# GENETIC VARIATION AND TRAIT RELATIONSHIP UNDER DIFFERENT GROWING SEASONS IN EGGPLANT (*SOLANUM* SPP.) GENOTYPES

Htwe Min Thant[1], Aye Aye Thwe[2], Moe Kyaw Thu[3], Nyo Mar Htwe[4] and Khin Thida Myint[5]

**Abstract**

Germplasm collection was started from May to November, 2015. And total forty two eggplant germplasm were collected from in and around the country having wider range of geographical conditions. The experiments were started from May, 2016 to April, 2017 (Monsoon & Post-monsoon seasons) at Department of Agricultural Research (DAR), Horticulture Research Section Field, Yezin, Nay Pyi Taw, Myanmar. The experiments were laid out in a randomized complete block design (RCBD) with three replications. All of the collected genotypes were distributed around the collected regions and states. Mandalay Region and Kachin State (each 6 genotypes) represented more of the genotypes than other states and regions. The PCV and GCV were comparatively high (during both seasons) for fruit weight, days to first flowering, plant height, fruit length, petiole length, fruit breadth, leaf width, and leaf length. For both seasons, very high heritability estimates were obtained for days to first flowering, fruit weight, fruit length, fruit breadth, plant height, leaf length and leaf width. The traits like fruit weight, days to first flowering and plant height and their positively correlation traits were emphasized on future breeding program. The existence of a significant negative correlation between days to first flowering and fruit hardness with leaf traits and fruit length suggests the existence of a physiological limit among these traits. The genetic components of the correlations were more important than the environmental, as the phenotype is a reflection of the genotype. The fruit weight and days to first flowering and plant height in the yield component with greatest importance in genetic improvement in eggplant.

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[1] PhD candidate, Dept. of Horticulture, Yezin Agricultural University (YAU)

[2] Supervisor & Associate Professor, Dept. of Horticulture, YAU

[3] Member & Lecturer, Dept. of Agric. Biotechnology, YAU

[4] Member & Deputy Director, ACARE, YAU

[5] Member, Professor & Head, Dept. of Horticulture, YAU

# INTRODUCTION

Brinjal or eggplant or aubergine (*Solanum melongena* L.) is indigenous to a vast area stretching from northeast India and Burma, to Northern Thailand, Laos, Vietnam and Southwest China and wild plants can still be found in these locations (Daunay and Janick, 2007). Eggplant was domesticated from wild forms in the Indo-Burma region with indications that it was cultivated in antiquity. Several Sanskrit documents, dated from as early as 300 BCE, mention this plant with various descriptive words, which suggest its wide popularity as food and medicine (Nadkarni, 1927). In the Ayurvedic, a Hindi system of medicine, white types were recommended for diabetic patients, and roots for the treatment of asthma (Khan, 1979).

Eggplant is widely cultivated as vegetable in both temperate and tropical areas, especially in Asia. Eggplant is a major fruit vegetable with world production exceeding 32 million tonnes (Mt). The world leading eggplant producers are China (18.2 Mt), India (15.6 Mt), Egypt (2.0 Mt), Turkey (1.3 Mt), Indonesia (0.7 Mt), Iraq (0.6 Mt) Japan (0.6 Mt) and Italy (0.5 Mt) (FAO, 2008). Eggplant is particularly favoured in Asia where it has been cultivated for millennia, and in India it is considered King of Vegetables (Ferdousi et al. 2013).

In Myanmar, there are number of local cultivars with a wide range of variability in size, shape and color of fruits available and for this easily fulfill the gap by developing high yielding hybrid variety. In spite of large number of varieties available in Myanmar, only a few have yield potentiality for both seasons. This fact draws the attention of plant breeder for its improvement for both seasons. Genetic variability plays an important role in a crop in selecting the best genotypes for making rapid improvement in yield and other desirable characters as well as to select the potential parent for hybridization programs. Heritability is an index for calculating the relative influence of environment on expression of genotypes. It becomes very different to judge how much of variability is heritable and how much is non-heritable. Therefore, information of the extent of variability available in some important economic traits and their heritability along with genetic advance will be helpful to the breeders in exercising the selection effectively and to formulate sound breeding programs.

# OBJECTIVES

Therefore, the present investigation was carried out

(1) to access the genetically heritability, genotypic coefficient of variation (GCV),

phenotypic coefficient of variation (PCV) and genetic advanced (GA) and

(2) to evaluate the phenotypic and genotypic correlation coefficient of the collected germplasm for both seasons.

## MATERIALS AND METHODS

### Germplasm collection

Germplasm collection was started from May to November, 2015. And total forty two eggplant germplasm were collected from in and around the country having wider range of geographical conditions. And evaluated the variations under field condition for yield, quality, physiological and other desirable traits like resistance to shoot and fruit borer. Eleven were obtained from Seed Bank, Department of Agricultural Research (DAR), Yezin and twenty three germplasm were collected from some different growing regions of the country. The regions of 42 eggplant germplasm collection sites were shown in figure 1.

### The experimental site

The experiments were started from May, 2016 to April, 2017 (Monsoon & Post-monsoon seasons) at Department of Agricultural Research (DAR), Horticulture Section Research Field, Yezin, Nay Pyi Taw, Myanmar situated at 9°5 latitude and 78°5 longitude and at an elevation of 147 meter above sea level (MSL). The soil type was sandy loam and soil pH was 6.7- 7.5.

The minimum and maximum temperature, rainfall (cm), relative humidity (RH%) and sunshine hours during the growing season of the experiments were shown in figure 2.

### Experimental design and layout

The experiments were laid out in a randomized complete block design (RCBD) with three replications. The unit plot size was (1 m x 9 m) and 9 plants were accommodated in a plot with a plant spacing of 90 cm maintaining a row distance of 90 cm. Experimental design and layout was shown in figure 3.

### Nursery and cultivation aspects

Twenty five to thirty days-old seedlings were raised in the nursery beds and they were transplanted on the ridges adopting a spacing of 60 x 60 cm. Recommended cultural practices were followed uniformly to all the genotypes. Observations were recorded in three randomly selected plants in each replication.

