in Uganda, which lies at 0^{o} 32'' N of the Equator and 32^{o} 37'' E, at an altitude of 1200 m above sea level. NaCRRI, it receives annual rainfall ranging between 800 and 1100 mm, with slightly humid (65%) conditions. The average annual temperature is 22^{o} C, with minimum and maximum temperatures of 16 and 28 ^{o}C, respectively. The soil type is reddish brown, sandy loam, with a *pH* range of 5.5 to 6.2 (Nsubuga *et al.*, 2011).

Genetic material

The OPV parental materials were collected from Uganda, Ethiopia, Kenya agricultural and the Livestock Research Organisation (KARLO), CIMMYT and Tanzania (Table 1).

Experimental design

Nineteen OPVs and 5 checks (Table 1) were planted during the first rainy season 2015 (on April 6, 2015A) at NaCRRI, Namulonge in a 4 x 6 α-Lattice design, replicated twice (with 6 blocks/replicate; that is 4 entries per block). Smaller blocks of 4 entries were used in the experiment to reduce the effect of heterogeneity within the experimental area. Two - row-plots of 5 m length were used, with an inter-row spacing of 0.75 m and intra - row spacing of 0.25 m, to achieve a population of 53,333 plants per hectare. Two border rows of Longe 6H maize variety was planted around the trial for each of the replications. An alley of 1.5 m wide in between the replicates was left for easy movement and management of the trial. Di-ammonium phosphate (18% phosphorus) fertiliser was added at planting at the rate of 120 kg ha^{-1}; while urea (46% nitrogen) was applied at a rate of 120 kg ha^{-1} month after planting. These two fertilisers were applied because they are key source of essential N and P elements both of which are often limiting in most tropical soils especially continuously cultivated fields like the experimental plots at NaCCRI. Three hand and hoe weedings were done to ensure weed free conditions.

Data collection

Data on agronomic and yield related characteristics were collected using 24 character descriptors, adopted from International Union for the Protection of New Varieties of Plants (UPOV), and the International Board for Plant Genetic Resources (IBPGR). Plant and ear height were averaged for randomly selected 5 plants of two rows. Number of rows per cob and number of kennels per row were averaged from 5 randomly selected cobs, while all disease related data including plant and ear aspect data were visually scored (scale 1 to 5) on a plot basis. Similarly, the disease scores were based on a scale of 1 to 5 as described by The International Maize and Wheat Improvement Center (CIMMYT, 1999). Data collected at vegetative and flowering stage (Before harvest) were: Days to anthesis (AD), Days to silking (SD), Anthesis-silking interval (ASI), Maize strike virus (MSV), Rust, Grey leaf spot (GLS), *Turcicum* leaf bligh (Turc), Plant height (PH), Ear Height (EH) and at harvest: Husk cover (HuskC), Number of 'ears'(Enum), Number of rows cob (Rcob), Number kernels row (Krow), Plant stand (Pnum), Plant aspect (Pasp), Ear aspect (Easp), Grain Texture (Tex), *Fuzarium* Ear rot (ERot), Stem lodging (SL), Root lodging (RL), Grain moisture (GMOI), Field weight (FW), Grain yield (GY).

Statistical analysis

Data for all 24 traits were analysed using linear mixed model (REML) using GenStat statistical package (12th edition) The genotypes were considered as fixed effects, while replications and blocks within replication were considered as random effects. Pearson's correlation analysis method was used to determine correlations between the different agronomic traits. The means were separated using Fisher's protected least significant difference (LSD). The following linear model was used:

$$Y_{ijk} = \mu + G_i + R_j + B_{k(j)} + \varepsilon_{ijk}$$

Where: Y_{ijk} = the observed value of trait from the ith genotype from the kth block nested in the jth replicate, μ is the overall mean, G_i = the effect of ith genotype, R_j is the effect of the jth replication and $B_{k(j)}$ is the effect kth block nested within the jth replicate and ε_{ijk} is a random error term ($\varepsilon_{ijk} \sim N(0, \sigma^2)$).

