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# Studies on genetic variability, heritability, genetic advanceand path coefficient analysis for genetic improvement in glory lily (*Gloriosa superba* L.) genotypes

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**Abstract**
An experiment was carried out on glory lily genotypes to study the genetic variability, and relationship among yield traits. Analysis of variance showed that the genotypes significantly differed for all the growth and yield parameters studied. From the variability analysis, it is found that all the traits have higher phenotypic coefficient of variation than the genotypic coefficient of variation. High heritability has plant height, stem girth, number of leaves/plant, leaf length, leaf width, number of branches/ plant, days to flowering, days to 50% flowering, number of flowers/plant, petiole length, fresh pod weight, dry seed weight, pod diameter, number of pods/ plant, fresh pod yield/plant, fresh seed yield/plant, pod setting percentage, fresh seed recovery, dry seed recovery, 100 fresh seed weight, 100 dry seed weight and dry seed yield per plant. Path coefficient analysis revealed that the fresh seed yield/plant, fresh pod weight and leaf length, husk weight, fresh pod yield/plant, pod setting percentage, fresh seed recovery, dry seed recovery, number of branches per plant, leaf width, pod diameter, number of pods per plant are the most important characters for selection and selection based on these traits would be more rewarding for improvement of glory lily. Hence selection for these morphological traits can be useful for yield improvement in glory lily.

**Keywords:** Glory lily, genetic variability, genotypic coefficient of variation, phenotypic coefficient of variation, heritability, genetic advance, path coefficient analysis

**Abbreviations:** PH- Plant height (cm); SG-Stem girth (cm); NLP- Number of leaves /plant; LL-leaf length (cm); LW-leaf width (cm); NBP- Number of branches/plant; DF- Days to flowering; D50%- days to 50% flowering; PL-Pedicel length (cm); DPM- Days to pod maturity; NPP- number of pods/plant; PL-Pod length (cm); PD- Pod diameter (cm); PSP- Pod setting percentage; FPYP- Fresh pod yield/plant (g); FPW- fresh pod weight (g);NSP- Number of seeds/pod; SD- Seed diameter (mm); FSWP- Fresh seed weight/pod (g);FSR- Fresh seed recovery (%); HFW- One hundred fresh seed weight (g); DSWP- Dry seed weight/ pod (g); HDW- One hundred dry seed weight (g); DSR- Dry seed recovery (%); DSYP- dry seed yield/plant (g); SHR-Seed husk ratio (g), DAS- Days after sowing.

## Introduction

Glory lily (*Gloriosa superba* L.), a high value medicinal crop, is a member of the Colchicaceae family, which is native to Africa and Southeast Asia. It is a perennial herbaceous climber that can reach a height of 3.5 to 6.0 meters (Patel *et al.*, 2020) [12]. It is one among India's most important medicinal herb, and its seeds are sold to developed countries. Colchicine and Col Chico side are two important alkaloids present in the seeds and tubers that are used to cure gout and rheumatism. Colchicine has been recognized as a potential anti-cancer drug due to its effect on spindle fibre development during cell division. Gloriosa tuber extracts are used for various ailments and has anti-toxic effects against snake bites (Gupta *et al.*, 2005) [7]. Leaf extracts contain superbine and gloriosine which has a bitter property which helps in preventing hair lice. They can be used in minimum concentrations as tonics for anti-abortive and cathartic medication. Because it contains purines, it is also used to treat gout. For parasitic skin diseases tuber is applied externally. It is suitable to grow under different climatic conditions and soil types. The plant grows in sandy-loam soil (Farooqui and Khan, 1991) [6]. Glory lily has low genetic variability due to continued vegetative propagation through tubers, which has low vigour and resistance to biotic and abiotic stress, resulting in low yields (Rajadurai, 2001) [13]. Gloriosa has a wide natural distribution, but due to over-exploitation of its tubers and poor seed germination, the species has become endangered (Mahajan *et al.*,

2016) [9]. Its demand in market is creating a bigger scope for crop improvement programes. The main objective of this study is to evaluate the genotypes for morpho -economic traits in order to understand the various component characters contributing for seed yield in *Gloriosa superba*.