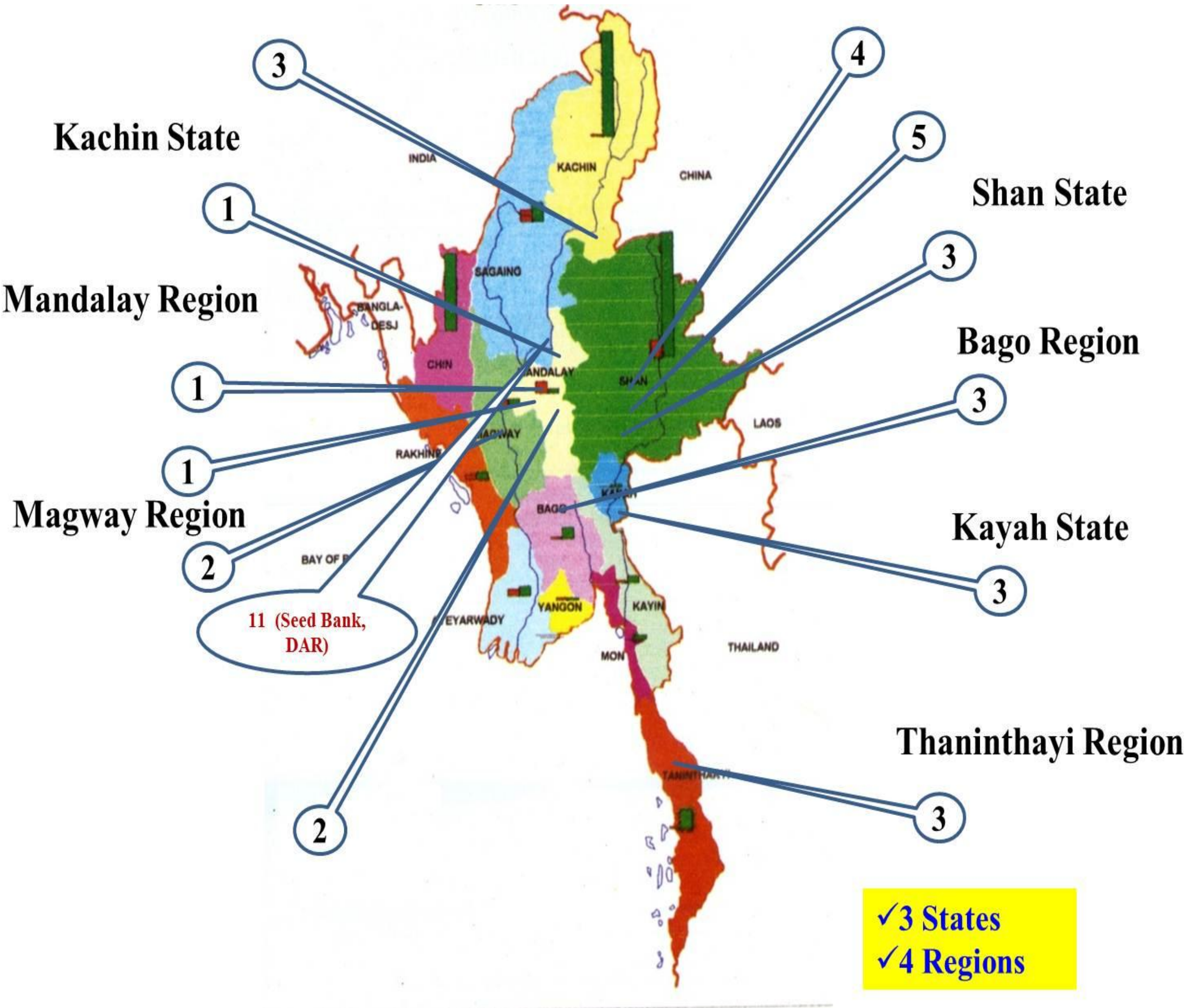



**Figure 1. The regions of 42 eggplant germplasm collection sites**

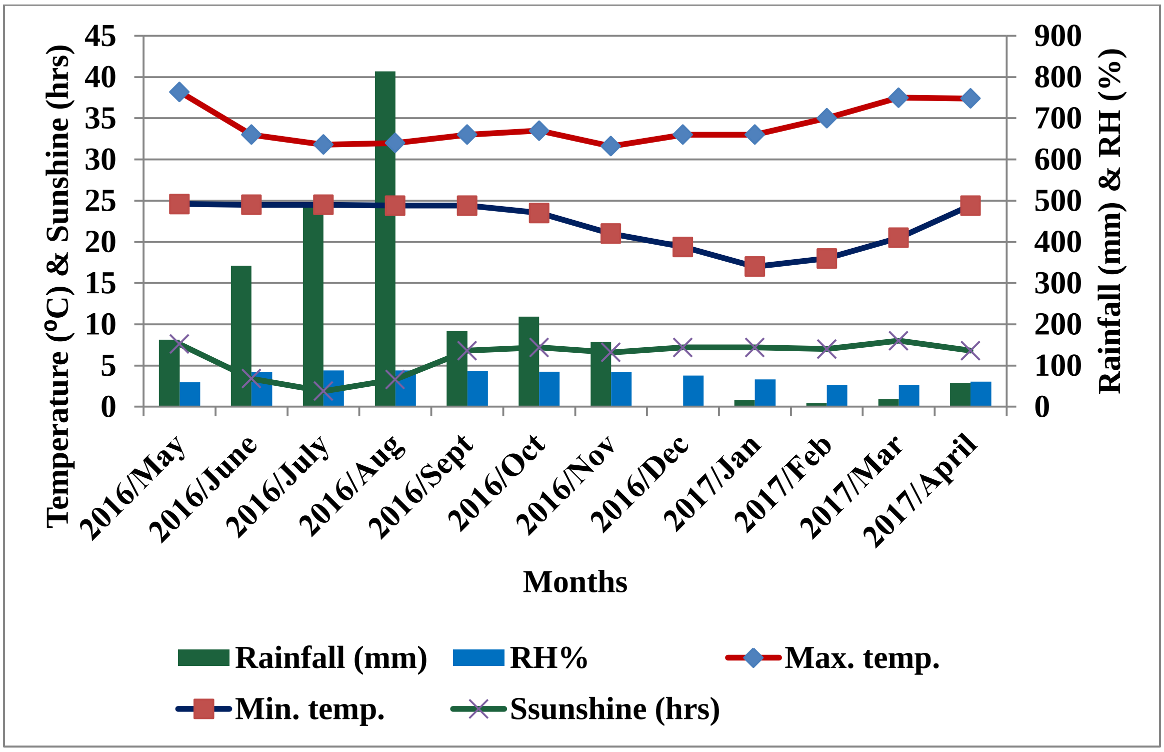
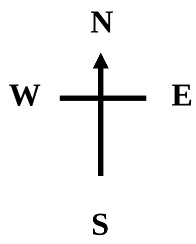



**Figure 2. The minimum and maximum temperature, sunshine (hrs), rainfall (mm) and relative humidity (RH%) for monsoon and post-monsoon seasons**




## Field Layout - (42 x 3) RCBD

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **32** | **9** | **16** | **36** | **40** | **4** | **41** | **1** | **38** | **19** | **40** | **42** | **41** | **39** | **8** | **4** | **37** | **42** | |
| | **42** | **39** | **38** | **3** | **13** | **11** | **32** | **27** | **16** | **3** | **13** | **36** | **12** | **11** | **13** | **32** | **36** | **15** | |
| | **14** | **35** | **25** | **6** | **17** | **41** | **14** | **35** | **25** | **6** | **17** | **4** | **3** | **16** | **31** | **17** | **9** | **10** | |
| | **2** | **19** | **31** | **19** | **10** | **29** | **2** | **9** | **31** | **39** | **10** | **29** | **1** | **21** | **5** | **2** | **29** | **6** | |
| | **30** | **22** | **8** | **20** | **34** | **5** | **22** | **8** | **20** | **34** | **5** | **30** | **23** | **24** | **38** | **28** | **35** | **14** | |
| | **21** | **7** | **26** | **28** | **27** | **24** | **21** | **37** | **7** | **28** | **18** | **12** | **27** | **18** | **22** | **20** | **25** | **30** | |
| **B** | **18** | **33** | **12** | **23** | **15** | **1** | **26** | **33** | **23** | **24** | **15** | **11** | **33** | **26** | **34** | **7** | **40** | **19** | **B** |
| | | | **RIII** | | | | | | **RII** | | | | | | **RI** | | | | |

**Figure 3. Experimental design and layout**

**Data Collection**

Data were recorded from three sub-sampling selected plants from each plot for quantitative traits.

**Quantitative Traits**

1. Plant height (cm) 2 weeks interval (PH)
2. Leaf numbers (2 weeks interval) (LNo.)
3. Leaf length (cm) (LLt)
4. Leaf width (cm) (LWdt)
5. Petiole length (cm) (PLt)
6. Fruit weight (g) (FWt)
7. Fruit length (cm) (FLt)
8. Fruit breadth (cm) (FBt)
9. Days to first flowering (DFF)
10. Days to first harvest (DFH)
11. 100 seeds weight (g) (100SWt)

**Physiological Traits**

1. Chlorophyll content (Chl)
2. Leaf temperature (LTem)
3. Fruit hardness (FHd)

**Statistical analysis**

Statistical parameters will be analysed according to the procedure described Gomez (1984) by using CropStat (7.3.2) and SPAR program. Mean data will be separated by using Fisher's LSD tests at alpha values of 0.05 (Gomez, 1984).