RESULTS

From this study, genotypes performances were significantly ($P < 0.001$) different for most traits measured, except for plant aspect, grey leaf spot and stem borer. (Table 3). Genotypes showed a wide range of variability, particularly for plant height, ear height, percentage of *fusarium* ear rot, stem and root lodging, number of days to anthesis and silking and number of ears per plot. The broad sense heritability calculated based on genotype mean square for the different traits showed considerable amount of variability. The highest broad sense heritability was recorded for days to anthesis and plant height with value of 99 % each while the least (0%) was recorded for plant aspect which was not presented here.

Print ISSN: ISSN 2053-5805(Print),
Online ISSN: ISSN 2053-5813(Online)

Flowering date, plant and ear height

The entry means for Days to flowering, plant and ear height are presented in Table 3. The lowest Days to anthesis and silking (60 and 62 days) was recorded for SITUKA MI; while the highest value recorded for these traits was (80 and 82 days) for Ambsyn2. Additionally, the tallest genotype was KCL2014 with plant (271.5 cm) and ear height (150.8 cm); whereas the least was 191.5 cm for Anbsyn2 and 95.9 cm for ECAVL17.

Yield and yield components

Grain yield and its components for each of nineteen OPVs and checks are shown in Table 3. The highest for grain yield was recorded for OPV SUWAN (10.22 t ha^{-1}) and the lowest was from Tester B and Ambsyn2, with 0.95 and 0.96 t ha^{-1}, respectively. OPV SITUKA MI, introduced form Tanzania, exhibited the lowest level of stem lodging (1.6 %); while the highest (55.6 %) was recorded for Ambsyn2, which was introduced from Ethiopia with.

Disease scores and related traits

Disease scores and related traits for phenotypic characterisation is shown in Table 3. The highest and lowest disease score value recorded for maize streak virus was 2.8 (for ECAVL 2, Longe 5 and Longe 6H) and 1.0 (for SITUKA MI and MM3); while for rust and *Turcicum* leaf blight the highest score was 3.0 (OUI-1) and 3.3 (STAHA) respectively. The least rust disease score (1.5) was observed for SUWAN; whereas for *Turcicum* leaf blight the lowest score was 1.3 (ECAVL2).

Correlation coefficients

Correlation coefficients among agronomic traits of 19 OPVs evaluated for phenotypic characterisation are shown in Table 4. Positive significant ($P < 0.001$) correlations were observed between days to anthesis and silking ($r = 0.99$). The highest negative and significant ($P < 0.001$) correlation was observed between percentage of *fuzarium* ear rot and number of kennels per row ($r = -0.67$).

DISCUSSION

Phenotypic diversity

The broad range of phenotypic variation existed within the 19 OPVs in the current study implying great potential for the development of improved open-pollinating varieties, inbred lines and hybrids which can be suitable for breeding for different agro-ecologies Several contrasts or variabilities were observed in plant and ear height, days to anthesis and silking, disease score, grain yield and its components. The work done by Estelle *et al.* (2014) on five maize open pollinated varieties which were carried out in Italy and France for 3 years in an area of 2000 m^2 and reported similar results on their phenotypic diversity.

Phenotypic characterisation and evaluation of the available maize germplasm for important agronomic traits is a necessary first step to facilitate maize breeding efforts. Variation in the phenotypic characteristics, which is to some extent an indication of genetic variability of breeding populations that can be exploited for crop improvement (Anumalla *et al.*, 2015).