## Materials and Methods

The experimental material consisted of eight genotypes collected from different places. The details of the genotypes are presented in Table 1. The experimental plot was situated at the Department of Medicinal and Aromatic crops, Botanical Garden, Tamil Nadu Agricultural University, Coimbatore during 2021-2022. The experiment was conducted in a randomized block design with three replications. Following the recommended agronomical practices, five randomly selected plants from each of the genotypes in each replication were tagged for recording the observations on plant height (cm), stem girth (cm), number of leaves /plant, leaf length (cm), leaf width (cm), number of branches/plant, days to flowering, days to 50% flowering, pedicel length (cm), days to pod maturity, number of pods/plant, pod length (cm), pod diameter (cm), pod setting percentage, fresh pod yield/plant (g), fresh pod weight (g), number of seeds/pod, seed diameter (mm), fresh seed weight/pod (g), fresh seed recovery (%), one hundred fresh seed weight (g), dry seed weight/ pod (g), one hundred dry seed weight (g), dry seed recovery (%), dry seed yield/plant (g), seed husk yield (g). The statistical parameters such as mean, standard error and critical difference for all the observations were assessed by adopting standard techniques, (Panse and Sukhatme, 1978) [11]. Genetic variability estimation, correlation and path analysis were done using the statistical packaging TNAUSTAT.

## Results and Discussion

Eight genotypes of glory lily were evaluated for growth and yield characters during the year 2021-2022. The genetic variability parameters such as mean, range, genotypic, and phenotypic coefficient of variation are presented in Table 2. ANOVA revealed significant differences across genotypes for all the traits studied. Range of mean values and coefficient of variation for the 28 traits, evaluated in eight genotypes is presented in (Table2). The mean performance of genotypes helps in identifying superior progenies (Monope *et al.*, 1973) [10]. Based on the mean performance for all the morphological characters (Table 2), it is observed that Gsu-1 was superior to other genotypes, recording higher mean values for plant height (cm), stem girth (cm), number of leaves/plant, leaf length(cm), leaf width(cm), number of branches, number of flowers/plant, fresh pod weight (g), number of seeds/ pod, fresh seed weight (g), dry seed weight (g), pod length (cm), pod diameter (cm), number of pods, fresh pod yield (g), fresh seed yield (g), fresh seed recovery (%), dry seed recovery (%) and dry seed yield (g) followed by Gsu-5. Early flowering was observed in Gsu-6and Gsu-5 (34 DAS). Late flowering was observed in Gsu-3 followed by Gsu-1 and Gsu-7 (47 DAS). Days taken for pod maturity was lower in Gsu-6 (125 DAS) and Gsu-3 (147 DAS) was a long duration genotype.

For all the traits evaluated, analysis of variance revealed extremely significant differences amongst genotypes. When genotypes have the largest mean and variability, selection will be successful (Allard, 1960). Environmental factors are responsible for the variation observed between genotypic and phenotypic variance (Ram and Singh, 1993). Previous studies have reported higher PCV % to that of GCV% for both morphological and yield characters. (Selvarasu and Kandhasamy, 2017) [16].

In the present study also, the phenotypic coefficient of variation was larger than the genotypic coefficient of variation for all the traits studied. A close range of variation between PCV and GCV was observed for characters such as plant height, stem girth, number of leaves/ plant, leaf length, number of branches per plant, days to flowering, days to 50% flowering, number of flowers/plant, pedicel length, fresh pod weight, pod length, pod diameter, number of pods/ plant, fresh pod yield/plant, fresh seed yield/plant, dry seed recovery and dry seed yield/plant which indicates that there is lower effect of environment over the genotypes for these traits, thus selection of such traits would be promising. Some of the characters such as stem girth, leaf width, days to pod maturity, seed diameter, fresh seed weight, dry seed weight, husk weight, pod length, pod diameter and 100 fresh seed weight were highly influenced by environment as the variation between genotypic co-efficient of variation and phenotypic co-efficient of variation was high. Hence selection made with such traits may not be effective and indicated that there is limited scope for improvement. These findings are in confirmation with the findings of Rajagopal and Kandhasamy (2009) [14] in glory lily.

