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VARIABILITY STUDIES ON TEN GENOTYPES OF EGGPLANT FOR GROWTH AND YIELD PERFORMANCE IN SOUTH EASTERN NIGERIA

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ABSTRACTS

Ten genotypes of eggplant collected from different parts of Nigeria were evaluated to estimate the magnitude of genetic variability, relationship of some important agronomic traits and their contributions to yield. The results obtained showed highly significant differences (P≤0.01) among the genotypes in all the traits studied. High broad sense heritability (h^2_{bs}) was recorded for number of fruits per plant (99.48%), fruit circumference (99.16%), and fruit yield per hectare (97.98%) for late planting and similar trend was obtained for early planting. The cluster analysis grouped the genotypes into four clusters for both early and late seasons planting, respectively. Principal component analysis showed that number of fruits per plant, plant height and number of leaves per plant contributed more to the total variations observed in the eggplant in both seasons. Correlation analysis under early season, showed that fruit yield correlated positively with fruit circumference (r=0.584) and fruit diameter (r=0.585). Number of fruits per plant had significant and positive correlation with number of branches per plant (r = 0.755*), number of leaves per plant (r =0.817**) and plant height (r=0.690*).The same trend of correlation was observed in the late season indicating that fruit yield can be increased indirectly by positive selection of plants with large fruits circumference and diameter. Applications of breeding methodology will improve the productivity of these eggplant genotypes since there is an existence of genetic variability among these genotypes as progress in breeding depends on this variation

Keywords: Variability, Eggplant, Heritability, Genetic variance, Genotypes, Correlation.

INTRODUCTION

Eggplant or brinjal *(Solanum* species) is the most popular and widely cultivated vegetable crop in the tropic and subtropics regions of the globe mainly for its immature fruits and leaves as vegetables (Manoko and Van der Weerden, 2004). It belongs to the family Solanaceae (Daunay *et al.,* 2001). Eggplants have indigenous medicinal uses, which range from weight reduction to treatment of several ailments including asthma, skin infections and constipation. Various parts of the plant are used in decoction for curing ailments such as diabetes, leprosy, gonorrhea, cholera, bronchitis, dysuria, dysentery, asthenia and hemorrhoids (Gill, 1992). In addition, it prevents heart diseases and control blood pressure (Grubben and Denton, 2004; Okon *et al*., 2010).

It is important to improve the productivity of the crop per unit area so as to satisfy the demands of dietary needs through vigorous breeding programs. The success of increasing the productivity of any crop through breeding largely depends on the presence of variability among the breeding materials (Adeyemo and Ojo, 1991). Furthermore, the choice of breeding programs depends on knowledge of the nature and magnitude of variations in the available material, magnitude of association of characters with yield, extent to which these characters are heritable as well as extent of environmental influence on them (Aruah *et al.,* 2012).

Effectiveness of selection directly depends on the amount of heritability and genetic advance in relation to the average performance of the character (Kumar *et al.,* 2013). Assessment of genetic diversity is very important in eggplant for further yield improvement owing to its increasing high demand in many parts of the world. Therefore, the aim of the research was to evaluate genetic variability among ten eggplant cultivars collected from different parts of the country and to determine agronomic traits that will be used for improving yield of the crop.

MATERIALS AND METHODS

The experiment was conducted at the Teaching and Research Field of Department of Crop Science, University of Nigeria, Nsukka. Nsukka is located on latitude $6^0 51^1$E, and longitude $7^0 29^1$N of 475m above sea level, characterized by lowland humid condition with bimodal annual rainfall distribution that ranges from 1155mm to 1955mm, a mean annual temperature of 29^0C to 31^0C and relative humidity that ranges from 69% to 79% (Uguru *et al*., 2011). The experiment was carried out in early (April to August, 2014) and late planting seasons (August to December, 2014). Monthly rainfall distribution, relative humidity and temperature in the entire duration of the experiment are presented in Table 1.