Phenotypic (PCV) and genotypic coefficient of variation (GCV), heritability ($h^2$) in broad sense and genetic advance (GA) will be estimated according to Singh and Chaundhary (1985) as given below:

$$PCV = \frac{\sqrt{\sigma_p^2}}{\bar{x}} \times 100 \qquad \text{Heritability}(h^2) = \frac{\sigma_g^2}{\sigma_p^2}$$

$$GCV = \frac{\sqrt{\sigma_g^2}}{\bar{x}} \times 100 \qquad \text{Heritability \%} = \frac{\sigma_g^2}{\sigma_p^2} \times 100$$

Expected genetic advance (GA) $= i\sigma_p h^2$

GA (%) $= (GA/\bar{x}) \times 100$

Where,

$\sigma 2p$ : phenotypic variance,

$\sigma 2g$ : genotypic variance,

$x$ : general mean of character,

$i$ : standardized selection differential,

$a$ : constant (2.06) and

$\sigma p$ : phenotypic standard deviation

Phenotypic and genotypic correlation coefficients were calculated using phenotypic and genotypic variances and co-variances as below:

$$r_g = \frac{\delta_{g1.2}}{\sqrt{\delta^2{}_{g1} \times \delta^2{}_{g2}}} \quad \text{(Miller } et\ al., \text{ 1980)}$$

$$r_p = \frac{\delta_{p1.2}}{\sqrt{\delta^2{}_{p1} \times \delta^2{}_{p2}}} \quad \text{(Miller } et\ al., \text{ 1980)}$$

Where,

$r_g$: genetic correlation coefficient,

$\delta_{g1.2}$ : genetic co-variance,

$r_p$: phenotypic correlation coefficient and

$\delta_{p1.2}$ : phenotypic co-variance

**Table A: Scale for phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV)**

| Scale | | Description |
|---|---|---|
| 20% | ≥ | High coefficient of variation |
| 10-20% | ≥ | Moderate coefficient of variation |
| 10 | ≤ | Low coefficient of variation |

**Table B: Scale for heritability in broad sense and expected genetic**

| Scale | | Description |
|---|---|---|
| 80% | ≥ | High |
| 50-80% | ≥ | Moderate |
| 50 | ≤ | Low |

Burton and DeVane (1953) and Johnson et al. (1955)

## RESULTS AND DISCUSSION

### Distribution of collected genotypes

All of the collected genotypes were distributed around the collected regions and states. Mandalay Region and Kachin State (each 6 genotypes) represented more of the genotypes than other states and regions. And minimum number of genotypes were collected from Bago (West) Region (3 genotypes) (Figure 4.).

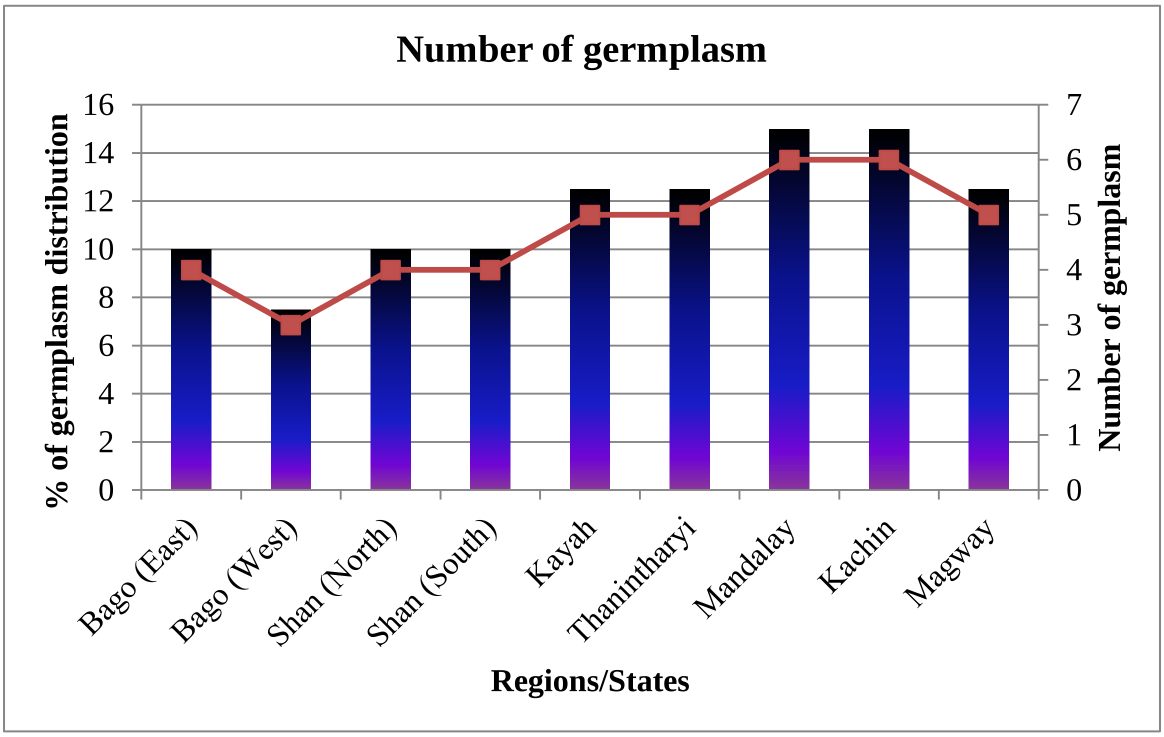



**Figure 4. The percentage and number of collected germplasm distribution around the regions and states**

### Analysis of variances

The analysis of variances confirmed the existence of variation among genotypes, season and the interaction between genotypes x seasons. There were also significant differences among genotypes and seasons. And in genotypes x seasons, except the petiole length and chlorophyll of the leaf all of the traits were significant interaction among the tested genotypes and growing seasons. Highly significant differences were recorded among the germplasm for all the characters suggesting that the genotypes included in the experiment were having appropriate variation for different traits and hence were suitable for further genetic analysis. The relative variability of different characters is presented in table 1.

This wide range of variability for different characters indicated the scope for selection of suitable initial material for breeding, in the improvement of brinjal. Similar result were reported by Chaudhary et al. (2014) and Madhavi et al. (2015) that analysis and variance revealed highly significant difference for almost all the characters studied indicating the existence of sufficient variability. The genotype exhibited large amount of variation for all of the traits in eggplants. And Helton et al. (2011) stated that the complex interaction between genotypes and growing seasons of carioca common bean in Goias/Distrito Feseral.

**Table 1. Analysis of variance (ANOVA) for fourteen traits in 42 eggplant genotypes**

| Source of variation | df | PH | Lno. | LWdt | LLt. | PetL | DFF | DFH | Hard | Fwt | FLt | FBdt | Chl | Ltemp. | 100 SWt. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Rep** | 2 | 23.13 | 2.94 | 31.98 | 92.48 | 2.05 | 0.19 | 0.84 | 0.00 | 9.99 | 4.08 | 0.52 | 4.42 | 2.19 | 0.00 |
| **Genotype** | 41 | 504.20** | 435.86** | 59.18** | 84.26** | 20.33** | 302.97** | 224.39** | 0.20** | 40212.70** | 97.03** | 17.77** | 179.88** | 36.82** | 0.00** |
| **Season** | 1 | 1708.62** | 192.36** | 570.53** | 1549.57** | 3.59* | 9131.19** | 13933.00** | 0.18** | 27307.90 | 14.06** | 0.03** | 210.54** | 915.16** | 0.00** |
| **G x S** | 41 | 2.06** | 0.23** | 0.80** | 1.91** | 0.30ns | 10.96** | 16.32** | 0.00** | 499.57** | 1.04** | 0.00** | 0.64ns | 4.99** | 0.00** |
| **Error** | 82 | 0.17 | 0.06 | 0.01 | 0.00 | 0.41 | 0.11 | 0.01 | 0.00 | 21.74 | 0.04 | 0.00 | 0.44 | 0.17 | 0.00 |
| **CV%** | | **0.60** | **0.40** | **0.90** | **0.10** | **14.20** | **0.50** | **0.10** | **0.20** | **5.00** | **2.20** | **0.10** | **1.50** | **1.30** | **0.00** |