Heritability is the proportion of total variability that is due to genetic cause or can be defined as the ratio of genotypic variance to the total variance. It is a way to assess the heritable characters from the parents to offspring (Falconer, 1960) [5]. High heritability has plant height, stem girth, number of leaves/plant, leaf length, leaf width, number of branches/ plant, days to flowering, days to 50% flowering, number of flowers/plant, petiole length, fresh pod weight, dry seed weight, pod diameter, number of pods/ plant, fresh pod yield/plant, fresh seed yield/plant, pod setting percentage, fresh seed recovery, dry seed recovery, 100 fresh seed weight, 100 dry seed weight and dry seed yield per plant. It indicates that improvement of these characters would be effective through phenotypic selection due to additive gene action.

Genetic advance is the genetic gain in the selected progenies, it shows the difference among the mean genotypic value of selected lines and the parental population (Johnson *et al.*, 1955) [8]. Assessment of heritability when coupled with genetic advance is more useful in estimating the improvement under selection (Johnson *et al*., 1955) [8].

In the present study high heritability coupled with high genetic advance was observed for traits *viz*., plant height, stem girth, number of leaves per plant, leaf length, leaf width, number of branches per plant, number of flower per plant, fresh pod weight, number of seeds per pod, fresh seed weight, dry seed weight, number of pods/plant, fresh pod yield/plant, fresh seed yield/plant, pod setting percentage, 100 fresh seed weight, 100 dry seed weight and dry seed yield per plant. Our results indicate that additive genes govern such characters and they can be better utilized in breeding programs and the selection may be effective. Wright (1921) [17]. Trait such as days to flowering, days to 50% flowering, petiole length, pod diameter and dry seed recovery recorded high heritability and limited genetic advance which shows non additive gene action and selection for such traits may not be rewarding (Panse and Sukhatme, 1978) [11]. These results are in contrast with the previous study done by Selvarasu and Kandhasamy (2017) [16] where in additive gene actions were observed for different characters and low heritability coupled with low genetic advance was recorded for days to pod maturity and seed diameter, indicating that these characters are highly influenced by environment and selection would be ineffective. Thus, the present study reveals the significance of various characters evaluated and their breeding value for crop improvement.

Genotypic correlation among different traits is presented in (table 3). Dry seed yield /plant showed a highly significant and positive genotypic correlation in the plant height, stem girth, days to 50% flowering, fresh pod weight, fresh seed weight, dry seed weight, husk weight, number of pods per plant, fresh pod yield/plant, fresh seed recovery, 100 fresh seed weight and dry seed recovery. Number of leaves/plant, leaf length, leaf width, number of branches per plant, days to flowering, petiole length, days to pod maturity, seed diameter, pod length, pod diameter, pod setting percentage and 100 dry seed weight had a non-significant positive correlation with dry seed yield/plant and these reports are in agreement with the findings of Chitra *et al.*, (2009).

Path coefficient analysis was out for different traits using the genotypic correlation coefficient and taking dry seed yield/plant as a dependent variable. The highest positive direct effect on dry seed yield was shown by the fresh seed yield/plant, fresh pod weight and leaf length, husk weight, fresh pod yield/plant, pod setting percentage, fresh seed recovery, dry seed recovery, number of branches per plant, leaf width, pod diameter, number of pods per plant and plant height, stem girth, number of leaves per plant, days to flowering, days to 50% flowering, number of flowers/plant, petiole length, days to pod maturity, seed diameter, fresh seed weight, dry seed weight, pod length, 100 fresh seed weight and 100 dry seed weight had a negative direct effect on dry seed yield. Thus, the path coefficient analysis revealed that the fresh seed yield/plant, fresh pod weight and leaf length, husk weight, fresh pod yield/plant, pod setting percentage, fresh seed recovery, dry seed recovery, number of branches per plant, leaf width, pod diameter, number of pods per plant the most important characters for selection and selection based on these traits would be more rewarding for improvement of glory lily as evidenced by Anandhi *et al.* (2013) [2].