Global Journal of Agricultural Research
Vol.9, No.1, pp.36-47, 2021
Print ISSN: ISSN 2053-5805(Print),
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Maturity

The ranges in the number of days to anthesis and silking were the most important traits for grouping the OPVs into different maturity groups. This is because date of maturity is estimated to be twice the number of days to anthesis or silking. The shorter the days required for flowering in maize the lower the days to maturity. Therefore, the ranges (60-80) in days to anthesis for example, suggest the possibility to develop cultivars with different maturity groups for the diverse agro ecologies in Uganda due to season to season differences in rain fall and drought problems. This variability, in days to anthesis and silking, may be attributed to their differential genetic constitution. Previously, Rahman *et al.* (2008), they carried out an experiment in Pakistan on genetic and phenotypic diversity for morphological and maturity traits in 4 maize OPVs and have reported similar results on their variability. for different maturity traits among maize genotypes.

Results shown in (Table 3) above revealed significant amount of variation for anthesis silking interval (ASI) and means in Table 4 showed range of -1 to 1 days of ASI exhibited among the genotypes, ECAVL1, Longe 4, MM3, KC2014 and TB i.e., both the pollen shedding and silking were well synchronized. The negative sign shows that the pollen shedding was earlier than the silking; while positive sign indicates that pollen shedding was late than silking. Genotypes with lesser ASI can be used to develop improved maize varieties with synchronisation in anthesis and silking parameters (Rahman *et al.*, 2008). Days to flowering, maturity date and anthesis to silking interval are some of those important phenotypic traits which are critical in generating early maturing to medium maturing and drought tolerant maize varieties. Days to anthesis silking interval (ASI) is an important trait in breeding for drought tolerant commercial varieties. According to Setimela *et al.*, (2014), early maturing maize varieties are able to yield fairly well because they mature before the detrimental effects from drought intensify, and hence, they are ideal crop varieties for food security. These early maturing (short cycle) varieties offer both technical and economic advantages: they can be accommodated more easily into intensive cropping patterns, including two or more crops a year; and they tolerate drought in areas where the rainy season is inconsistent. Flowering in maize is a crucial trait in breeding for drought tolerance. When maize flowers under drought, there is a delay in silking and the period between male, and female flowering increases giving rise to anthesis silking interval (ASI). There is also a possibility to select those genotypes that showed lower ASI but intermediate to late maturing. Edmeades *et al.*, (1997) showed that maize genotypes that are normally late maturing but have a short ASI, produced higher grain yields under drought stress than the genotypes that were early-maturing but had a longer ASI.

Plant and ear height

The observed highly significant variation in plant and ear height ranged from 191.5 cm – 271.5 and 95cm – 150.8cm respectively revealed the possibility of estimating ear position and existence of resistant genotype for root and stem lodging. Plant and ear height play important role in plant lodging. The higher plant and ear height, the more logging will occur and viscera. This is because when height is increased, genotypes will be more exposed to root and stem damage by wind. (Szoke *et al.*, 2002) . Therefore, ECAVAL1 and VP MAX varieties were with least EH and PH and could be included in resistance breeding for lodging. Several researchers have reported significant phenotypic and genetic differences in plant and ear height in maize genotypes (Devi *et al.*, 2013; Noor, *et al*, 2013). High heritability estimates were observed for plant height and ear height. High heritability of both these traits indicates potential for improvement of these two traits. Significant phenotypic variability for local and introduced maize OPVs was observed indicating that possibility to made selection for breeder to incorporate them in breeding program for the trait of interest. Similarly, a significant amount of variability for ear and plant height among different maize populations was also observed by Shrestha, (2014).

Grain yield and related components.

Phenotype is expressed as genotype plus environment. Concerning the grain yield and related traits, grain yield is a complex phenomenon which results from the interaction of various contributing factors (Noor *et al.*, 2013). The highest for grain yield was recorded for an OPV SUWAN (10.22 t ha^{-1}) and the least was for Ambsyn2 with 0.96 t ha^{-1}. Grain yield and related components showed highly significant differences indicating the existence of genetic potential of local and introduced OPVs for use in maize yield improvement program. The result conforms to previous studies by Aman *et al.* (2016), Shanthi *et al.* (2011) and Lika *et al.*, (1995), who indicated that it could be possible to develop genotypes which are comparable or even better in agronomic performances compared to local maize genotypes.

