



## VARIATION AND CORRELATION AMONG AGRONOMIC TRAITS IN 10 ACCESSIONS OF GARDEN EGG PLANT (*Solanum gilo* Raddi) IN GHANA

<sup>1</sup>Jones Abrefa Danquah & <sup>2</sup>Kwadwo Ofori

<sup>1</sup> Faculty of Science and Forestry, School of Forest Sciences, University of Eastern Finland,  
Post Office Box 111, Joensuu; Fin-80101, Finland

<sup>2</sup>Department of crop Science, School of Agriculture, College of Agriculture and Consumer Sciences,  
University of Ghana, Post Office Box LG 68, Legon-Accra, Ghana  
Corresponding Author: E-mail: abrefad@gmail.com ; Fax: + 358-132-512050

### ABSTRACT

Garden egg (*Solanum gilo* Raddi) is an important solanaceous vegetable crop in Ghana. However, the species has wider distribution throughout tropical Africa. Ten accessions were grown in Randomized Complete Block Design with three replications to determine extent of genetic variability, strength of association and the level of heritability among seven agronomic traits. Variances component method was used to estimate phenotypic and genotypic variation and heritability in the study. High Phenotypic and Genotypic coefficient of variances were observed for fruit length, number of seeds per fruit, fruit weight and height at flowering. In addition, genetic and phenotypic variances were higher in fruit weight, height at flowering, days to flowering and number of seeds per fruits. High heritability estimates were recorded for fruit length, days to flowering, fruit weight and height at flowering. However, number of seeds per fruit exhibited moderately high heritability. Fruit weight showed significant positive association with fruit diameter and fruit length. Days to flowering registered significant positive correlations with height at flowering and fruit length at both phenotypic and genotypic levels. The most striking result was significant negative correlation between number of seeds per fruit and fruit length. Thus suggesting that selection for accessions with long fruits characteristics will lead to reduction in seed content of the fruits. The seed content of the fruits is the main prohibitive factor to the acceptance of garden eggs to the larger consumers in Ghana.

**Keyword:** Heritability, genetic variability, trait association, phenotypic variation.

### INTRODUCTION

African eggplant or garden eggplant (*Solanum gilo* Raddi) is synonyms to *Solanum aethiopicum* Gilo group (Norman, 1992; Lester and Seck, 2004, Shackleton *et al.*, 2009). *Solanum gilo* Raddi is a member of the *solanaceous* family, is an important vegetable in West, Central and East Africa (Blay and Oakes, 1996). In fact, the species of this genus is widely distributed in tropical sub-Saharan Africa (Norman, 1992). *Solanum gilo* Raddi has also been reported in Asia (Blay and Oakes, 1996). However, *Solanum aethiopicum* has been classified into four main complex or groups based on utilization of edible parts in accordance with the international code on nomenclature for cultivated plants (Shackleton *et al.*, 2009; Lester *et al.*, 1986; Anaso, 1991). These are Gilo, Shum, Kumba and Aculeatum (Horna *et al.*, 2007). The most largely cultivated cultivar in Ghana is the Gilo group (Horna *et al.*, 2007; Lester *et al.*, 1990). The Gilo and the Kumba groups are mainly cultivated for their edible fruits (berries). Both the leaves and fruits of Shum and Kumba groups, and *Solanum macrocarpon* (L) are eaten

especially in Uganda and other parts of Eastern Africa. However, the Aculeatum has inedible fruits and prickly leaves and more or less considered as an ornamental plant (Lester, 1986; Lester and Niakan, 1986; Shackleton *et al.*, 2009).