Based on the results of present investigation, it is concluded that a wide range of variability is found among the genotypes for all the characters studied revealing that considerable scope exists for the improvement of glory lily genotypes through selection. Genetic parameters in association with genetic variability, correlation and path analysis study shows that while selecting for elite genotypes, primary importance should be given on the number of branches/ plant, fresh pod weight, number of seeds/pod, pod diameter, number of pods/plant, fresh pod yield/plant, fresh seed yield/plant, pod setting percentage and dry seed recovery.

**Table 1:** Genotype details of *Gloriosa superba*

| Name of germplasm | Accessions |
|---|---|
| Vetharanyam | Gsu 1 |
| Maharashtra large | Gsu 2 |
| Maharashtra small | Gsu 3 |
| Sathyamangalam | Gsu 4 |
| Andra local | Gsu 5 |
| Kallimanthayam | Gsu 6 |
| Thenkasi | Gsu 7 |
| Aruppukottai | Gsu 8 |

**Table 2:** Genetic variability parameters for different characters of Glory lily genotypes

| Character | Mean | Maximum | minimum | PCV% | GCV% | Heritability (%) | Genetic advance as % mean |
|---|---|---|---|---|---|---|---|
| Plant height | 146.3 | 178.6 | 103.0 | 21.14 | 20.66 | 95.50 | 41.59 |
| Stem girth | 1.81 | 2.43 | 1.37 | 22.03 | 19.91 | 81.70 | 37.08 |
| Number of leaves / plant | 138.3 | 176.7 | 97.0 | 24.22 | 23.48 | 94.06 | 46.92 |
| Leaf length | 13.66 | 16.89 | 10.00 | 19.49 | 18.64 | 91.53 | 36.74 |
| Leaf width | 2.47 | 3.17 | 1.67 | 22.02 | 17.94 | 66.38 | 30.11 |
| Number of branches/plant | 7.7 | 11.3 | 5.3 | 32.11 | 30.71 | 91.45 | 60.49 |
| Days to flowering | 42.0 | 47.3 | 34.0 | 13.87 | 12.93 | 86.89 | 24.82 |
| Days to 50% flowering | 32.1 | 38.0 | 26.3 | 14.45 | 12.92 | 79.90 | 23.79 |
| Number of flowers /plant | 27.92 | 43.00 | 14.00 | 34.32 | 33.98 | 98.00 | 69.29 |
| Petiole length | 12.33 | 13.43 | 10.77 | 7.99 | 6.88 | 74.25 | 12.22 |
| Days to pod maturity | 139.8 | 147.3 | 125.0 | 7.28 | 2.87 | 15.57 | 2.34 |
| Fresh pod weight | 8.9 | 11.8 | 7.0 | 19.72 | 17.59 | 79.50 | 32.30 |
| Number of seeds /pod | 43.29 | 72.33 | 16.33 | 40.63 | 39.88 | 96.31 | 80.62 |
| Seed diameter | 3.67 | 4.69 | 3.29 | 16.51 | 10.49 | 40.34 | 13.72 |
| Fresh seed weight | 5.82 | 7.90 | 3.46 | 27.67 | 20.36 | 54.15 | 30.87 |
| Dry seed weight | 1.35 | 1.89 | 1.02 | 22.75 | 20.27 | 79.38 | 37.20 |
| Husk weight | 3.35 | 4.11 | 2.55 | 18.59 | 14.26 | 58.78 | 22.52 |
| Pod length | 7.1 | 7.8 | 5.8 | 11.16 | 8.19 | 53.86 | 12.38 |
| Pod diameter | 6.24 | 6.97 | 5.33 | 10.86 | 8.51 | 61.40 | 13.74 |
| Number of pods/plant | 19.8 | 35.0 | 9.3 | 46.28 | 45.49 | 96.62 | 92.12 |
| Fresh pod yield/plant | 110.77 | 138.40 | 74.24 | 21.91 | 21.33 | 94.78 | 42.77 |
| Fresh seed yield/ plant | 72.75 | 120.03 | 41.06 | 38.21 | 38.05 | 99.16 | 78.06 |
| Pod setting percentage | 68.22 | 84.67 | 55.62 | 17.51 | 16.90 | 93.19 | 33.61 |
| Fresh seed recovery | 64.10 | 86.86 | 52.26 | 19.85 | 19.27 | 94.21 | 38.52 |
| Dry seed recovery | 26.99 | 35.32 | 23.64 | 15.59 | 13.83 | 78.68 | 25.27 |
| 100 fresh seed weight | 11.62 | 15.96 | 9.13 | 22.89 | 18.76 | 67.15 | 31.66 |
| 100 dry seed weight | 2.2 | 3.6 | 1.0 | 36.83 | 34.38 | 87.14 | 66.12 |
| Dry seed yield/ plant | 20.50 | 42.44 | 9.71 | 54.40 | 53.59 | 97.04 | 108.75 |