The experimental design used was a randomized complete block design (RCBD) with three replications. Each block had ten plots measuring 3x3 m^2. Planting was done at a spacing of 60 x 60 cm between and within row respectively. Each plot had twenty five plants of each genotype. Inorganic compound fertilizer, N. P. K 20: 10: 10 was applied at the rate of 300 kg per hectare at two weeks after transplanting. Weeding was done manually when due. The data collected comprised: plant height, number of leaves, number of branches, stem girth, days to 50% flowering, and number of fruits per plant, fruit yield per plant, fruit yield per hectare, fruit circumference and diameter.

The data collected were subjected to analysis of variance (ANOVA) following GenStat Release 10.3DE Discovery Edition4 software (GenStat, 2010). The phenotypic variation for each trait was partitioned into genetic and non-genetic (environmental) factors according to (Sharma, 1988).

$V_e = MS_e$; $V_g = (MS_g – MS_e)/r$; $V_p = V_{g+} V_e$

Where V_p, V_g and V_e are phenotypic variance, genotypic variance and environmental variance, respectively, and MS_g, MS_e and r are the mean squares of genotypes, mean squares of error and number of replications, respectively.

To compare the variations among traits, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV) and environmental coefficient of variation (ECV) were computed according to (Burton, 1952):

$$GCV = \frac{\sqrt{Vg}}{\bar{x}} \times 100$$

$$PCV = \frac{\sqrt{Vp}}{\bar{x}} \times 100$$

$$ECV = \frac{\sqrt{Ve}}{\bar{x}} \times 100$$

Where, $\overline{x}$ is the grand mean for the trait under consideration.

Broad sense heritability (h^2_{bs}) expressed as the percentage of the ratio of the genotypic variance (V_g) to the phenotypic variance (V_p) was estimated as described by (Uguru, 2005; Acquaah, 2007).

$$H_{bs} = \frac{Vg}{Vp} X\ 100$$

Genetic advance (GA) was estimated by the methods of (Johnson *et al.*, 1955) as:

$$GA = K\ X\ \frac{GV}{\sqrt{PV}}$$

Where K is a constant (2.06) at 5% selection intensity, PV is the phenotypic variance and GV is genotypic variance. Correlations analysis was done to examine inter-relationship among the traits using SPSS version 16 software. Cluster analysis was done to group the genotypes base on their similarity and Principal Components Analysis (PCA) was also done to estimate the contribution of each trait to the total phenotypic variation observed among the eggplant genotypes using GenStat Release 10.3DE Discovery Edition 4 software (GenStat, 2010).

RESULTS

Cluster analysis: The cluster analysis on figure 1 grouped the genotypes of egplant into four clusters (A, B, C and D) based on the diversity of the traits studied using scale of 0.8 on the similarity axis. Cluster A consists of Ogbojioroke and Iyoyo; cluster B comprises of Yalo and Kaduna 2; cluster C consists of Kotobi, Kaduna 3 and Ibere while cluster D comprises Uyo and Ewa genotypes in the early season planting. For the late season planting, there were four clusters as well. Cluster A consist of Yalo, Uyo and Kaduna 3; cluster B consist of Kaduna 2, Kotobi, Kaduna 1 and Ibere, cluster C made up of Ogbojioroke, while cluster D comprises of Iyoyo and Ewa genotypes (figure 2).

Genetic and Phenotypic variability: The mean squares and genetic parameters of ten genotypes of eggplant planted in the early and late planting seasons of 2014 are presented in Table 3. The analysis of variance showed that the mean squares for the genotypes were highly significant ($P \leq 0.01$) for all the traits under study in both early and late season planting experiments. Genotypic variances ranging from 0.04 (fruits yield per plant) to 604.43 (number of fruits per plant) and phenotypic variances ranging from 0.08 (fruits yield per plant) to 725.83 (number of fruits per plant) among the agronomic traits considered were observed in the early season planting. In the late season planting, genotypic variances ranged from 0.02 (fruits yield per plant) to 450.23 (number of leaves per plant) whereas phenotypic variances ranged from 0.03 (fruits yield per plant) to 456.45 (number of leaves per plant). High genotypic variance values of 604.43, 91.48, and 69.09 were obtained for number of fruits per plant, days to 50% flowering, and plant height, respectively in early season planting. Similarly, high genotypic variances of 450.23, 415.07, and 262.69 were also obtained for number of leaves per plant, number of fruits per pant, and plant height, respectively in late season planting experiments.

