
RESEARCH ARTICLE

Genetic variability for yield parameters in garden eggs (*Solanum spp.*)

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Abstract

The present research was undertaken to evaluate 15 accessions of garden eggs in Ghana for growth and yield related traits. Randomized Complete Block Design (RCBD) was employed in laying the experiment with three replications. The result revealed significant differences among the accessions for all the characters studied except stem girth. High significant effect of season for all the characters was also observed except for stem girth, number of branches per plant and number of seeds per fruit. The phenotypic coefficient of variation values was greater than their corresponding genotypic coefficient of variation values for all the characters considered indicating some level of environmental influence on the traits. All the characters studied recorded high heritability except for stem girth, fifty per cent flowering, yield per plant and number of days to maturity. High GA value was recorded for number of seeds per fruit. Yield per plant was significantly and positively correlated with fruit number per plant, number of flowers per plant, flowers developed to matured fruit/plant, number of flower drooped per plant, plant height at flowering, number of leaves per plant, 10 fruit weight, and number of branches.

Key words: Genotypic coefficient, phenotypic coefficient, garden eggs, variability

Introduction

Garden egg (*Solanum spp.*) is an edible vegetable in the Solanaceae family. It is one of the most important plant families of tropical origin (Nwanna *et al.*, 2016). Majority of the species are wild but some species such as, *S. macrocarpon*, *S. aethiopicum*, *S. aquiva* and *S. gilo* bear edible fruit (Nwanna *et al.*, 2016). It forms essential parts of people's diet which are vital for health and wellbeing are vegetable and fruit. Most research showed that garden eggs and other members of the solanaceae family are excellent sources of vitamins, minerals, antioxidant, and phytonutrients. There are several challenges associated with garden eggs production, harsh environmental conditions, and disease and pest. They further explained that the fruit holds within them beneficial phytochemical and has nutritional and therapeutic value with the potential for synthesizing excessive aluminum deficient, calcium and low organic matter. Garden egg is attacked by several local pest and diseases (Addo, 2010).

Fruit stem borer is the most significant biotic constraints for garden egg which cause major economic losses. The crop is cultivated extensively as vegetable and its growing season coincides with the rainy season particularly the fruit-bearing stage and therefore subject the crop to many pests such as nematode, bacterial, viral, and fungal diseases. The crop is grown mainly due to its prolific production, quick maturation, good phosphorus, calcium, magnesium, potassium, and sodium sources that are important in preventing bronchitis, dysuria and asthma (Ghimire *et al.*, 2007). Also, the fruits can be stored up to three months and can also be dried before storing for later use in off season (National Research Council, 2006). All these benefits, including high yield and long lasting fruiting and harvesting period lure the farmers into eggplant cultivation (Ghimire *et al.*, 2007). Despite the obvious importance of garden eggs in our daily lives, little attention has been paid to this crop to enhance productivity in the past. It is not possible to identify a set of growth, flower and fruit traits for the common garden egg characteristics due to the great diversity of the genus *Solanum* (Hazra *et al.*, 2003). So it is essential to collect data on eggplant traits and variability in order to develop robust and effective eggplant breeding programs (Sekara *et al.*, 2007). Hence, the objectives of the present work were to determine the heritability and genetic variability among garden eggs accessions collected from Ghana region for growth and yield traits.

Materials and methods

Seeds of fifteen (15) accessions of garden eggs were sourced from the Council for Scientific and Industrial Research - Plant Genetic Resources and Research Institute, Bunso. The codes and names of the accessions used in the study are presented in Table 1 with their description. Seeds of the fifteen genotypes were nursed on beds under good management practices and transplanted to their permanent field 42 days after