**Table 3:** Genotypic path analysis with dependent variable

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PH** | **-0.0038** | **-0.0587** | **-0.0415** | **0.1398** | **0.0332** | **0.0581** | **0.0223** | **0.0054** | **-0.4711** | **0.0052** | **0.0247** | **0.2823** | **0.0383** | **-0.0258** | **-0.0504** | **-0.0739** | **-0.0005** | **-0.0479** | **0.0579** | **0.0118** | **0.1234** | **0.5373** | **0.0306** | **0.0469** | **0.1074** | **-0.0073** | **-0.0079** | **0.7358** |
| SG | -0.0035 | -0.0636 | -0.0408 | 0.1792 | 0.0602 | 0.0675 | 0.0104 | 0.0039 | -0.5318 | 0.0196 | 0.0093 | 0.2988 | 0.0483 | -0.0291 | -0.054 | -0.0938 | 0.0284 | -0.0564 | 0.0848 | 0.0148 | 0.1132 | 0.5981 | 0.0498 | 0.0612 | 0.1461 | -0.0076 | -0.0036 | 0.9094 |
| NLP | -0.0036 | -0.0604 | -0.043 | 0.1627 | 0.0445 | 0.0625 | 0.0207 | 0.0051 | -0.4938 | -0.0035 | 0.0239 | 0.2836 | 0.0376 | -0.0107 | -0.0486 | -0.0765 | -0.0071 | -0.0476 | 0.0635 | 0.0126 | 0.1191 | 0.5605 | 0.033 | 0.0529 | 0.1222 | -0.0056 | -0.0061 | 0.7977 |
| LL | -0.0021 | -0.0463 | -0.0284 | 0.2461 | 0.0758 | 0.0423 | 0.004 | 0.0015 | -0.4431 | -0.0593 | 0.0091 | 0.148 | 0.0283 | 0.0521 | -0.0396 | -0.0657 | 0.0157 | -0.0532 | 0.0467 | 0.0131 | 0.09 | 0.4386 | 0.051 | 0.0409 | 0.1258 | -0.0041 | 0.0085 | 0.6956 |
| LW | -0.0015 | -0.0472 | -0.0236 | 0.2295 | 0.0812 | 0.0442 | -0.0106 | -0.0008 | -0.4506 | 0.0273 | -0.0135 | 0.1512 | 0.0235 | -0.0158 | -0.0362 | -0.0731 | 0.0258 | -0.0135 | 0.0963 | 0.013 | 0.0725 | 0.4294 | 0.0433 | 0.0472 | 0.1226 | -0.0067 | -0.01 | 0.704 |
| NBP | -0.0033 | -0.0656 | -0.0411 | 0.1589 | 0.0549 | 0.0655 | 0.0149 | 0.0043 | -0.489 | 0.0178 | 0.0079 | 0.2885 | 0.0467 | -0.0038 | -0.0502 | -0.0767 | -0.0167 | -0.0507 | 0.0725 | 0.014 | 0.1054 | 0.5832 | 0.048 | 0.062 | 0.1342 | -0.0061 | -0.0008 | 0.8748 |
| DF | 0.0022 | 0.0171 | 0.0229 | -0.0252 | 0.0221 | -0.0251 | -0.0388 | -0.0069 | 0.0612 | 0.049 | -0.0269 | -0.0162 | -0.0101 | -0.0491 | 0.0033 | -0.0241 | 0.159 | 0.0272 | 0.0113 | -0.0021 | -0.055 | -0.1895 | -0.0087 | -0.0146 | 0.009 | -0.0041 | -0.01 | -0.1221 |