*** significant at 1%, * significant at 5%, $^{ns}$ non-significant**

**PH=Plant height, Lno.=Leaves number, LWdt=Leaf weight, LLt.=Leaf length, PetL,=Petiole length, DFF=Days to first flowering, DFH=Days to first harvest, Hard=Hardness of fruit, Fwt.=Fruit weight, FLt=Fruit length, FBdt.=Fruit breadth, Chl=Chlorophyll content of leaf, Ltemp=Leaf temperature, 100SWt.=One hundred seeds weight**

**Phenotypic and genotypic coefficient of variation**

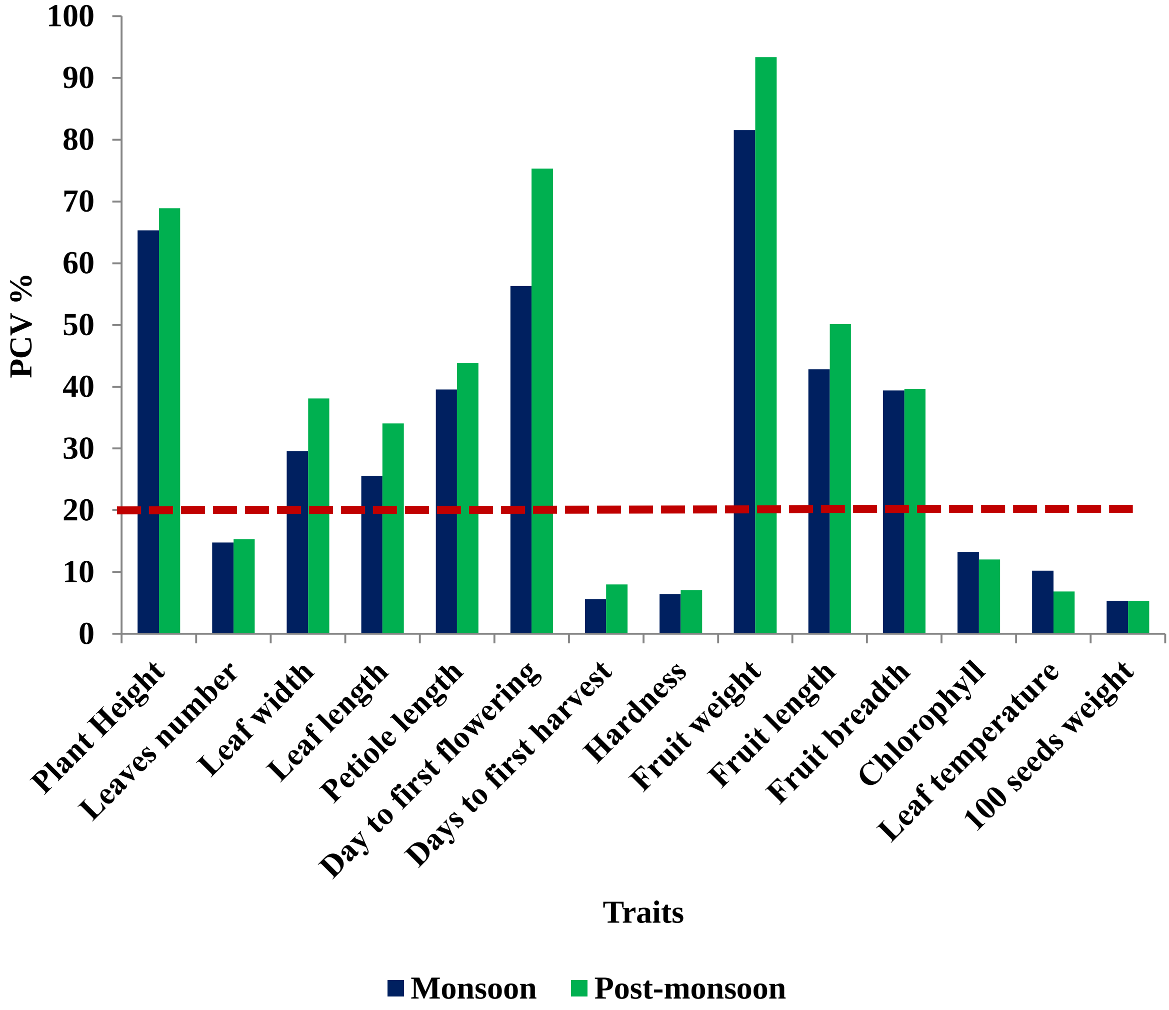
A perusal of data presented in Table 2 and 3 showed wide range of phenotypic and genotypic variability in the experimental material both for monsoon and post-monsoon seasons. **.** Phenotypic (A) and Genotypic (B) coefficient of variation of 14 traits for monsoon and post-monsoon seasons were shown in figure 5.

In the experimental material during monsoon season, phenotypic coefficient of variation (PCV) ranged from 5.36 to 81.54 percent and genotypic coefficient of variation (GCV) ranged from 3.60 to 80.48 percent for different traits. PCV and GCV estimates were very high (>20%) for fruit weight (81.54 & 80.48%), and followed by plant height (65.32 & 59.32%), days to first flowering (56.32 & 55.32%), fruit length (42.81 & 41.97 %), fruit breadth (39.41 & 38.50 %), petiole length (39.55 & 32.28 %) and leaf width (29.56 & 28.20 %), and leaf length (25.54 & 24.48 %) respectively. PCV and GCV estimates were moderate (10-20%) for leaves number (14.77 & 11.94 %) and chlorophyll content (13.26 & 10.41 %) respectively (Table 2.).

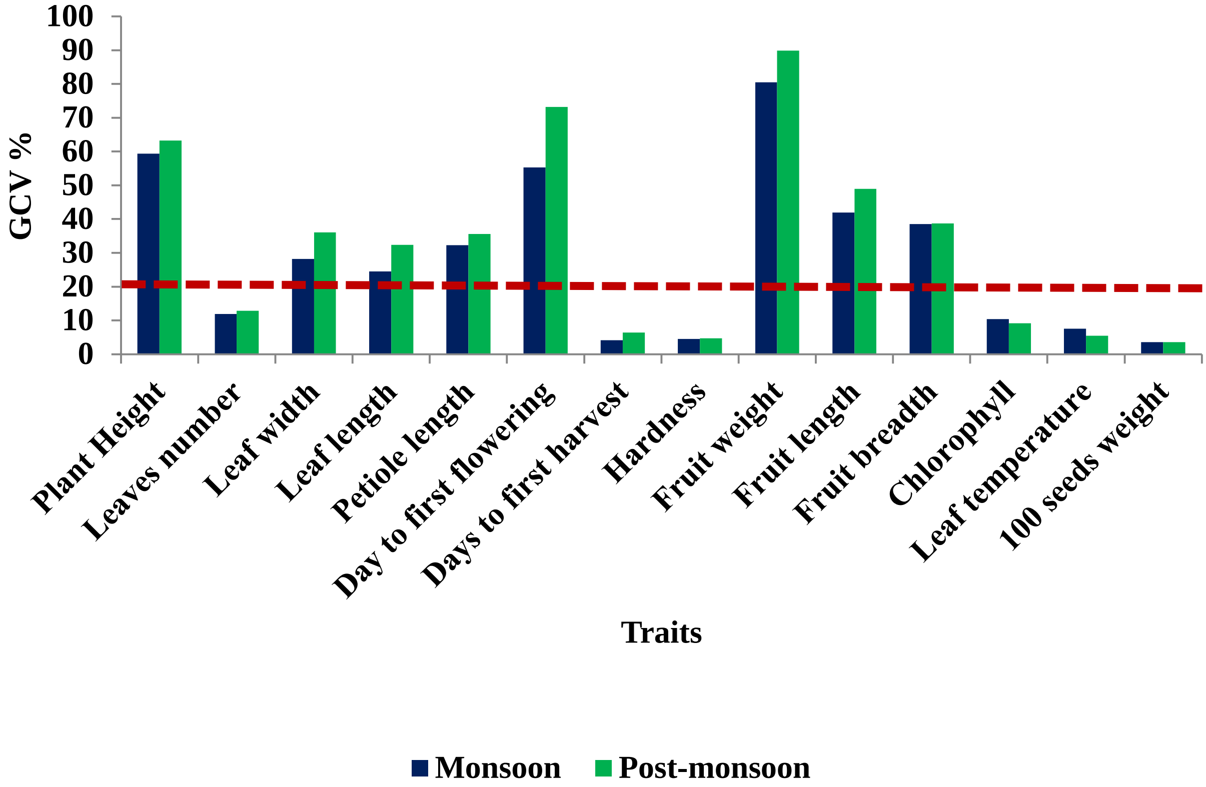
In post-monsoon season, PCV ranged from 5.37 to 93.39 % and GCV ranged from 3.56 to 89.85% for different traits. The higher PCV and GCV estimates were observed in fruit weight (93.39 & 89.85%), and followed by days to first flowering (75.32 & 73.21%), plant height (68.90 & 63.28%), fruit length (50.16 & 48.95 %), petiole length (43.81 & 35.56 %), fruit breadth (39.61 & 38.70 %), leaf width (38.09 & 36.10%), and leaf length (34.05 & 32.33 %) respectively. PCV and GCV estimates were moderate for leaves number (15.32 & 12.88 %)(Table 3.).