Correlation coefficient analysis

Correlation analysis is an important tool for estimating the value and association of various characters with grain yield (Edmeades *et al.*, 1997). In this study, most of the agronomic traits were positively correlated among themselves, which ranged from low to high level of correlation as indicated in (Table 4). The traits, plant and ear height, number of ears per plant, number of rows and kernels per cob were showed positive and highly significant correlation with grain yield and each other. This indicated that such traits were probably equally important in determining maize productivity. On the other hand, the negative correlation prevents the simultaneous improvement of those traits along with each other. For example, both days to anthesis and silking, ear rot and stem lodging exhibited negative significant correlation with grain yield, hence, these traits seem undesirable for indirect selection for yield. Negative correlation between two traits implies selection for improvement of one trait will likely cause decrease in another trait and vice versa. In agreement with this study, Premlatha and Kalamani (2010) and Zhang *et al.* (2014), who reported that correlation among yield and yield components and other quantitative traits help in understanding the dependence of the traits.

CONCLUSION AND RECOMMENDATIONS

The phenotypic characterization of open pollinated maize varieties for a number of traits, according to principles of the UPOV Descriptor, was basically effective in distinguishing the collected germplasms. More variations were observed from plant growth, maturity, yield and yield related components than were in yield related agronomic traits. This high level of variability exhibited by this set of local and introduced OPVs indicated the existence of genetic potential and hence heterosis could be utilized to produce a superior hybrid which can be used to enhance maize production in Uganda. The promising OPV genotypes SITUKA MI, OUI-1, Longe 5RS, ECAVL 2 ECAVL 1, MM3, KC2014 which were could be successfully utilized in a breeding programme that is aimed at improving yield and nutrition of the community in which maize is grown. However, for an effective broadening the gene pool of OPV and to use them as genetically diverse source in a breeding programme, OPV genotypes from other sources need to be included.

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ACKNOWLEDGEMENT

The authors are grateful to the Maize Breeding program at NaCRRI, Namulonge for their technical support. The author is also grateful to Alliance for Green revolution (AGRA) in Africa, for funding this study.

Global Journal of Agricultural Research
Vol.9, No.1, pp.36-47, 2021
Print ISSN: ISSN 2053-5805(Print),
Online ISSN: ISSN 2053-5813(Online)

APENDIX

ILLUSTRATIONS

TABLE 1:NAME AND ORIGIN OF 19 OPEN POLLINATED MAIZE VARAITIESAND 5 CHECKS USED TO DETERMINE THEIR PHENOTYPIC DIVERSITY IN UGANDA, 2015A

Entry	Stock	Name	Origin
	OPV1	MM3	NACRRI
	OPV2	Longe 4	NACRRI
	OPV3	Longe 5	NACRRI
	OPV4	Longe 5D	NACRRI
	OPV5	Longe 5SR	NACRRI
	OPV6	STK	Tanzania
	OPV7	STAHA	Tanzania
	OPV8	TMV	Tanzania
	OPV9	ECAVL 1	CIMKEN
	OPV10	ECAVL 2	CIMKEN
	OPV11	ECAVL 17	CIMKEN
	OPV12	ECAVL 18	CIMKEN
	OPV13	KakSyn-II	KARLO
	OPV14	Ambsyn2	Ethiopia
	OPV15	Ambsyn5	Ethiopia
	OPV16	KC2014	NACRRI
	OPV17	SUWAN	NACRRI
	OPV18	VP MAX	NACRRI
	OPV19	OUI-1	NACRRI
	Checks		
	TA	Tester A	CIMMYT
	TB	Tester B	CIMMYT
	Longe 6H	Longe 6H	NACRRI
	Longe 10H	Longe 10H	NACRRI
	UH5354	UH5354	NACRRI
Total			25