In Ghana, the production of garden eggs is throughout the country, but commercial production is concentrated mostly in the forest zone. It is grown as commercial crop for domestic consumption and also for export (Daunay *et al.*, 2001). In 1997, approximately 750 tons of garden egg fruits were exported from Ghana and this constituted about 5% of total production at that time (Danquah, 2000). However, it is currently estimated that the total national production of garden eggs fruits to be around 30,000 metric tons (Horn *et al.*, 2007). In Côte d'Ivoire, it was reported to be the most important vegetable crop ranked next to Okra (*Abelmoschus esculentus*) in terms of production (Aliero, 2007; Siemonsma, 1981). Garden egg production is one of the major sources of income to rural women and their household in Ghana. Nutritionally, it reserves of micronutrients, vitamins and proteins which can be used to address potential deficiencies (Chinedu *et al.*, 2011). It is very rich in iron and

lower in vitamin C as compared to tomato (Horn *et al.*, 2007; Okon *et al.*, 2010). The African eggplants play central role of tradition and cultural of people sub-Saharan Africa (Chinedu *et al.*, 2011). According to Chinedu *et al.* (2011) it is offered as gift in traditional ceremonies such as marriage, child naming and other social occasions as sign of blessing and fruitfulness. It is very important plant in traditional folklore medicine; hence it is used to treat certain ailments. It has proven benefit to patients suffering from anaemia because of its rich iron content. Rich meal of garden eggs is used to induce lactation in freshly delivered women (Blay, 1991). Frequent consumption of garden eggs reduces intraocular pressure (glaucoma) and convergence insufficiency (Igwe *et al.*, 2003). In addition, it prevents heart diseases and blood pressure (Okon *et al.*, 2010; Grubben and Denton, 2004). Phytochemical investigation of garden egg plant and relatives of this genus has revealed presence of high levels of steroidal glycoalkaloids, tannins sesquiterpenoids and other essential bioactive compounds (Chinedu *et al.*, 2011; Aliero, 2007; Khan, 1979; Cipollini and Levey, 1997; Nagoaka *et al.*, 2001; Shamin *et al.*, 2004). In spite of the beneficial uses of garden eggs, research into garden egg production and general improvement through breeding has received very little attention in the country. Garden eggs gilo group is highly heterogeneous due to crosspollination (Horna *et al.*, 2007). The species varies considerable in several agronomic traits or characters. A wide variation has been observed in fruit shape, immature fruit colour, fruit size, diameter of corolla, petiole length, leaf blade and taste (Blay, 1978; Chinedu *et al.*, 2011; Osei *et al.*, 2010; Gisbert *et al.*, 2006). Garden egg cultivars also vary in branching habit, time of flowering, time of fruit maturity and fruit yield (Blay, 1978). However, virtually no studies have been done so far done to determine the inheritance of these quantitative characters in garden egg. Furthermore, association among various characters has not been established. Heritability is important in helping the plant breeder plan and executes effective breeding strategy. Knowledge of correlation among characters is important in deciding on what selection strategy to use. Hence, there is the need to determine genetic parameters in order to design selection programmes aimed at improving the crop through selection among accessions or through hybridization. The objectives of this study were to determine the amount of genetic variability available for selection in the accessions and, to access the strength of association and to estimate the level or amount of heritability among agronomic traits.

## MATERIALS AND METHODS

### Study site

The materials for the study comprised 10 accession of garden eggs were obtained from Plant Genetic Resource

Institute of Council for Scientific and Industrial Research (CSRI) of Ghana, Bunsu. The experiment was conducted at University of Ghana Farm, Legon, Accra. The research site is located at latitude 5° 38' 45''N and longitude 00° 11' 13''E. The elevation in the study area is approximately 300 meters above sea level and topography is undulating terrain. The area records mean annual rainfall of approximately 1100 mm and mean annual temperature of 31°C (Cobbina, 1987). The soils at the research site are light textured, well drained and easy to work with, but are inherently poor in nutrients (Brammer, 1962). Based on Ghana classification systems, these soils are generally called savannah Ochrosols (Brammer, 1962). However, according to World Reference Base and FAO systems, these soils fall within Lixisols /Luvisols / Plinthosols (ISSS/ISRIC/ FAO, 1998; FAO, 1988).