High amount of genotypic coefficient of variation (GCV) was obtained in number of fruits per plant (101.86%) followed by fruit circumference (66.07%) and number of branches per plant (49.82%) while the least GCV was obtained in stem girth (12.73%) in the early season planting experiment. The results obtained in the late season planting experiment showed that number of fruits per plant (114.07%) had the highest GCV followed by fruit yield per hectare (44.11%), and fruit yield per plant (40.77%) while the least GCV was also observed in stem girth (13.20%). A high phenotypic coefficient of variation (PCV) was observed in number of fruits per plant (110.86%) followed by fruits circumference (67.49%), and number of branches per plant (53.87%) while the least PCV was observed in stem girth (11.21%) in the early season planting experiment. Also, the results obtained for late season planting experiment showed that number of fruits per plant (114.37%) had the highest PCV, followed by fruits yield per hectare (44.49%), and fruits yield per plant (41.61%) while the lowest value of PCV was obtained in stem girth (13.48%).

Heritability: In the early season planting, high broad sense heritability (h^2_{bs}) estimates were recorded for fruit circumference (98.37%), fruits diameter (97.44%), Days to 50% flowering (96.69%),number of fruit per plant (83.27%) and fruit yield per plant (50.00%) while the results for late season planting experiment showed that fruit yield per hectare (98.08%), number of fruits per plant (99.48%), fruit circumference (99.16%), and fruit diameter (98.50%) were among traits with high broad sense heritability.

Principal Component Analysis (PCA): The principal component analysis (Table 4) revealed that the first and second principal component accounted for 81.34% and 8.39%, respectively for the total variation in early planting season. For the late planting season, first and second principal component accounted for 81.09% and 14.35%, respectively for the total variation observed among eggplant genotypes. Table 4 further revealed that in principal component 1, number of fruits per plant contributed the most (0.90) followed by number of leaves per plant (0.29) and plant height (0.23) for the variation among the genotypes. For the principal component 2, the most part of the variation was contributed by number of leaves per plant (0.93) followed by plant height (-0.29) and number of fruits per plant (-0.23).

In the late season planting, number branches per plant contributed the highest (0.66) variation among the genotypes followed by number of fruits per plant (-0.58) and plant height (0.45) for the principal component 1. For the principal component 2, number of fruits per plant contributed the highest (0.71) followed plant height (-0.54) and number of leaves per plant (-0.29).

Correlation Coefficients Analysis: The results of the correlation coefficient among studied agronomic traits of eggplant are shown in Table 5. In the early season planting, fruit yield per plant correlated positively with stem girth (0.59), fruit circumference (0.55) and fruit diameter (0.53), though not significant. Conversely, fruit yield per plant exhibited negative correlation with number branches per plant (-0.29), number of leaves per plant (-0.41) and number of fruits per plant (-0.08) but non-significant at 5% probability level. However, number of fruits per plant was positively and significantly correlated with number of branches per plant (r = 0.75), number of leaves per plant (r = 0.82) and plant height (r=0.69). Similar trend of correlation was observed in the late season planting.

Table 1. Meteorological Data of the Entire Duration of the Experiment (April to December, 2014).

		Temperature (^{O}C)		Relative Humidity (%)	
Month	**Rainfall (mm)**	**Min**	**Max**	**10am**	**4pm**
April	105.16	22.30	31.30	69.93	70.53
May	241.14	21.06	28.29	72.26	72.26
June	271.79	20.87	29.13	72.00	72.00
July	195.81	20.9	27.74	72.19	72.19
August	92.36	20.71	27.29	73.00	73.00
September	401.99	20.33	27.90	73.00	73.00
October	211.08	20.84	28.90	73.00	72.77
November	77.22	21.00	30.07	73.80	71.97
December	4.83	19.03	30.65	70.58	70.06

Table 2. Description of the genotypes used in the present study.