The above findings are in consonance with finding of Muniappan et al. (2010), where high PCV for number of branches per plant, fruit length, fruit breadth, fruits per plant, average fruit weight and fruit yield per plant in eggplant was observed. Islam and Uddin (2009) obtained high PCV for fruits per plant, individual fruit weight, and yield per plant. Singh and Kumar (2005) observed that average fruit weight showed the highest PCV closely followed by fruits per plant. The lowest values were recorded in days to flowering. Mohanty (2002) observed high to moderate PCV for the fruits per plant, yield and average fruit weight, but low for branches per plant and plant height in eggplant. High values of PCV for length and diameter of fruits, yield of fruits per plant, fruit weight were observed by Patel et al. (2004) and Behera et al. (1999).

The PCV and GCV were comparatively high (during both seasons) for fruit weight, days to first flowering, plant height, fruit length, petiole length, fruit breadth, leaf width, and leaf length. In all the cases, GCV were less than the phenotypic ones, indicating the role of environment in the expressions of the traits under observations. Characters like 100 seeds weight, leaf temperature, hardness and days to first harvest did not show any difference between PCV and GCV. However, there was narrow difference in most of the characters, which indicated low environmental influence (in both seasons) for the expression of these traits. It implies that phenotypic variability is a reliable measure of genotypic variability in this case and selection for improvement is possible and effective on the basis of phenotypic expression. The character having high genotypic coefficients of variability possessed better potential for the improvement through selection. Hence, direct selection in eggplant is possible for traits like fruit weight, fruit length, petiole length, fruit breadth, leaf width, and leaf length.




**(A)**




(B)

**Figure 5. Phenotypic (A) and Genotypic (B) coefficient of variation of 14 traits for monsoon and post-monsoon seasons**

**Heritability percent ($h^2$ %)**

In present study, high to moderate heritability estimates (>80%) were obtained for most of the characters in both the environmental conditions. In the experimental material, during monsoon and post-monsoon seasons, heritability ranged from 70.04 to 99.99 per cent for monsoon and 70.75 to 99.89 percent for post-monsoon (Table 2. & 3.). Heritability percent ($h^2$%) of 14 traits for monsoon and post-monsoon seasons was shown in figure 6.

In monsoon season, very high heritability estimates were obtained for days to first flowering (97.81%), fruit weight (97.41%), fruit length (96.13%), fruit breadth (95.46%), plant height (93.41%), leaf length (91.86%) and leaf width (91.02%) respectively. Moderately heritability (50-80%) was obtained for leaves number (65.31%), chlorophyll (61.65%), days to first harvest (54.20%) and leaf temperature (53.81%) (Table 2.).

In post-monsoon season, the traits like fruit breadth, fruit length, plant height, days to first flowering, fruit weight, leaf length and leaf width occupied the high heritability percent such as 95.46, 95.24, 93.32, 92.00, 92.57, 90.11 and 89.84 % respectively. Leaves number (70.75%), petiole length (65.89%), leaf temperature (64.71%), days to first harvest (63.71%), chlorophyll (57.52%) occupied moderately heritability percent among the traits (Table 3.). Manpreet et al. (2013), Behera et al. (1999), Prasad et al. (1999), Naik et al. (2010), Islam and Uddin (2009) and Singh and Kumar (2005) reported that the maximum heritability for fruit and vegetative traits were observed on eggplant genotypes on their experiments.

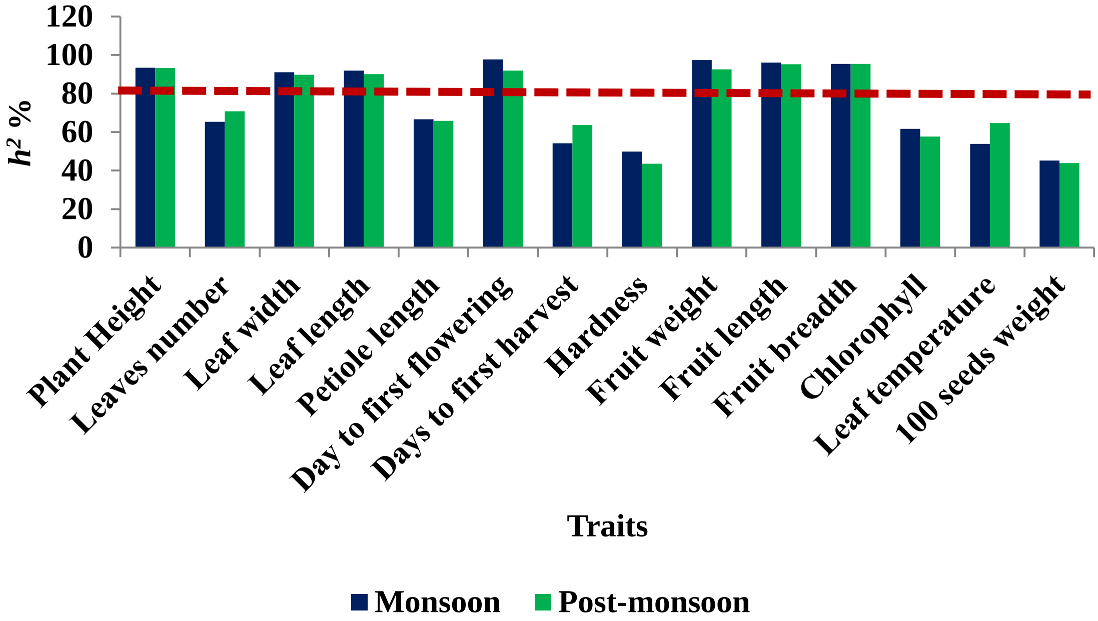



**Figure 6. Heritability percent ($h^2$%) of 14 traits for monsoon and post-monsoon seasons**

**Genetic advance percent (GA%)**

In the present study for monsoon season, the highest genetic advance was predicted for fruit weight (163.63 %), days to first flowering (96.02%), plant height (87.13%) and fruit length (84.77%) respectively. The moderate genetic advanced percent was predicted for fruit breadth (77.49%) and leaf width (55.43%) (Table 2.). Genetic advance percent (GA %) of 14 traits for monsoon and post-monsoon seasons was shown in figure 7.