germination. The research was conducted in Abetenasi in the Biakoye District of the Oti Region of Ghana. The area can be found between longitude 00 15'E and 00 45 E and latitude 60 45'N and 70 15'N. The yearly rainfall averages around 1,500 mm. Research field was lined and pegged before transplanting of seedlings on a Randomized Complete Block Design (RCBD). Each genotype was sown in three rows of a nine plant with three replicates. Rows and plant spacing was 1m apart. All the cultural practices were adapted to raise healthy crop. Data were collected on six tagged plants per accession from each replication. Data were taken on the growth, reproductive, yield and seeds characteristics of the accessions. Vegetative data were taken in the intervals of two weeks. Twenty-one traits were studied which includes plant height, stem girth, canopy spread, number of branches, number of leaves, number of days to 50% flowering, the type of inflorescence (single, cluster, and mixed), number of flowers per plant, number of flowers dropped, number of flowers developed to mature fruit, number of to 50% fruiting, days to first harvest, number of days to maturity, fruit number per plant, fruit length (cm), fruit diameter (cm), fruit weight (g), yield per plant (g), 100 seed weight (g), number of damaged seed per fruit, number of whole seed/fruit. Analysis of variance, phenotypic plasticity analysis and correlation analysis, using Pearson's product moment method were performed using the Agricolae package in R statistical software, version 4.0.2. The phenotypic, genotypic and environmental variances, broad sense heritability and genetic advance were computed using the formula from Johnson *et al.*, (1955).

Results and discussion

Genetic diversity among the accessions for growth and yield.

Table 2 show the results from the ANOVA for growth and yield related characters respectively.

Table1: Garden eggs genotypes used in the present study

Accessions	Fruit attribute	Remarks
1. GH 4943	White to light yellow, erect fruit	Sweet in taste and preferred by famers
2. GH 3953	White to yellow, oblong, dense in flesh density	Bitter in taste
3. NE2	Green to orange at commercial ripeness, small fruit breadth/length	Bitter in taste
4. GH 3952	Green to orange, oblong, erect fruit position	Bitter in taste
5. GH 3918	White to yellow, slightly longer than broad, intermediate in length	Sweet in taste and preferred by famers
6. GH 3970	Green to white, erect in fruit position, oblong	Sweet in taste and preferred by famers
7. GH 3904	Green to light yellow, long than broad, semi erect fruit	Sweet in taste and preferred by famers
8. GH 1157	Deep green broader than long, erect fruit	Bitter in taste
9. GH 1072	Deep green, oblong, erect fruit position	Bitter in taste
10. NE4	Green to light yellow, oblong	Very bitter in taste
11. GH 4945	White to yellow, long than broader, erect in fruit	Sweet in taste and preferred by famers
12. GH 3944	Light green, slightly curved, erect in fruit	Sweet in taste and preferred by famers
13. GH 5174	White to orange, oblong, erect fruit	Sweet in taste and preferred by famers
14. NE9	Green to violet, very small	Very sweet in taste
15. NE8	Deep green to orange, small in breadth/length	Bitter in taste

The analysis showed statistical differences within the genotypes for all the evaluated traits except for stem girth. The different morphological characteristics revealed in this research support the results of (Tumbilen *et al.*, 2011). Accessions NE4, GH 4943, GH1072 recorded the highest plant height at flowering while NE9 recorded the least plant height among the accessions. The highest mean stem girth (1.96cm) was observed in accession GH3944 while accession NE9 had the lowest mean stem girth of 1.42cm. Accession GH3944, NE9 and NE8 had the highest number of laves per plant with GH1157 recording the least number of leaves / plant. For canopy spread GH3970 was observed to have the highest (83.30cm) while accession NE9 had the least among the accessions. NE9 recorded the highest mean branches per plant of 63 and GH 1072 had the lowest of 9.36. The highest days to 50% flowering was recorded by GH3952 (79.67) followed by GH1072 (7367). The lowest number

of days to 50% flowering was observed in NE9. NE9 and NE2 had the highest flower number/plant and also aborted flowers/plant than the remaining genotypes. NE9 was found to have the highest number of flowers developing to maturity while GH 1157 had the least. Accessions GH3952, GH1157, GH1072, and NE4 took a longer period for the fruits to reach physiological maturity while accessions NE8 had their fruits maturing earlier. NE9 had more number of fruits per plot followed by NE8 and NE2 respectively while GH 3944 had the least fruit number/per plot. The fruits of GH3970 were heavier, wider and longer than the remaining accessions. Fruits of GH3904 contains more seeds than the other accessions. The least mean yield per plant was observed in GH1157.. The significant effect of the interaction between the season x genotype for most of the traits, indicates that genotypic variability in these traits was significantly influenced by the environment.