S/N	Name of genotypes	Source	Description of the genotypes
1	Uyo	Uyo, AkwaIbom State	Medium round green colour fruit
2	Kotobi	Nsukka, Enugu State	Medium round white fruit size
3	Yala	Nsukka, Enugu State	Big and green stripe fruits
4	Ewa	Umudike, Abia State	Small fruit size and scanty spine on the stem
5	Iyoyo	Umudike, Abia State	Small fruit size, well branching
6	Ogborojioke	Umudike, Abia State	Tiny fruit size, well branching
7	Ibere	Umudike, Abia State	Medium fruit size and round shape fruit
8	Kaduna 1	Kaduna, Kaduna State	Medium fruit size and round shape fruit.
9	Kaduna 2	Kaduna, Kaduna State	White fruit colour, round big fruit size fruit shape
10	Kaduna3	Kaduna, Kaduna State	Uplong fruit shape, medium size fruit and branching

Table 3.Variance, broad sense heritability and genetic advance estimates for some traits of the eggplant genotypes studied in early and late season plantings.

Traits	Mean	Msg	Ve	Vg	Vp	GCV	PCV	ECV	Hb_s	GA
Early										
D50F	27.26	277.57**	3.13	91.48	94.61	35.07	35.69	6.49	96.69	19.36
FC	14.47	102.14**	0.56	33.86	34.42	66.07	67.24	5.18	98.37	11.89
FD	8.13	28.82**	0.25	9.25	9.77	38.01	38.50	6.15	97.44	6.26
NB	8.15	52.35**	2.78	16.52	19.30	49.82	53.87	20.49	85.60	7.75
NF/P	24.3	1934.70**	121.4	604.43	725.83	101.19	110.86	45.35	83.27	46.23
NL	45.8	227.10**	107.8	39.77	147.57	13.78	26.53	22.66	26.95	6.74
PH	40.65	233.05**	25.78	69.09	94.87	20.44	23.96	12.50	72.83	14.61
SG	3.30	0.68**	0.14	0.18	0.32	12.73	17.27	11.21	56.25	0.66
FY/P	0.56	0.15**	0.04	0.04	0.08	35.71	50.00	35.71	50.00	0.29
FY/H	11.33	63.67**	16.83	15.61	32.44	34.86	50.31	36.19	48.12	5.64
Late										
D50F	30.89	148.17**	1.79	48.79	50.58	22.61	23.02	4.33	96.46	14.13
FC	14.08	67.12**	0.19	22.31	22.50	33.55	33.69	3.10	99.16	9.74
FD	6.80	14.21**	0.07	4.71	4.78	31.92	32.15	3.89	98.50	4.43
NB	11.27	60.40**	0.42	19.99	20.41	39.67	40.09	5.75	97.94	9.11
NF/P	17.86	1247.35**	2.15	415.07	417.22	114.07	114.34	8.21	99.48	41.86
NL	61.76	1356.90**	6.22	450.23	456.45	34.36	34.59	4.04	98.64	43.42
PH	41.08	792.49**	4.49	262.69	267.12	39.45	39.79	5.12	98.34	33.12
SG	3.71	0.74**	0.01	0.24	0.25	13.20	13.48	2.70	96.00	0.99
FY/P	0.38	0.07**	0.001	0.02	0.03	40.77	41.61	8.32	97.98	0.31
FY/H	10.52	64.94**	0.42	21.51	21.93	44.11	44.49	6.18	98.08	9.48

** Significant at 1% probability level, D50F= Days to 50% flowering, FC= Fruit circumference (cm), FD= Fruit diameter (cm), NB= Number of branches per plant, NF/P= Number of fruits per plant, NL= Number leaves per plant, PH= Plant height (cm), SG= Stem girth (cm), FY/P= Fruit yield per plant (kg), FY/H= Fruit yield per hectare (tone), Msg= mean square of the genotypes in ANOVA, Ve= Environmental variance, Vg= Genotypic variance, Vp= Phenotypic variance, %C.V= Percentage coefficient of variation, GCV= Genotypic coefficient of variation, PCV= Phenotypic coefficient of variation, ECV= Environmental coefficient of variation, Hbs = Broad sense heritability (%), GA= Genetic advance.