The experimental material during post-monsoon season showed highest genetic advance predicted for fruit weight (178.09%), days to first flowering (98.50%), fruit length (98.40%) and plant height (83.61%). The moderate genetic advance percent was predicted for fruit breadth (77.88%), leaf width (70.49%), leaf length (63.21%) and petiole length (59.46%) (Table 3.).

Naik et al. (2010) recorded high genetic advance for fruits length, fruits per plant and total yield per plant. Islam and Uddin (2009), Singh and Kumar (2005) and Patel et al. (2004) obtained high genetic advance for fruits per plant, individual fruit weight, and yield per plant. Mohanty (2002) observed low value of genetic advance for plant height, days to first harvest and yield, whereas moderate to high genetic advance for average fruit weight, fruits per plant and branches per plant. High genetic advance for diameter and length of fruit and fruit yield was observed by Behera et al. (1999). Based upon high heritability as well as high genetic advance, it could be concluded that improvement by direct selection in eggplant was possible for the traits like fruits per plant, fruit weight, fruit yield per plant, long style flowers, medium style flowers, seeds per fruit.

The heritable variation can be estimated with greater degree of accuracy when heritability is studied along with genetic advance. A high heritability coupled with high genetic advance gives effective criterion for selection. The reason for this is that selection for a particular character is done on the basis of phenotype and the phenotype is produced by joint action of genotype and environment. Hence, the phenotypic superiority of selected plants may not be due to their superior genotype, but can be due to favorable environmental conditions that causes inflation in estimates.

In such situations genetic advance gives good idea for actual position. Burton (1953) and Johnson et al. (1955) also stressed that heritability estimates along with the knowledge of genetic gain are more useful than heritability alone in predicting the values of selection.

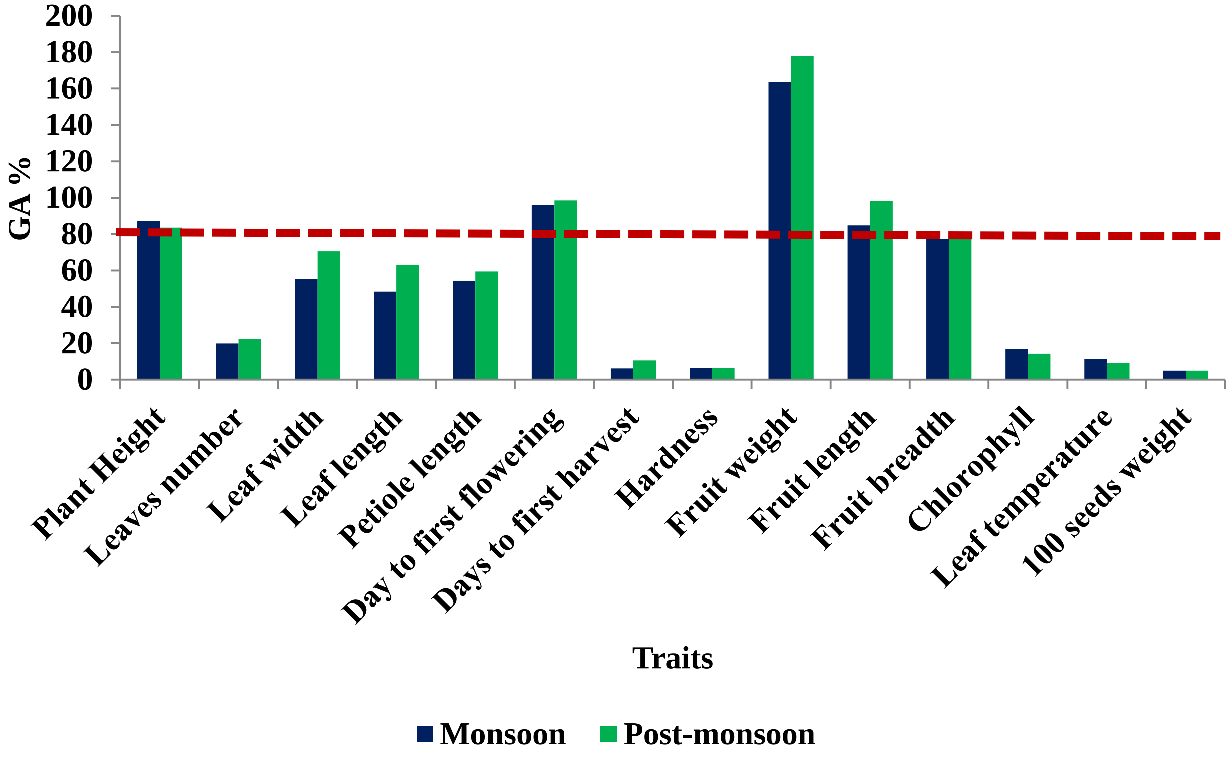



**Figure 7. Genetic advance percent (GA %) of 14 traits for monsoon and post monsoon seasons**

**Table 2. Genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability ($h^2$) and genetic advance (GA) for various traits during monsoon season**

| | $s^2_G$ | $s^2_E$ | $s^2_P$ | GM | GCV% | PCV% | $h^2$ | $h^2$% | GA | GA% |
|---|---|---|---|---|---|---|---|---|---|---|
| **Plant Height** | 266.30 | 18.77 | 285.08 | 72.57 | 59.32 | 65.32 | 0.93 | 93.41 | 63.23 | 87.13 |
| **Leaves number** | 47.20 | 25.08 | 72.28 | 57.57 | 11.94 | 14.77 | 0.65 | 65.31 | 11.44 | 19.87 |
| **Leaf width** | 9.69 | 0.96 | 10.65 | 11.04 | 28.20 | 29.56 | 0.91 | 91.02 | 6.12 | 55.43 |
| **Leaf length** | 14.47 | 1.28 | 15.75 | 15.54 | 24.48 | 25.54 | 0.92 | 91.86 | 7.51 | 48.33 |
| **Petiole length** | 2.24 | 1.12 | 3.36 | 4.63 | 32.28 | 39.55 | 0.67 | 66.63 | 2.51 | 54.29 |
| **Day to first flowering** | 183.65 | 4.12 | 187.77 | 72.20 | 55.32 | 56.32 | 0.98 | 97.81 | 69.32 | 96.02 |
| **Days to first harvest** | 17.45 | 14.74 | 32.19 | 101.45 | 4.12 | 5.59 | 0.54 | 54.20 | 6.33 | 6.24 |
| **Hardness** | 0.00 | 0.00 | 0.00 | 0.90 | 4.54 | 6.43 | 0.50 | 49.93 | 0.06 | 6.61 |
| **Fruit weight** | 6936.47 | 184.10 | 7120.57 | 103.49 | 80.48 | 81.54 | 0.97 | 97.41 | 169.34 | 163.63 |
| **Fruit length** | 17.35 | 0.70 | 18.05 | 9.93 | 41.97 | 42.81 | 0.96 | 96.13 | 8.41 | 84.77 |
| **Fruit breadth** | 2.83 | 0.13 | 2.96 | 4.37 | 38.50 | 39.41 | 0.95 | 95.46 | 3.38 | 77.49 |
| **Chlorophyll** | 19.45 | 12.10 | 31.55 | 42.35 | 10.41 | 13.26 | 0.62 | 61.65 | 7.13 | 16.84 |
| **Leaf temperature** | 4.78 | 4.10 | 8.88 | 29.11 | 7.51 | 10.23 | 0.54 | 53.81 | 3.30 | 11.34 |
| **100 seeds weight** | 0.00 | 0.00 | 0.00 | 0.29 | 3.60 | 5.36 | 0.45 | 45.22 | 0.01 | 4.99 |