Table 2: Mean squares from the analysis of variance of growth related traits

Source of variation	DF	Plant height at flowering (cm)	Stem girth (cm)	Number of leaves	Canopy spread (cm)	No. of branches	No. of days to maturity	50% flowering	No. of flowers per plant	No. of flower dropped per plant	Flowers dev. to matured fruit/plant	50% fruiting (%)	Fruit no. /plant	10 fruit weight (kg)	Fruit length (cm)	Fruit diameter (cm)	No. of seed per fruit	100 seed weight	Yield/Plant (kg)
Replicate	2	137.8*	0.11	11754**	352.3**	326.7	207.3	41.8 ns	334.3*	16.3	301.9*	11	35.3	0.14	0.27	1.61	8	0.00	3.1
Accession	14	340.6**	0.19	17577**	453.3**	1179.1**	510.7**	474.7**	3465**	283.9**	2247.3**	497.2**	4680.8**	79**	193.7**	136.4**	403014**	0.1**	25.5**
Season	1	7052.7**	0.31	21878**	1703.5**	549.1	9217.7**	8382.8**	2405.4**	384.3**	1230.9**	9438.2**	1627.1**	51.8**	1.0**	6.88*	620	0.03**	430.9**
Accession × Season	14	83.6**	0.11	3429	99.31	200.7	320.3**	203.4**	472.1**	76.8	278.7**	144.9**	648.7**	2.3**	1.1**	1.91	7323**	0.0	19.6**
Residual	58	34.4	0.2	2242	57.75	247.41	111.3	18.8	96.1	44	62.71	6	18.4	0.07	0.14	1.32	390	0.0004	1.58

*=Significant at P ≤ 0.05; **=Significant at P ≤ 0.01

Genetic parameters, heritability estimation and association studies

Table 3 shows the estimation of variability parameters. The phenotypic variance and phenotypic coefficient of variance being greater compared to their corresponding genotypic variance and coefficient of variance of the genotype for all the traits studied in this experiment indicate that, the expression of these traits were controlled by season. Related findings were observed by Islam and Uddin (2009). According to Sivasubramanian and Menon (1973) PCV and GCV values >20% are considered as high, whereas values <10% are considered to be low and values between 10 and 20% to be moderate. Based on this formula, stem girth and days to maturity recorded low GCV values. Moderate values were observed for plant height at flowering, canopy spread and 50% flowering while high values were recorded for

the remaining traits. High PCV values (>20%) were observed for all the traits studied except stem girth, plant height at flowering, canopy spread, 50% flowering, 50% fruiting, days to maturity which were moderate (10 – 20%). The PCV values were higher for all the characters studied than their corresponding GCV values. The high (>20%) phenotypic and genotypic coefficients of variation observed for yield per plant indicate the existence of high variability among the accessions for future fruit number development via selection. This result supports that of Anyaoha *et al.*, (2018) who earlier indicated high genotypic coefficient of variance and phenotypic coefficient of variance for yield among 77 accessions screened in Nigeria. The magnitude of the variation between genotypic coefficient of variance and phenotypic coefficient of variance shows the rate of climatic influence on a particular character.