Table 4. Principal component analysis (PCA) of eggplant genotypes in early and late season plantings.

	Early season		Late season	
Traits	**PC 1**	**PC 2**	**PC 1**	**PC 2**
FC	**-0.16**	**0.03**	0.10	**-0.16**
FD	-0.08	0.02	0.05	-0.07
NB	0.12	0.02	**-0.13**	0.07
NF/P	**0.90**	**-0.23**	**-0.58**	0.07
NL	**0.29**	**0.93**	**-0.66**	**-0.29**

PH	**0.23**	-0.29	**-0.45**	**-0.54**
SG	-0.01	-0.01	0.00	-0.02
FY/H	-0.05	-0.01	0.00	-0.01
FY/P	-0.01	-0.00	-0.01	**-0.29**
percentage variation	81.43	8.39	81.09	14.35

D50F= Days to 50% flowering, FC= Fruit circumference (cm), FD= Fruit diameter (cm), NB= Number of branches per plant, NF/P= Number of fruits per plant, NL= Number leaves per plant, PH= Plant height (cm), SG= Stem girth (cm), FY/P= Fruit yield per plant (kg), FY/H= Fruit yield per hectare (tone).

Table 5.Correlation coefficients among traits of eggplant genotypes in early and late season plantings.

Traits	NB	NL	PH	SG	D50F	FC	FD	NF/P	FW/P
Early									
NB	1								
NL	0.86**	1							
PH	0.67*	0.76*	1						
SG	-0.44	-0.35	0.20	1					
D50F	-0.44	-0.61	-0.86**	-0.19	1				
FC	-0.76*	-0.82**	-0.79**	0.36	0.64*	1			
FD	-0.76*	-0.84**	-0.79**	0.36	0.64*	0.98**	1		
NF/P	0.75*	0.82**	0.69*	-0.12	-0.45	-0.61	-0.64*	1	
FY/P	-0.29	-0.41	-0.15	0.59	0.17	0.55	0.53	-0.08	1
Late									
NB	1								
NL	0.97**	1							
PH	0.69*	0.80**	1						
SG	-0.24	-0.11	0.07	1					
D50F	-0.62	-0.73*	-0.90**	0.02	1				
FC	-0.76*	-0.73*	-0.55	0.40	0.54	1			
FD	-0.78**	-0.74*	-0.56	0.40	0.56	0.99**	1		
NF/P	0.90**	0.90**	0.54	-0.04	-0.49	-0.68*	-0.68*	1	
FY/P	-0.12	-0.01	0.15	0.34	-0.06	0.58	0.59	-0.13	1

*, ** Significant at 0.05 and 0.01 probability levels, respectively. D50F= Days to 50% flowering, FC= Fruit circumference (cm), FD= Fruit diameter (cm), NB= Number of branches per plant, NF/P= Number of fruits per plant, NL= Number of leaves per plant, PH= Plant height (cm), SG= Stem girth (cm), FY/P= Fruit yield per plant (kg).