NaCRRI-National Crop Resource Research Institute, CIMMYT- International Centre for Maize and Wheat Improvement, CIMKEN-CIMMYT Kenya

TABLE 2: MEAN SQUARES OF ANOVA FOR NINETEEN PHENOTYPICALLY CHARACTERIZED LOCAL AND INTRODUCED OPVS WITH 5 LOCAL CHECKS AT NACRRI IN 2015A

SOV	Genotype (d.f.=23)	Residual (d.f.=13)	LEE (d.f.=13)	SED	CV (%)	Mean	BSH
AD	52.41 ***	0.55	0.67	0.82	1.2	70.98	0.99
SD	54.17 ***	0.93	1.11	1.05	1.5	72.48	0.98
ASI	1.28 ***	0.19	0.21	0.46	30.6	1.50	0.83
PH	926.36***	12.35	-	3.51	1.5	234.50	0.99
EH	460.38 ***	11.85	-	3.44	3.0	114.70	0.97
Pnum	72.15 *	18.19	22.00	4.69	16.2	29.04	0.69
Enum	106.91 *	26.47	30.46	5.52	18.4	30.02	0.71
HuskC	0.38 ***	0.06	0.06	0.25	19.0	1.29	0.83
Pasp	0.30 ns	0.32	0.35	0.59	33.5	1.76	0.00
Easp	0.56 ****	0.05	0.06	0.24	0.17	13.92	1.76
MSV	0.64 ***	0.13	-	0.36	19.6	1.84	0.80
GLS	0.30 ns	0.15	0.16	0.40	25.1	1.59	0.42
ERot	15.24 ***	1.09	1.39	1.18	84.4	1.40	0.90
Rust	0.44 *	0.09	0.11	0.33	14.3	2.31	0.74
Turc	0.69 **	0.13	0.14	0.38	18.6	2.01	0.79
SB	0.09 ns	0.07	-	0.27	23.4	1.14	0.19
Tex	0.71 **	0.09	0.09	0.30	10.8	2.78	0.87
RL	498.24 ***	67.74	79.09	8.89	71.3	12.48	0.83
SL	218.44 ***	44.01	-	6.63	56.8	11.67	0.78
Rcob	3.84 ***	0.55	0.66	0.81	6.1	13.42	0.81
Krow	53.48 ***	13.82	-	3.72	9.5	39.00	0.74
FW	6.49 ***	0.46	0.47	0.69	16.5	4.15	0.93
GMOI	2.79 ***	0.11	0.13	0.37	2.3	15.87	0.95
GY	9.18 ***	0.62	0.74	0.86	17.2	5.01	0.90

*, **, ***Statistically significant $\propto = 0.05, 0.01$ and 0.001, respectively, ns-statistically non-significant, SOV-source of variation, d.f-degree of freedom, AD-days to anthesis, SD-days to silking, ASI-anthesis silking interval (SD-AD), PH-plant height, EH-ear height, RL-% age root lodging, SL-% age stem lodging, ERot- # age of *fuzarium* ear rot, Krow-# of kernel per row, GY-adjusted grain yield, GMOI- % age grain moisture content, Rep-replication, LEE- lattice effective error, SEM-standard error of the mean, MSV- maize streak virus, Rus**t**-Leaf rust Turc- *Turcicum* leaf blight, CV-coefficient of variation

Global Journal of Agricultural Research

Vol.9, No.1, pp.36-47, 2021

Print ISSN: ISSN 2053-5805(Print),

Online ISSN: ISSN 2053-5813(Online)

TABLE 3: MEAN OF GENOTYPES FOR YIELD, GROWTH, DISEASE REACTION AND OTHER TRAITS OF OPEN POLLINATED MAIZE VARIETIES IN UGANDA, 2015A