Table 3: Estimates of genetic parameters, for the *Solanum* species

Source of variation	Mean	Vg	Genotype by season interaction variance	Vp	GCV	PCV	H ² (%)	GA
Plant height at flowering (cm)	47.7	42.0	18.0	56.7	13.5	15.7	73.9	11.4
Stem girth (cm)	1.6	0.0	0.0	0.0	6.9	10.7	42.1	0.1
Number of leaves	93.6	2358.0	395.6	299.5	51.8	57.8	80.4	89.7
Canopy spread (cm)	66.4	59.0	13.8	75.6	11.5	13.0	78.1	13.9
No. of branches	17.6	163.0	-15.5	196.5	72.1	79.2	82.9	23.9
50% flowering (%)	62.0	45.2	61.5	79.1	10.8	14.3	57.1	10.4
No. of flowers per plant	24.3	498.8	125.3	577.5	91.8	98.8	86.3	42.7
No of flower dropped / plant	7.1	34.5	10.9	47.3	82.6	96.7	72.9	10.3
Flowers develop to maturity	17.9	328.1	72.0	374.6	100.7	107.6	87.6	34.9
50% Fruiting (%)	71.6	58.7	46.3	82.8	10.6	12.7	70.8	13.2
No. of days to maturity	83.8	31.7	69.6	85.1	6.7	11.0	37.2	7.09
Fruit number/plant	27.3	672.0	210.1	780.1	94.7	102.0	86.1	49.5
10 Fruit weight (kg)	1.7	0.9	0.7	1.3	55.7	66.6	69.9	1.6
Fruit length (cm)	5.8	32.9	0.3	33.1	98.3	98.5	99.4	11.7
Fruit diameter (cm)	5.4	22.4	0.2	22.7	87.5	88.1	98.6	9.6
No. of seed per fruit	385.4	65947	2312.6	6769.0	66.6	67.2	98.1	524
100 seed weight	0.3	0.0	0.0	0.0	41.6	41.7	99.4	0.2
Yield (kg)	3.3	0.9	6.0	4.2	29.5	61.3	23.1	0.9

Similar observation was reported by Pessarakli and Dris (2004) for these traits. However, the other characters like dropped flowers/plant and 10 fruit weight which observed a greater variation among genotypic coefficient of variance and phenotypic coefficient of variance showed that season effect on the expression of those characters was greater. The heritability (H₂) analyses determine how much genetic and non-genetic variability contributes to total phenotypic variance in a population (Falconer and Mackay, 1996). Heritability in broad sense (H₂) estimate ranged from 23.1 - 99.4 per cent for yield per plant and 100 seeds weight respectively. The greater H₂ estimates observed by all the characters with the exception of yield/plant, stem girth, days to 50% flowering and maturity days, indicate a high response to selection for those parameters. Similar findings were observed by Kaushik *et al.*, (2018), which support the present findings. This result disagrees with that of Abdourasmane *et al.*, (2016) who earlier indicated high H₂ estimates for 50 per cent flowering. Genetic advancement is most useful as a selection tool when used in conjunction with H₂. The GA value ranged from 0.15 for stem girth to 524.18 for number of seeds per fruit (Table 3). The high H₂ associated with the GA for the number of seeds per fruit, leaves per plant revealed in this study could explain that the activity of additive genes and their selection can take place in the first generations. Similar observations were reported by Khan and Khan (2019). According to Wolie *et al.*, (2013), the genetic advancement in selection is the improvement of traits in genotypic value of a new population over the base population over a cycle of selection at a certain intensity of selection. The genetic progress estimate of 0.98 kg/yielding plant/plant showed that, whenever the best 5% high yielding accessions were selected as parents,

the average yield/plant of the offspring can be improved by 0.98 kg.

The association among parameters is very vital in crop improvement. The association can be applied as an indirect selection method. The selection of parameters that simultaneously contribute to a genotype will be improved in subsequent segregating populations (Nor *et al.*, 2013). The correlation analysis results presented in Table 4 shows highly significant correlation between majorities of the characters studied. The high positive significant correlation between yield per plant and most of parameters means that improving these traits directly improves yield per plant. Therefore, plants with high fruit weight, fruit number, branch number, flower number, flowers developed to mature fruit, plant height at flowering have higher yield. The negative significant correlation between yield per plant and 50% flowering and fruiting, maturity days, seed per fruit and 100 seed weight shows selecting for lower values will improve the yield of garden eggs. The significant and positive correlation means that, continuous selection for these traits would result in improvement of yield per plant. The non-significant correlation observed between yield per plant and Stem girth, canopy spread, fruit length and fruit diameter suggests that, improving the yield of *Solanum spp* will not depend on these characters. This observation is in accordance with that of Nor *et al.*, (2013). However, the non-significant correlation between yield and fruit size (length and diameter) is in contrast with the previous study of Kaushik *et al.*, (2018) who reported significant correlation among these parameters. The positive correlation between plant height and yield/plant also disagrees with the findings of Khan *et al.*, (2014) and Moosavi *et al.*, (2015) who presented an inverse correlation between plant height and yield/plant.