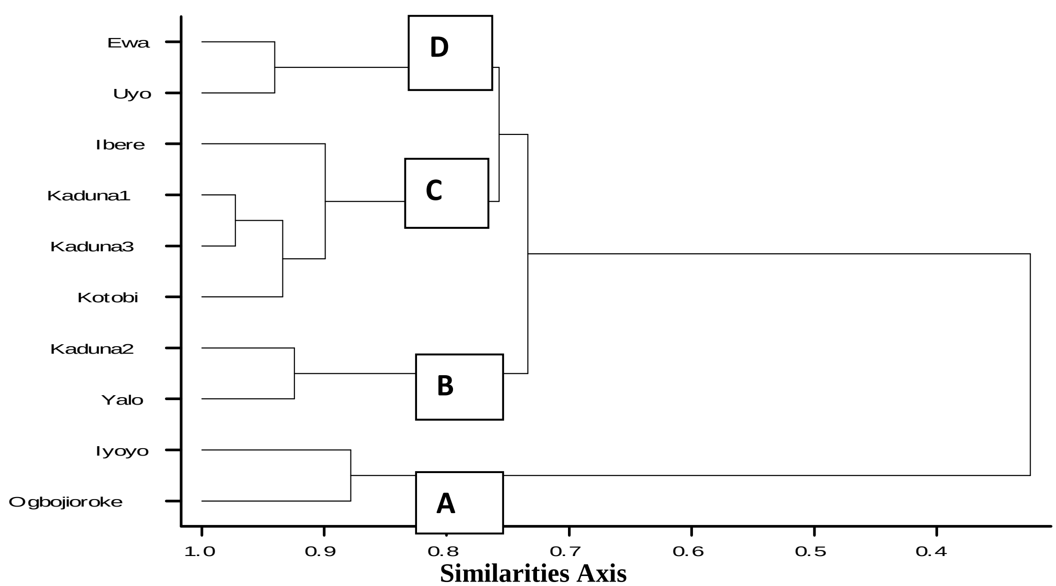

Figure 1. Dendrogram showing the classification of 10 genotypes of eggplant for the early planting season

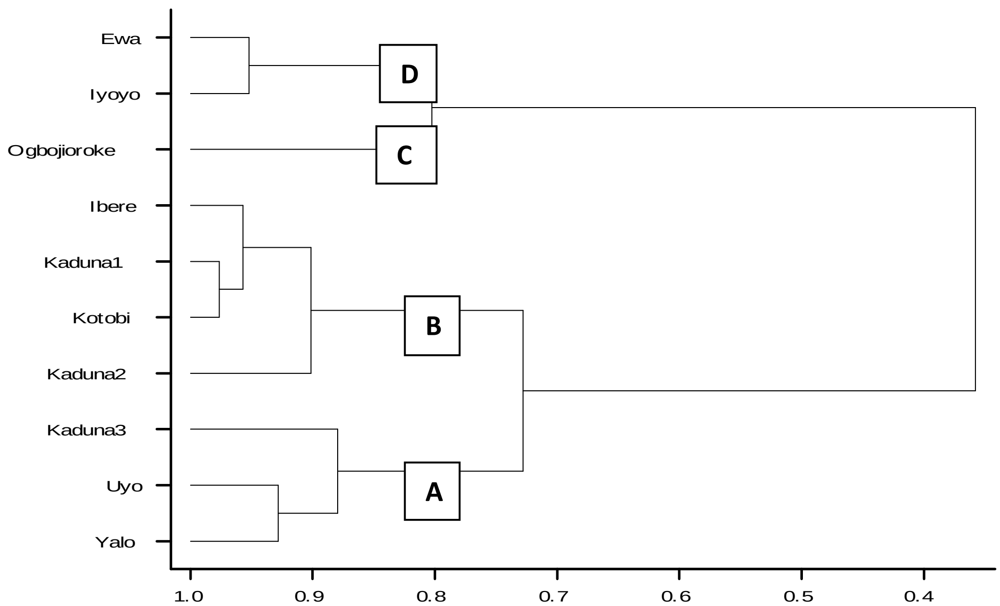

Figure 2. Dendrogram showing the classification of 10 genotypes of eggplant for the late planting season

DISCUSSION

Genetic assessment of germplasm is commonly undertaken by plant breeders to understand genetic variation in the germplasm and to discover patterns of genetic diversity. Analysis of genetic diversity levels in germplasm helps plant breeders to make proper choices of parents to use in breeding programs (Acquaah, 2007). The result of cluster analysis gouped the genotypes of eggplant into four clusters for both early and late season planting. This is in accordance with (Kumar *et al*., 2008; Nyadanu *et al*., 2014) who reveals wide diversity in eggplant. This result is also in line with (Kumar *et al*., 2013) who have earlier reported the existence of genetic variation among eggplant genotypes. Estimation of variability is an important prerequisite for realizing response to selection as the progress in the breeding depends upon its amount, nature and magnitude (Kumar *et al*., 2013). Genetic variation in populations of crop species is important for successful selection and yield improvement programs (Idahosa *et al*., 2010). The significant differences observed among the genotypes for all the traits in planting under both seasons suggest the existence of sufficient inherent genetic variability among the genotypes. This variation can be exploited for further yield improvement of eggplants. The phenotypic variances of the traits under study were partitioned into heritable (genotypic variance) and non-heritable (environmental variance) components in both early and late season planting experiments. The magnitude of environmental variances was lower than their corresponding genotypic variances for most of the traits. This is an indication that the genotypic component of variation was the major contributor to total variation in the traits studied. Similarly, Islam and Uddin (2009) and Naik *et al*. (2010) observed high genotypic and corresponding phenotypic variances involving other varieties of eggplant.