| DFF | 0.0029 | 0.0345 | 0.0305 | -0.053 | 0.0094 | -0.0397 | -0.0376 | -0.0071 | 0.1663 | 0.0268 | -0.0238 | -0.0935 | -0.0223 | -0.0475 | 0.0124 | -0.0028 | 0.1576 | 0.0343 | -0.0077 | -0.0053 | -0.0775 | -0.3314 | -0.0194 | -0.0305 | -0.0288 | -0.0017 | -0.0081 | -0.3629 |
| NFP | -0.0032 | -0.061 | -0.0383 | 0.1965 | 0.066 | 0.0577 | 0.0043 | 0.0021 | -0.555 | 0.0188 | 0.0132 | 0.2971 | 0.0369 | -0.0391 | -0.055 | -0.0999 | 0.0675 | -0.0428 | 0.0796 | 0.0139 | 0.1152 | 0.5433 | 0.037 | 0.0501 | 0.1378 | -0.0104 | -0.0128 | 0.8195 |
| PL | 0.0001 | 0.0082 | -0.001 | 0.0954 | -0.0145 | -0.0076 | 0.0124 | 0.0013 | 0.0682 | -0.1529` | 0.0296 | -0.1169 | 0.0035 | 0.1721 | 0.0094 | 0.0292 | -0.0506 | -0.0475 | -0.0817 | 0.0001 | 0.002 | -0.0265 | 0.0186 | -0.0072 | 0.0163 | 0.009 | 0.0392 | 0.0081 |
| DPM | 0.003 | 0.0194 | 0.0337 | -0.0733 | 0.0358 | -0.017 | -0.0341 | -0.0056 | 0.2391 | 0.148 | -0.0306 | -0.2403 | -0.0065 | -0.0439 | 0.0264 | 0.0665 | -0.1154 | 0.0492 | 0.0364 | -0.002 | -0.1085 | -0.2688 | 0.0216 | -0.003 | -0.0434 | 0.0007 | 0.0004 | -0.3119 |
| FPW | -0.0032 | -0.0564 | -0.0362 | 0.1081 | 0.0365 | 0.056 | 0.0019 | 0.002 | -0.4894 | 0.0531 | 0.0218 | 0.3369 | 0.0402 | -0.0581 | -0.0515 | -0.1052 | 0.1026 | -0.0326` | 0.0664 | 0.0111 | 0.0999 | 0.4975 | 0.0211 | 0.0482 | 0.1311 | -0.0107 | -0.0163 | 0.775 |
| NSP | -0.0026 | -0.0555 | -0.0291 | 0.1257 | 0.0345 | 0.0552 | 0.0071 | 0.0029 | -0.3693 | -0.0097 | 0.0036 | 0.2446 | 0.0554` | 0.0176 | -0.0475 | -0.0613 | 0.0116 | -0.0703 | 0.0384 | 0.0124 | 0.0757 | 0.4671 | 0.0595 | 0.0521 | 0.1225 | -0.0061 | 0.0181 | 0.7524 |
| SD | -0.0007 | -0.0137 | -0.0034 | -0.0947 | 0.0095 | 0.0018 | -0.0141 | -0.0025 | -0.1604 | 0.1944 | -0.0099 | 0.1445 | -0.0072 | -0.1354 | -0.0132 | -0.0511 | 0.0919 | 0.0522 | 0.0563 | 0.0001 | 0.0153 | 0.0148 | -0.0305 | -0.0016 | -0.0084 | -0.0159 | -0.051 | -0.0331 |
| FSW | -0.0035 | -0.0643 | -0.0391 | 0.1822 | 0.0551 | 0.0615 | 0.0024 | 0.0017 | -0.5711 | 0.0269 | 0.0151 | 0.3248 | 0.0493 | -0.0334 | -0.0534 | -0.1116 | 0.0996 | -0.0572 | 0.059 | 0.0144 | 0.1116 | 0.5482 | 0.0432 | 0.0523 | 0.1435 | -0.0136 | -0.005 | 0.8383 |