Entry	AD	SD	ASI	PH	EH	Enum	Rcob	Tex	Easp	GY	HuskC	Krow	RL	SL	MSV	ERot	Rust	Tuc
SITUKA	60	62	2	209	99	32	14.5	2.8	1.5	5.54	1.5	38.5	9.6	1.6	1.0	3.1	2.8	2.3
Longe 4	62	62.5	0.5	220.5	106.5	34.5	13	3	2.0	5.05	1.0	36	7.9	4.8	1.5	4.4	2.3	2.3
MM3	62	64	2	215.5	96	30.5	11.5	2.8	1.0	4.75	1.0	41	12.8	7.9	1.0	0	2.8	1.8
VP MAX	66	67.5	1.5	238.5	97.5	26	14	3.3	2.3	4.7	1.3	38	11.5	7.2	1.5	1.5	2.5	1.8
SUWAN	67	69	2	246.5	120	41.5	13	2.3	1.8	10.22	1.8	44.5	9.8	6.5	1.8	1	1.5	2.5
KakSyn-II	67.5	69.5	2	262.2	112.5	35	12.5	3.3	2.5	7.37	1.0	36	2.9	9.7	2.0	1.2	1.8	1.5
ECAVL1	70	72	2	206	97.5	20.5	14.5	2.8	2.0	3.84	1.0	37.5	15.6	15.8	2.3	0	1.5	2.5
Longe 5D	70	72	2	246.5	122.5	32.5	15	2.5	1.5	5.83	1.3	36.5	10.7	7.6	2.3	0	2.0	3.0
Longe 5RS	70	69	-1	212.5	98.5	32.5	14	3.5	2.8	5.58	1.8	39	3.2	6.1	1.8	0	2.5	2.5
Longe 5	71	71.5	0.5	241	111	32	13.5	2	2.0	4.99	1.0	41.5	5.1	10.5	2.8	1.7	2.3	2.5
ECAVL2	71.5	73	1.5	229	110.7	34	12.5	2.5	1.8	5.83	1.8	42.5	8.1	14.4	2.8	1.4	2.5	1.3
KC2014	72	73	1	271.5	150.8	26.5	13	3.8	1.5	4.95	1.0	40	11.1	15.9	1.8	1.7	2.3	2.0
TB	72	73	1	246.5	119.5	38	12	3.5	2.3	0.95	1.0	41.5	9.5	5.5	2.3	0	1.5	1.3
OUI-1	72.5	73.5	1	259	136.5	24.5	16.5	1.8	1.0	4.76	1.0	41	6	14.9	2.5	0	3.0	2.8
TMV1	72.5	73.5	1	237.5	122.5	38	13.5	2.5	2.0	5.82	1.8	39.5	15	6	1.5	2.6	2.8	1.5
ECAVL18	73	75	2	270.5	138	27.5	13.5	3.5	2.0	4.75	1.8	40.5	11.1	9.7	1.3	0	2.0	1.5
STAHA	73	75	2	229.5	120.6	30.5	14	1.8	1.0	4.64	1.8	33	4.7	9.6	1.5	0	2.8	3.3
ECAVL17	73.5	75.5	2	222.5	95.9	28	13	2.8	1.5	5.3	2.0	34.5	3.5	7.4	1.8	0	3.0	2.5
Ambsyn5	74	75.5	1.5	227	126.5	14.5	12.5	2.5	2.3	1.46	1.0	40	36.3	21.6	1.3	0	3.0	1.5
TA	75.5	78.5	3	210	111	32.5	12	3.3	1.8	4.22	1.5	42	5.6	6.3	1.3	1.4	2.5	1.5
Longe 10H	76	78	2	227.3	107	36	13.5	3	1.3	6.51	1.0	45.5	9.2	8.9	1.3	0	2.3	2.3
Longe 6H	76	77	1	246	126.5	34.5	15.5	2.3	1.3	5.92	1.0	42	6	9	2.8	1.6	1.8	1.8
UH5354	76.5	78	1.5	261.5	129.4	30.5	14.5	3.8	1.3	6.2	1.0	45.5	6.7	17.5	2.3	0	1.8	1.5
Ambsyn2	80	82	2	191.5	97.6	8.5	10.5	2	2.3	0.96	1.0	20	77.8	55.6	2.5	11.8	2.8	1.3
LSD	1.8	2.3	0.95	7.27	7	11.7	1.76	0.3	0.5	1.85	0.43	7.7	19	13.7	0.74	2.68	0.7	0.8