Genotypic coefficient of variation (GCV) provides a measure of genetic variability present in various quantitative traits. High GCV indicates the presence of high genetic variability for these traits which may facilitate selection (Yandav *et al.*, 2009). In this study, high GCV obtained in traits such as number of fruits per plant, fruit circumference and diameter indicates that there is considerable genetic variation present in these traits to warrant selection for better eggplant genotypes. These traits can, therefore, be given special attention in selections aimed at yield improvement of eggplants. High phenotypic coefficient of variation (PCV) is an indication of the existence of greater scope for selection of the trait under consideration which is dependent on the amount of variability present (Khan *et al*., 2009). Thus, a greater potential is expected in the selection for number of fruits per plant, fruits circumference, number of branches per plant and yield fruit per plant among the eggplant genotypes study due to their PCV values, while there is a narrow scope for selection for stem girth on account of low amount of variability among the eggplant genotypes studied. In this study, GCV and PCV with respect to all characters did not differ much in magnitude indicating that these characters are not much affected by environmental factors, and successful selection may be achieved using their phenotypic values. This corroborates with the findings of (Kumar *et al.,* 2013) who observed a slight difference between GCV and PCV in eggplant.

In the present study, high heritability coupled with high genetic advance was observed for fruit yield, number of fruit per plant, number of branches per plant, and fruit circumference, which suggested that the selection based on these traits, can bring about significant improvement in fruit yield of eggplant genotypes. This is in conformity with the findings of (Pathania *et al*. 2002; Chung-won *et al*. 2003 and Kumar *et al*., 2013). Furthermore, high heritability combined with high expected genetic advance proved the involvement of additive genetic variance, therefore simple selection may be effective for improvement of these traits.

The result of principal component analysis of the present study corroborated with the findings (Rahman, 1999; Uddin *et al*., 2014) who found that number of fruits per plant contributed the highest for total variation in eggplant genotypes as observed in this study. Rahman (1999) and Uddin *et al*. (2014) further noted that fruit weight, fruit length, and days to 50% flowering were also important to some extent for the variation. Similar observation was noted by (Rajput *et al*., 1996) in eggplant. Correlation of yield and other traits is important in indirect selection of genotypes for yield improvement (Machikowa and Laosuwan, 2011). Significant and positive correlation between two characters suggests that these characters can be improved simultaneously in a selection programme. This is because it shows mutual relationship among characters and selection for one will translate to selection and improvement of the other (Fayeun *et al*., 2012).

In this study, stem girth, fruit circumference and fruit diameter were positively correlated with fruit yield per plant, which is an indication that fruit yield per plant of eggplant can be indirectly improved by selecting for these traits. This result conforms to the findings of (Jones and Kwadwo, 2012) who observed that fruit weight was positively associated with fruit diameter. Consistent negative correlations were observed between fruit yield per plant and traits such as, number of fruits per plant, number of branches per plant in the two planting seasons indicate that fruit yield can improved by selecting against number of fruits per plant and number of branches per plant. These results collaborate with the findings of (Denton and Nwangburuka, 2011) who reported negative correlation between number of branches per plant and fruit yield in eggplant *Solanum anguivi*. Number of branches per plant, number of leaves per plant and plant height were found to be positively and significantly correlated with number of fruits per plant, indicating that number of fruits per plant can be increased by positive selection of these traits. This result is in agreement with the findings of Muniappan *et al.* (2010) who reported a positive correlation between plant height and number of fruits in eggplant.

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