Table 4: Correlation coefficients among the traits studied

	Plant height at flowering (cm)	Stem girth (cm)	Number of leaves	Canopy spread (cm)	No. of branches	50% flowering (%)	No. of flowers per plant	No. of flower dropped per plant	Flowers dev. to matured fruit/plant	50% fruiting (%)	No. of days to maturity	No. of fruit per plant	10 fruit weight (kg)	Fruit length (cm)	Fruit diameter (cm)	No. of Seed / fruit	100/ Seed weight/ g
Stem girth (cm)	0.29**	1.00															
Number of leaves	0.09	-0.01	1.00														
Canopy spread (cm)	0.59**	0.38**	0.01	1.00													
No. of branches	-0.04	-0.07	0.85**	-0.14	1.00												
50 % flowering (%)	-0.42**	-0.04	-0.41**	-0.20	-0.34**	1.00											
No. of flowers per plant	-0.02	-0.07	0.62**	-0.20	0.63**	-0.47**	1.00										
No of flower dropped per plant	0.05	-0.02	0.46**	-0.11	0.52**	-0.40**	0.83**	1.00									
Flowers dev. to matured fruit/plant	-0.06	-0.13	0.66**	-0.25*	0.66**	-0.45**	0.98**	0.80**	1.00								
50% fruiting (%)	-0.46**	-0.08	-0.46**	-0.21*	-0.38**	0.95**	-0.53**	-0.45**	-0.51**	1.00							
No. of days to maturity	-0.33**	-0.10	-0.30**	-0.16	-0.26**	0.75**	-0.47**	-0.40**	-0.46**	0.80**	1.00						
No of fruit per plant	-0.06	-0.12	0.61**	-0.28**	0.58**	-0.41**	0.88**	0.64**	0.89**	-0.48**	-0.40**	1.00					
10 Fruit weight (kg)	0.58**	0.25*	-0.07	0.63**	-0.14	-0.37**	-0.22*	-0.13	-0.25	-0.32**	-0.20	-0.31**	1.00				
Fruit length (cm)	0.19	0.27**	-0.21*	0.58**	-0.23*	-0.09	-0.42**	-0.25*	-0.44**	0.01	0.03	-0.53**	0.68**	1.00			
Fruit diameter (cm)	0.24*	0.22*	-0.24*	0.53**	-0.24*	-0.06	-0.45**	-0.29**	-0.47**	0.06	0.07	-0.54**	0.69**	0.93**	1.00		
NSPF	-0.03	-0.07	-0.37**	0.08	-0.33**	0.28**	-0.53**	-0.41**	-0.52**	0.32**	0.26**	-0.55**	0.06	0.20	0.31**	1.00	
100/seed weight/g	0.02	0.08	-0.47**	0.07	-0.42**	0.20	-0.50**	-0.28**	-0.51**	0.23*	0.16	-0.58**	0.16	0.25*	0.33**	0.58**	1.00
Yield/plant(kg)	0.46**	0.04	0.45**	0.20	0.30**	-0.57**	0.57**	0.49**	0.53**	-0.63**	-0.41**	0.62**	0.32**	-0.18	-0.19	-0.36**	-0.34**