Vol.9, No.1, pp.36-47, 2021
Print ISSN: ISSN 2053-5805(Print),
Online ISSN: ISSN 2053-5813(Online)

	AD	GY	DM	EH	ERot	Enum	FW	GMOI	Krow	PH	Pasp	Pnum	RL	Rcob	SD	SL
AD	*															
GY	-0.3*	*														
DM	0.92***	-0.31*	*													
EH	0.32*	0.08	0.35*	*												
ERot	0.13	-0.32*	0.04	-0.25	*											
Enum	-0.27	0.54***	-0.32*	0.06	-0.3*	*										
FW	-0.27	0.97***	-0.28*	0.08	-0.29*	0.68***	*									
GMOI	0.4**	-0.11	0.34*	0.23	0.19	-0.29*	-0.12	*								
Krow	-0.13	0.4**	-0.08	0.33*	-0.67***	0.44**	0.41**	-0.09	*							
PH	0.09	0.32*	0.1	0.8***	-0.41**	0.29*	0.32*	0.07	0.39**	*						
Pasp	0.07	-0.36*	0.07	0.15	0.08	-0.24	-0.35*	0.18	-0.14	0.01	*					
Pnum	-0.24	0.37**	-0.23	0.05	-0.36*	0.88***	0.55***	-0.43**	0.39**	0.28*	-0.18	*				
RL	0.31*	-0.45**	0.26	-0.12	0.66***	-0.61***	-0.5***	0.37**	-0.58***	-0.38**	0.25	-0.69***	*			
Rcob	-0.05	0.33*	-0.07	0.28*	-0.37*	0.18	0.31*	-0.22	0.3*	0.32*	-0.06	0.2	-0.41**	*		
SD	0.99***	-0.29*	0.92**	0.3*	0.14	-0.27	-0.26	0.41**	-0.14	0.07	0.08	-0.24	0.32*	-0.07	*	
SL	0.5**	-0.39**	0.44**	0.01	0.59***	-0.64***	-0.44**	0.44**	-0.45**	-0.23	0.11	-0.7***	0.73***	-0.29*	0.5***	*

AD-days to anthesis, **SD**-days to silking, **AS**I-anthesis silking interval **(SD-AD), PH**-plant height, **Easp**- Ear aspect, **EH**-ear height, **ERot**- # age of *fuzarium* ear rot,**Enum- number of ears per plot, RL**-% age root lodging, **SL**-% age stem lodging, **Krow**-# of kernel per row, **Rcob**- number of rows per cob,**GY**-adjusted grain yield,**HuskC**-husk cover, **LSD (%)-** Least significant difference, **MSV**- maize streak virus, **Rust**-Leaf rust, **Tex**-grain texture, **Turc**- *Turcicum* leaf blight

TABLE 4: CORRELATION COEFFICIENT BETWEEN IMPORTANT AGRONOMIC TRAITS FOR 19 OPVS EVALUATED AT NACRRI IN 2015A

*, **, ***Statistically significant $\propto = 0.05, 0.01$ and 0.001 respectively, ns-statistically non-significant, PH-plant height, AD-days to anthesis, ERot- # age of *fusarium* ear rot, RL-% age root lodging, GY-adjusted grain yield, SL-% age stem lodging, Krow-# of kernel per row, Enum-# of ear per plot