**Table 3. Genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability ($h^2$) and genetic advance (GA) for various traits during post- monsoon season**

| | $s^2_G$ | $s^2_E$ | $s^2_P$ | GM | GCV% | PCV% | $h^2$ | $h^2$% | GA | GA% |
|---|---|---|---|---|---|---|---|---|---|---|
| **Plant Height** | 168.70 | 33.21 | 180.77 | 67.36 | 63.28 | 68.90 | 0.93 | 93.32 | 56.32 | 83.61 |
| **Leaves number** | 51.71 | 61.13 | 73.08 | 55.82 | 12.88 | 15.32 | 0.71 | 70.75 | 12.46 | 22.32 |
| **Leaf width** | 8.40 | -0.15 | 9.35 | 8.03 | 36.10 | 38.09 | 0.90 | 89.84 | 5.66 | 70.49 |
| **Leaf length** | 11.69 | 0.85 | 12.97 | 10.58 | 32.33 | 34.05 | 0.90 | 90.11 | 6.69 | 63.21 |
| **Petiole length** | 2.16 | 0.35 | 3.27 | 4.13 | 35.56 | 43.81 | 0.66 | 65.89 | 2.46 | 59.46 |
| **Day to first flowering** | 173.67 | 42.32 | 188.77 | 60.22 | 73.21 | 75.32 | 0.92 | 92.00 | 59.32 | 98.50 |
| **Days to first harvest** | 30.61 | 49.30 | 48.05 | 86.61 | 6.39 | 8.00 | 0.64 | 63.71 | 9.10 | 10.50 |
| **Hardness** | 0.00 | -2.99 | 0.00 | 0.84 | 4.66 | 7.05 | 0.44 | 43.59 | 0.05 | 6.33 |
| **Fruit weight** | 5052.21 | 1212.67 | 5457.43 | 79.11 | 89.85 | 93.39 | 0.93 | 92.57 | 140.88 | 178.09 |
| **Fruit length** | 13.94 | -0.91 | 14.64 | 7.63 | 48.95 | 50.16 | 0.95 | 95.24 | 7.51 | 98.40 |
| **Fruit breadth** | 2.83 | -2.60 | 2.96 | 4.35 | 38.70 | 39.61 | 0.95 | 95.46 | 3.38 | 77.88 |
| **Chlorophyll** | 16.52 | 33.30 | 28.62 | 44.40 | 9.15 | 12.05 | 0.58 | 57.72 | 6.36 | 14.33 |
| **Leaf temperature** | 3.28 | 2.36 | 5.06 | 32.96 | 5.49 | 6.83 | 0.65 | 64.71 | 3.00 | 9.10 |
| **100 seeds weight** | 0.00 | -3.00 | 0.00 | 0.29 | 3.56 | 5.37 | 0.44 | 43.92 | 0.01 | 4.86 |

**Phenotypic and genotypic correlation coefficients (PCC & GCC)**

The values for the genotypic correlations were greater or of equal magnitude to the phenotypic correlations (Table 4. & 5.), indicating that the relationship between the variables depends on additive genetic factors present in the study material, and not on the existence of environmental effects, which is in accordance with the findings of Martínez & Torregroza (1988), Yadav et al. (1997), Leggese et al. (1999), Ferreira et al. (2003), Espitia et al. (2005, 2008a, 2008b), with coincidence between coefficient pairs. These results can be explained by the reduction in experimental error in the Analysis of Variance, as when this is close to a value of zero (0), both the phenotypic and the genotypic correlations tend to be identical (Legesse et al., 1999).

In monsoon season, plant height is significantly positive correlated with leaves number, leaf width, chlorophyll content of leaf, leaf length and petiole length for genotypic and phenotypic coefficient correlation. Leaves number is positively correlated with chlorophyll content of leaf and leaf width is also correlated with leaf length. Petiole length is positively correlated with leaf width and leaf length. Days to first flowering is positively correlated with days to first harvest and leaf temperature and negatively correlated with leaf width and leaf length. Days to first harvest is positively correlated with fruit weight and fruit hardness is negatively correlated with fruit length. Fruit weight is positively correlated with fruit breadth and 100 seeds weight for genotypic and phenotypic coefficient correlation (Table 4.).

In post-monsoon season, plant height is positively correlated with leaves number, leaf width, leaf length and chlorophyll content of leaf for both coefficient correlations. Also leaves number is highly correlated with chlorophyll content of leaf and leaf width is correlated with leaf length and petiole length. Days to first flowering is positively correlated days to first harvest. Days to first harvest is highly correlated with fruit weight. And fruit hardness is negatively correlated with leaf width, leaf length, fruit length and leaf temperature and positively correlated with leaves number. Fruit weight is correlated with fruit breadth and 100 seeds weight. Fruit breadth is also correlated with 100 seeds weight and leaf temperature is negatively correlated with fruit hardness for genotypic and phenotypic coefficient correlations (Table 5.).

The phenotypic and genetic coefficients of correlation between plant height and measured characters, as well as the associations between these, indicate that plant height is not correlated with fruit length, fruit weight, fruit breadth. However, it was revealed that there was a positive and highly significant correlation with respect to the number of leaves, leaf width and leaf length. Kruiteva (1985) did not find a correlation between yield and plant height, nor fruit length, but a correlation was found between the number of fruits and the fruit weight, in agreement with Damnjanovic et al. (2002) and Rodríguez et al. (2008), due to the high heritability that these two variable possess, being little affected by the environment nor additive genetic variation. Ingale and Patil (1995), Bansal and Metha (2008), and Lohakare et al. (2008) found a positive correlation between yield and the number of fruits, and the absence of a correlation with fruit weight. Gutiérrez del Río et al. (2004) and Zorzoli et al. (2000) found that the correlation between yield and fruit weight in eggplant varied as a function of the size of the fruits of the evaluated genotypes. The results of the present study indicate that the improvement of fruit yield of eggplant cultivars may be obtained through increasing the fruit weight, length, breadth and plant height. Vadivel and Bapu (1988a, 1988b, 1989a) considered the number of productive branches as an important trait in yield breeding programs, as it possesses a high coheritability and moderate heritability, allowing genetic advances due to the predominance of additive genetic action.

Since in most cases genotypic correlation coefficients are higher than phenotypic correlation coefficients, it can be concluded that the environment effects had moderated correlation between the two traits. A positive significant phenotypic and genotypic correlation was observed between grain yield and grain number per spike. This correlation was also reported by other researchers such as Doting and Knight, 1992; Ehdaie and Waines, 1989; Saed-Moucheshi et al., 2013a and Garcia del Moral et al., 1991. Spike number per square meter had a high positive significant correlation with grain yield. These results were reported in barley and wheat, Darwinkel et al.(1982) and Nerson (1980).

**Table 4. Genotypic coefficient correlation (GCC) and phenotypic coefficient correlation (PCC) for various traits during monsoon season**