### Experimental Design and Data collection

The seeds of ten accessions were nursed in small boxes with soils sterilized with combination of hot water and Furadan (Carbofuran) an insecticide-nematicide at rate of 20g/m<sup>2</sup> against nematodes. In addition, to prevent incidence of dumping-off two days after seedlings emergence Dithane M45 (*Mancozeb*) a broad spectrum fungicide was applied at rate of 5g/litre. However, seedlings were pricked-out into larger nursing boxes at 12 days after emergence and subsequently transplanted onto the field 6 weeks after germination. A compound fertilizer N: P: K (15-15-15) was applied at the rate of 250kg/ha at 4 weeks after transplanting. In addition, split dose of Ammonium Sulphate ((NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>) at the initiation of flowering through fruiting. Watering was done daily for the initial 6 weeks after transplanting to facilitate rooting and establishment of the young plants. Thereafter, once a week irrigation schedule was maintained. Moreover, other recommended packages of practices were followed to raise the accessions. The experimental design used in the study was Randomized Complete Block Design (RCBD) with ten (10) treatments (Accessions) and three replications. Each plot (block) consists of ten rows of dimension 9 m in length and 90cm between the rows. Thus, given 9m X 9m experimental plot design. However, square-planting of dimension 90cm X 90cm was used in the design. There were total of 100 plants per plot of which 10 for each accession. Moreover, each accession was represented randomly as a row per replicate. Morphometric measurements on agronomic traits or characters (Table 1) were taken on five plants per each accession on each plot, which were systematically sampled. This involved selection of first, third, fifth, seventh and ninth plants on the row. The sampled plants were tagged with plastic band and data were generated from the same plants throughout the experimental period under consideration.

**TABLE 1.** Description of agronomical traits examined in the study.

Agronomic Trait	Description
Days to flowering	Days to flowering from seedling emergence to time of first flower opening the recorded plants
Height at flowering (cm)	The height from soil level to the growing tip of the shoot at first flowering opening
Fruit weight(g)	Weight of fresh matured fruit harvested from the sampled plants. The average from the first 10 matured fruits per plant were used
Number of seeds per fruit	Seeds from first five fruits per plant were extracted and counted accordingly
Fruit length(cm)	Vernier caliper was used to measure the fruit length from the base of the fruit stalk to the apex of the fruit
Fruit diameter (cm)	Vernier caliper was used to measure the fruit diameter at the middle portion of the fruit
Number of fruiting branches per plant	The number of fruiting branches of the sampled plants were counted at the end of growing season or the experiment

### Statistical Analysis

The mean performance of each individual genotype or accession was employed in the statistical analysis and to estimate major genetic components in this study. Heritability in the broad sense was derived based on the formula given by Allard (1960) and Burton and de Vane (1953). Estimates of genotypic and phenotypic correlation were obtained using the formula given by Al-Jibouri *et al.* (1958). However, the Genotypic Coefficient of Variance (GCV) and Phenotypic Coefficient of Variance (PCV) were computed by adopting

the method of Burton and de Vane (1953) and Burton (1952).

### RESULTS AND DISCUSSION

#### Phenotypic and genotypic variations

We recorded genotypic variances ranging between 0.02 and 4109.30 and phenotypic variances ranging between 0.06 and 6194.96 for the agronomic traits considered in study (Table 3). Relatively higher genotypic variance values of 4109.30, 31.60 and 24.52 were obtained for number of seeds, height at flowering and days to flowering respectively.

**TABLE 2 .** Genotypic ( $\sigma_g^2$ ) and Phenotypic ( $\sigma_{ph}^2$ ) Variances, Genetic (GCV) and Phenotypic (PCV) coefficient of variation and Heritability ( $\sigma_g^2/\sigma_p^2$ ) estimates for ten accessions of Garden Egg

Agronomic Trait	$\sigma_g^2$	$\sigma_{ph}^2$	GCV (%)	PCV (%)	$\sigma_g^2/\sigma_p^2$ (%)
Fruit Length(cm)	0.70	0.74	22.7	23.4	94.7
Fruit Diameter(cm)	0.02	0.06	4.0	6.8	34.5
Fruit Weight(g)	12.86	16.91	15.4	17.7	76.0
Height at flowering (cm)	31.60	42.63	16.6	19.3	74.1
Days to flowering	24.52	29.37	9.6	10.5	83.5
Number of seeds per fruit	4109.30	6194.96	22.6	27.8	66.3
Number of fruiting branches	4.14	7.56	8.9	12.0	54.7