*=Significant at $P \leq 0.05$; **=Significant at $P \leq 0.01$

References

1. Abdourasmane, K., Zongo, A., Kam H., Sanni A. and Alain, A. 2016. Genetic variability and correlation analysis of rice (*Oryza sativa* L.) inbred lines based on agro-morphological traits. *African J. Agril. Res.*, 11: 3340-3346.
2. Addo, K.A. 2010. Urban and peri - urban agriculture in developing countries student using remote Sensing and in situ methods. *Remote Sensing*, 2(2): 497-513.
3. Anyaoha, C., Adegbehingbe, F., Uba, U., Popoola, B., Gracen, V., Mande, S., Onotugoma, E. and Fofana, M. 2018. Genetic diversity of selected upland rice genotypes (*Oryza sativa* L.) for grain yield and related traits. *Int. J. Plant Soil Sci.*, 22(5): 1-9.
4. Falconer, D.S. and Mackay, T.F.C. 1996. *Introduction to quantitative genetics*. 4th Edn., Benjamin Cummings, England.
5. Ghimire, K.H., Koirala, K.B., Prasai, H.K. and Poudel, R.P. 2007. Full season maize varietal research in western hills of Nepal (2004-2006). pp. 147-156. In: Gurung, D. B., Paudel, D. C., Upadhyaya, S.R. and Pokhrel, B.B. (eds.) *Proceedings of the 25th National Summer Crops Research Workshop on Maize Research and Production in Nepal held at NARC, Khumaltar, Lalitpur, Nepal*.
6. Hazra, P., Rout, A., Roy, U., Nath, S., Roy, T. *et al.*, 2003. Characterization of brinjal (*Solanum melongena* L.) germplasm. *Vegetable Science*, 30: 145-149.
7. Islam, M.S. and Uddin, M.S. 2009. Genetic variation and trait relationship in the exotic and local eggplant germplasm. *Bangladesh J. Agril. Res.*, 34(1): 91-96.
8. Johnson, H.W., Robinson, H.F. and Comstock, R.E. 1955. Estimation of genetic and environmental variability in soybeans. *Agronomy J.*, 47: 314-318.
9. Kaushik, P., Plazas, M., Prohens, J., Vilanova, S. and Gramazio, P. 2018. Diallel genetic analysis for multiple traits in eggplant and assessment of genetic distances for predicting hybrids performance. *PLoS ONE*, 13(6): 1-20.
10. Khan, M.S.K., Iqbal, J. and Saeed, M. 2014. Comparative study of agronomic traits of different rice varieties grown under saline and normal conditions. *J. Animal Plant Sci.*, 24(2): 634-642.
11. Khan M. and Khan, M.A. 2019. Estimates of variability, heritability and genetic advance for elite germplasm accessions in maize. *J. Genet. Genom. Plant Breed.*, 3(1): 11-16.
12. Moosavi, M., Ranjbar, G., Zarrini, H.N. and Gilani, A. 2015. Correlation between morphological and physiological traits and path analysis of grain yield in rice genotypes under Khuzestan. *Biol. Forum- An Int. J.*, 7(1): 43-47.
13. Nor, A.H., Abdul, R.H., Mohd, R.Y., Norain, M.N. and NurIzzah, J. 2013. Correlation analysis on agronomic characters in F₁ population derived from a cross of PongsuSeribu2 and MR264. *J. App. Sci. Agril.*, 9(18): 143-147.
14. 1Nwanna, E.E., Ibukun, E.O. and Oboh, G. 2016. Effect of some tropical eggplant fruits (*Solanum Spp.*) supplemented diet on diabetic neuropathy in experimental male Wistar rats in-vivo. *Functional Foods Health Dis.*, 6(10): 661-676.6.
15. Pessarakli, M.M. and Dris, R. 2004. Pollination and breeding of eggplants. *Journal of Food Agriculture and Environment*, 2: 218-219.
16. R Core Team. 2021. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.
17. Şekara, A., Cebula, S. and Kunicki, E. 2007. Cultivated eggplants—origin, breeding objectives and genetic resources, a review. *Folia Horti.*, 19(1): 97-1.
18. Sivasubramanian, S. and Menon, M. 1973. Heterosis and inbreeding depression in rice. *Madras Agril.J.*, 60(7): 1139-1140.
19. Tümbilen, Y., Frary, A., Daunay, M.C. and Doğanlar, S. 2011. Application of EST-SSRs to examine genetic diversity in eggplant and its close relatives. *Turkish J. Bio.*, 35(2): 125-136.
20. Wolie, A., Dessalegn, T. and Belete, K. 2013. Heritability, variance components and genetic advance of some yield and yield related traits in Ethiopian collections of finger millet (*Eleusine coracana* (L.) Gaertn.) genotypes. *African J. Biotech.*, 12(36).