| | PH | Lno. | LWdt | LLt. | PetL | DFF | DFH | Hard | Fwt | FLt | FBdt | Chl | Ltemp. | 100SWt. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PH** | 1.00 | 0.47*** | 0.49*** | 0.38** | 0.36** | 0.00 | 0.03 | -0.12 | 0.04 | 0.14 | 0.00 | 0.50*** | 0.00 | 0.13 |
| **Lno.** | 0.39** | 1.00 | -0.05 | -0.04 | -0.09 | -0.21 | -0.42 | 0.38** | -0.17 | -0.28* | -0.17 | 0.66*** | -0.26 | 0.02 |
| **LWdt** | 0.40** | -0.04 | 1.00 | 0.92*** | 0.78*** | -0.27* | 0.15 | -0.29* | 0.15 | 0.21 | 0.11 | 0.07 | -0.25 | 0.33** |
| **LLt.** | 0.33** | -0.02 | 0.88*** | 1.00 | 0.68*** | -0.33** | 0.02 | -0.31* | 0.13 | 0.19 | 0.07 | 0.07 | -0.30* | 0.38** |
| **PetL** | 0.29* | -0.04 | 0.71 | 0.66*** | 1.00 | -0.09 | 0.15 | -0.26 | -0.05 | 0.22 | -0.13 | 0.08 | -0.20 | 0.06 |
| **DFF** | 0.00 | -0.14 | -0.24 | -0.29 | -0.07 | 1.00 | 0.50*** | 0.00 | 0.00 | 0.28* | -0.06 | 0.14 | 0.46*** | -0.33** |
| **DFH** | 0.04 | -0.28* | 0.14 | 0.02 | 0.13 | 0.49*** | 1.00 | -0.20 | 0.50*** | 0.29* | 0.37** | 0.04 | 0.29* | 0.31* |
| **Hard** | -0.08 | 0.24 | -0.17 | -0.20 | -0.13 | 0.00 | -0.18 | 1.00 | -0.14 | -0.50*** | 0.01 | 0.18 | -0.33** | -0.22 |
| **Fwt** | 0.04 | -0.10 | 0.13 | 0.11 | -0.05 | 0.00 | 0.49*** | -0.12 | 1.00 | 0.35** | 0.87*** | 0.08 | 0.23 | 0.53*** |
| **FLt** | 0.15 | -0.17 | 0.16 | 0.15 | 0.15 | 0.26 | 0.28* | -0.41*** | 0.34 | 1.00 | -0.02 | 0.14 | 0.35** | 0.03 |
| **FBdt** | 0.02 | -0.07 | 0.09 | 0.04 | -0.11 | -0.06 | 0.36** | -0.02 | 0.81*** | 0.05 | 1.00 | -0.02 | 0.15 | 0.58*** |
| **Chl** | 0.41*** | 0.43*** | 0.09 | 0.08 | 0.04 | 0.11 | 0.03 | 0.06 | 0.06 | 0.10 | -0.01 | 1.00 | 0.07 | 0.07 |
| **Ltemp.** | -0.01 | -0.18 | -0.21 | -0.27* | -0.18 | 0.43*** | 0.26 | -0.25 | 0.21 | 0.29* | 0.14 | 0.07 | 1.00 | -0.06 |
| **100SWt.** | 0.10 | 0.02 | 0.29* | 0.33 | 0.04 | -0.31 | 0.29* | -0.17 | 0.49*** | 0.02 | 0.50*** | 0.09 | -0.10 | 1.00 |

*** significant at 1%, * significant at 5%, ns non-significant**

**PH=Plant height, Lno.=Leaves number, LWdt=Leaf weight, LLt.=Leaf length, PetL,=Petiole length, DFF=Days to first flowering, DFH=Days to first harvest, Hard=Hardness of fruit, Fwt.=Fruit weight, FLt=Fruit length, FBdt.=Fruit breadth, Chl=Chlorophyll content of leaf, Ltemp=Leaf temperature, 100SWt.=One hundred seeds weight**

**Table 5. Genotypic coefficient correlation (GCC) and phenotypic coefficient correlation (PCC) for various traits during post-monsoon season**

| | PH | Lno. | LWdt | LLt. | PetL | DFF | DFH | Hard | Fwt | FLt | FBdt | Chl | Ltemp. | 100SWt. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PH** | 1.00 | 0.49*** | 0.51*** | 0.40** | 0.30* | 0.11 | 0.11 | -0.07 | 0.04 | 0.16 | 0.01 | 0.54*** | 0.00 | 0.10 |
| **Lno.** | 0.40** | 1.00 | -0.05 | -0.03 | -0.16 | -0.09 | -0.27* | 0.41*** | -0.17 | -0.18 | -0.17 | 0.70*** | -0.39** | 0.01 |
| **LWdt** | 0.41** | -0.03 | 1.00 | 0.91*** | 0.83*** | -0.17 | 0.09 | -0.32** | 0.21 | 0.25 | 0.13 | 0.17 | 0.02 | 0.28* |
| **LLt.** | 0.34** | -0.01 | 0.87*** | 1.00 | 0.73*** | -0.20 | -0.04 | -0.36** | 0.20 | 0.24 | 0.11 | 0.19 | 0.02 | 0.34** |
| **PetL** | 0.28* | -0.10 | 0.71*** | 0.63*** | 1.00 | -0.12 | 0.04 | -0.24 | -0.02 | 0.18 | -0.12 | 0.07 | -0.09 | 0.06 |
| **DFF** | 0.10 | -0.06 | -0.14 | -0.17 | -0.11 | 1.00 | 0.71*** | 0.18 | 0.03 | 0.32** | -0.01 | 0.19 | 0.13 | -0.28* |
| **DFH** | 0.10 | -0.18 | 0.08 | -0.03 | 0.04 | 0.71*** | 1.00 | -0.01 | 0.46*** | 0.32** | 0.35** | 0.14 | 0.25 | 0.19 |
| **Hard** | -0.04 | 0.26 | -0.19 | -0.24 | -0.17 | 0.16 | -0.02 | 1.00 | -0.13 | -0.34** | 0.03 | 0.26 | -0.45*** | -0.25 |
| **Fwt** | 0.03 | -0.11 | 0.17 | 0.17 | -0.03 | 0.03 | 0.46*** | -0.11 | 1.00 | 0.32** | 0.87*** | 0.02 | 0.19 | 0.60*** |
| **FLt** | 0.16 | -0.11 | 0.18 | 0.18 | 0.14 | 0.30* | 0.31* | -0.28* | 0.30* | 1.00 | -0.05 | 0.14 | 0.21 | 0.03 |
| **FBdt** | 0.03 | -0.07 | 0.10 | 0.07 | -0.10 | -0.01 | 0.34** | 0.00 | 0.82*** | 0.04 | 1.00 | -0.06 | 0.16 | 0.59*** |
| **Chl** | 0.45*** | 0.46*** | 0.16 | 0.17 | 0.04 | 0.15 | 0.11 | 0.13 | 0.01 | 0.11 | -0.03 | 1.00 | -0.25 | 0.05 |
| **Ltemp.** | -0.02 | -0.29* | -0.01 | -0.03 | -0.06 | 0.12 | 0.21 | -0.32** | 0.17 | 0.16 | 0.13 | -0.15 | 1.00 | 0.12 |
| **100SWt.** | 0.08 | 0.02 | 0.25 | 0.29* | 0.03 | -0.26 | 0.18 | -0.20 | 0.56*** | 0.03 | 0.51*** | 0.08 | 0.04 | 1.00 |

*** significant at 1%, * significant at 5%, $^{ns}$ non-significant**

**PH=Plant height, Lno.=Leaves number, LWdt=Leaf weight, LLt.=Leaf length, PetL,=Petiole length, DFF=Days to first flowering, DFH=Days to first harvest, Hard=Hardness of fruit, Fwt.=Fruit weight, FLt=Fruit length, FBdt.=Fruit breadth, Chl=Chlorophyll content of leaf, Ltemp=Leaf temperature, 100SWt.=One hundred seeds weight**

## CONCLUSION

The PCV and GCV were high (during both seasons) for traits like fruit weight, plant height, days to first flowering, fruit length, petiole length, fruit breadth, leaf width and leaf length. The GCV for all the traits was less than PCV indicated the role of environment in expressions of traits under observation. The high values of GCV and GA were exhibited by fruit weight, days to first flowering, plant height, fruit length and fruit breadth during both the seasons. Hence, these traits have high potential for improvement through selection. Heritability and genetic advance were also high for all these traits indicating the possibility of selection to improve these characters. Hence, it could be concluded that improvement by direct selection in eggplant was possible for the traits like fruit weight, days to first flowering, plant height, fruit length and fruit breadth. The traits like the fruit weight, days to first flowering and plant height in the yield component with greatest importance in genetic improvement in eggplant.

The traits like fruit weight, days to first flowering and plant height and their positively correlation traits were emphasized on future breeding program. The existence of a significant negative correlation between days to first flowering and fruit hardness with leaf traits and fruit length suggests the existence of a physiological limit among these traits. The genetic components of the correlations were more important than the environmental, as the phenotype is a reflection of the genotype. The fruit weight and days to first flowering and plant height in the yield component with greatest importance in genetic improvement in eggplant.

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