Similarly, the phenotypic variances for these agronomic traits were almost as high, indicating that the genotype could be reflected by the phenotype and the effectiveness selection based on the phenotypic performance of these traits could be achieved. These results are line with some studies involving other varieties of eggplant (Islam and Uddin, 2009; Naik *et al.*, 2010; Hitomi *et al.*, 1998; Vadivel and Bapu, 1990a). High genotypic and phenotypic variances of the number seeds per fruit, height at flowering and days to flowering in this study are not uncommon with *solanaceous* vegetable crops (Sood *et al.*, 2009; Tumbilen *et al.*, 2011; Farhad *et al.*, 2008; Aliero, 2007). In general, the values of Phenotypic Coefficients of variation (PCV) are slightly higher than that of Genotypic Coefficients of Variation (GCV). But the magnitude of the difference between PCV and GCV is a little lower, as an indication that less environmental influence on the expression of these

attributes. This corroborates with the findings of Jalata *et al.* (2011) in *Hordeum vulgare* landraces. However, Desmukh *et al.* (1986) categorized PCV and GCV values into following classes; as high (>20%), medium (10-20%) and low (<10%). In this study, PCV values ranged from 6.8% in fruit diameter to 27.8% in number of seeds per fruit (Degwione *et al.*, 2011). The GCV ranged from 4.0% in fruit diameter to 22.7% in fruit length (Table 3). Based on Desmukh *et al.* (1986) classification the only agronomic traits which recorded very low values for PCV and GCV was fruit diameter. Thus, limited progress could be made in terms of selection for improvement in the fruit diameter. However, other agronomic characters or traits recorded values of GCV and PCV well above the medium range. Thus, suggesting sufficient genetic variability to facilitate improvement through selection of these agronomic traits. The development of effective breeding programme depend

existence of genetic variability. The results of this study fall within the limits of other studies involving different species of eggplant (Denton and Nwangburuka, 2011; Naik *et al.*, 2010; Vadivel and Bapu, 1990b; Hitomi *et al.*, 1998).

#### Estimates of heritability in the broad sense

Heritability estimates determine the measure of precision of a trial or a series of trial for standardization of their selection (Bilgin *et al.*, 2010). In addition, it gives an indication as to how a given trait or agronomic character will respond to selection (Falconer and Mackay, 1996). In this study the broad sense heritability estimates on the basis of genotypic and phenotypic variances ranged between 34.5% and 94.7% for all traits considered in the analysis (Table 3). Fruit diameter had the lowest value (34.5%) followed by number of fruiting branches (54.7%). Fruit length had the highest heritability estimate (94.7%) followed by days to flowering (83.5%). The heritabilities for fruit weight, height at flowering and number of seeds per fruit were 76.0%, 74.1% and 66.3% respectively. Denton and Nwangburuka (2011) reported almost similar result in *Solanum anguivi*. In a related study, Islam and Uddin (2009) reported high heritability estimates of 91.5% for fruit length and 62.7% for days to first flowering in *Solanum melongena*, which are in line with this work. The high heritability values recorded for fruit length, days to flowering, fruit weight and height at flowering suggest that selection could be practiced for these agronomic traits. Little progress is expected from selection for fruit diameter in this accession. However, high heritability value alone is not enough guarantee to ensure a high genetic gain (Ibrahim and Hussein, 2006).

#### Correlations among agronomic traits

The values of the genotypic correlation were little higher and in most cases almost the same as phenotypic correlation coefficient values. Fruit weight was significantly and positively associated with fruit diameter ( $r_p=0.81$ ,  $P<0.01$ ) and fruit length ( $r_p=0.75$ ,  $P<0.01$ ) at phenotypic level (Table 3). In addition, at genotypic level fruit weight showed positively correlated with fruit length ( $r_g=0.64$ ,  $P<0.05$ ). Singh *et al.* (2011) reported similar results in *Pisum sativum*. There was significant positive phenotypic and genotypic correlation between days to flowering and height at flowering ( $r_p=0.82$ ,  $P<0.01$ ;  $r_g=0.83$ ,  $P<0.01$ ) as well as fruit length ( $r_p=0.73$ ,  $P<0.05$ ;  $r_g=0.73$ ,  $P<0.05$ ) (Table 3). The results suggest selection for shorter plants could lead to earliness in this collection of accessions. However, longer fruit length which attract premium price on the market, selection for this agronomic trait could increase the gestation period. The high correlation coefficient values at both phenotypic and genotypic level indicate that these agronomic traits are biologically meaningful (Skinner *et al.*, 1999), as more than 50% of the variation in one trait is predicted by the other (Snedecor and Cochran, 1980; Swamy *et al.*, 2003). Height at flowering revealed significant and highly positive association with fruit length ( $r_p=0.72$ ,  $P<0.05$ ;  $r_g=0.72$ ,  $P<0.05$ ) at both phenotypic and genotypic levels. The positive association between height at flowering and fruit length has been noted elsewhere (Swamy *et al.*, 2003).

**TABLE 3.** Phenotypic correlation ( $r_p$ ) and genotypic correlation ( $r_g$ ) coefficients among 7 agronomic characters in garden eggs

Character	1	2	3	4	5	6	7
1. Fruit weight	-	<b>0.53</b>	<b>0.60</b>	<b>0.81**</b>	<b>0.21</b>	<b>-0.20</b>	<b>0.75**</b>
	-	<b>0.58</b>	<b>0.57</b>	<b>0.51</b>	<b>0.26</b>	<b>-0.08</b>	<b>0.64*</b>
2. Days to flowering	-	-	<b>0.82**</b>	<b>0.49</b>	<b>-0.42</b>	<b>-0.35</b>	<b>0.73*</b>
	-	-	<b>0.82**</b>	<b>-0.14</b>	<b>-0.42</b>	<b>-0.35</b>	<b>0.73*</b>
3. Height at flowering	-	-	-	<b>0.50</b>	<b>-0.38</b>	<b>-0.36</b>	<b>0.72*</b>
	-	-	-	<b>0.15</b>	<b>-0.38</b>	<b>-0.36</b>	<b>0.72*</b>
4. Fruit diameter	-	-	-	-	<b>0.51</b>	<b>-0.13</b>	<b>-0.29</b>
	-	-	-	-	<b>0.61</b>	<b>0.84**</b>	<b>-0.29</b>
5. Number of fruiting branches	-	-	-	-	-	<b>0.36</b>	<b>0.18</b>
	-	-	-	-	-	<b>0.36</b>	<b>0.18</b>
6. Number of seeds per fruit	-	-	-	-	-	-	<b>-0.68*</b>
	-	-	-	-	-	-	<b>-0.68*</b>
7. Fruit length	-	-	-	-	-	-	-

Note//: \* and \*\* indicate significant at 0.05, 0.01 probability levels respectively. The values of coefficients in red represent genotypic correlation and the black phenotypic correlation.

However, Denton and Nwangburuka (2011) reported significant negative association at phenotypic level and positive correlation at genotypic level between plant height and fruit length in *Solanum anguivi*. Fruit diameter showed significant positive association with number of seeds per fruit ( $r_g=0.84$ ,  $P<0.01$ ). Similar results were reported by Tumbilen *et al.*, 2011. However, in related studies Ofusu-

Budu (1984) and Badea *et al.* (1996) reported that seed content of fruit of garden egg varies with fruit size and it is higher in large fruits. Additionally, number of seeds per fruit showed significant negative correlation with fruit length ( $r_p=-0.68$ ,  $P<0.05$ ;  $r_g=-0.68$ ,  $P<0.05$ ). The major drawback to consumption of fruits African eggplant by urban consumer, particular the Gilo group is the seed content. The seed

content is associated with bitter principle of the fruit and difficulty in processing. This is because the mucilage surrounding the seeds contains high level of saponins and alkaloids (Chinedu *et al.* 2011). Thus, any breeding programme that will facilitate a reduction in the seed content of the fruit will be helpful. Based on the results a purposeful selection for accessions with large fruit length will lead to generations with low seed content. This is in keeping with the fact that high heritability values were registered for these two agronomic traits in these accessions of garden eggs.

## CONCLUSION

The availability of significant genetic variability and high level of heritability concerning fruit length, days to flowering, fruit weight, height at flowering and number of seeds per fruit in the accessions points out that selection might be conducted to improve these traits. Moreover, the notable result is the negative association of fruit length with seed content of the fruit. Thus, selecting for fruit length in the accessions could improve the quality of the fruit through reduction in seed content.

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