| DSW | -0.0027 | -0.0569 | -0.0314 | 0.1541 | 0.0566 | 0.0478 | -0.0089 | -0.0002 | -0.5284 | 0.0425 | 0.0194 | 0.3376 | 0.0324 | -0.066 | -0.0568 | -0.105 | 0.1279 | -0.0267 | 0.0703 | 0.0119 | 0.1004 | 0.4688 | 0.022 | 0.042 | 0.1319 | -0.0127 | -0.0214 | 0.7487 |
| HW | 0.000 | -0.0092 | 0.0016 | 0.0197 | 0.0107 | -0.0056 | -0.0315 | -0.0057 | -0.1915 | 0.0396 | 0.018 | 0.1767 | 0.0033 | -0.0635 | -0.0272 | -0.0686 | 0.1957 | 0.0123 | 0.0097 | 0.0016 | 0.0124 | 0.0036 | -0.0129 | -0.0064 | 0.0342 | -0.0136 | -0.0238 | 0.0796 |
| PL | -0.0026 | -0.0509 | -0.029 | 0.1855 | 0.0155 | 0.047 | 0.015 | 0.0035 | -0.3368 | -0.103 | 0.0213 | 0.1557 | 0.0552 | 0.1002 | -0.0433 | -0.0398 | -0.0341 | -0.0705 | -0.0028 | 0.0122 | 0.0823 | 0.4362 | 0.066 | 0.0441 | 0.1047 | -0.0039 | 0.0371 | 0.6647 |
| PD | -0.0022 | -0.0557 | -0.0281 | 0.1184 | 0.0806 | 0.049 | -0.0045 | 0.0006 | -0.4555 | 0.1288 | -0.0115 | 0.2306 | 0.022 | -0.0786 | -0.0325 | -0.076 | 0.0196 | 0.002 | 0.097 | 0.0113 | 0.0761 | 0.4453 | 0.0221 | 0.0495 | 0.1081 | -0.0102 | -0.028 | 0.6781 |
| NPP | -0.0029 | -0.0623 | -0.036 | 0.214 | 0.0698 | 0.0609 | 0.0054 | 0.0025 | -0.5132 | -0.0012 | 0.004 | 0.2489 | 0.0456 | -0.0005 | -0.0511 | -0.0831 | 0.0211 | -0.0571 | 0.0729 | 0.0151 | 0.1034 | 0.5561 | 0.0567 | 0.0571 | 0.1447 | -0.0075 | 0.0033 | 0.8664 |
| FPY | -0.0037 | -0.0573 | -0.0407 | 0.1761 | 0.0468 | 0.0549 | 0.017 | 0.0044 | -0.5086 | -0.0024 | 0.0264 | 0.2677 | 0.0333 | -0.0165 | -0.0474 | -0.0838 | 0.0193 | -0.0462 | 0.0587 | 0.0124 | 0.1257 | 0.5366 | 0.0307 | 0.0457 | 0.1141 | -0.0082 | -0.0105 | 0.7446 |
| FSY | -0.0034 | -0.0644 | -0.0408 | 0.1826 | 0.059 | 0.0646 | 0.0125 | 0.004 | -0.5102 | 0.0069 | 0.0139 | 0.2836 | 0.0438 | -0.0034 | -0.0496 | -0.0833 | 0.0012 | -0.052 | 0.0731 | 0.0142 | 0.1142 | 0.591 | 0.046 | 0.0595 | 0.1432 | -0.0062 | -0.0024 | 0.8974 |
| PSP | -0.0016 | -0.0452 | -0.0202 | 0.1791 | 0.0502 | 0.0448 | 0.0048 | 0.002 | -0.293 | -0.0405 | -0.0094 | 0.1015 | 0.047 | 0.0589 | -0.0329 | -0.033 | -0.0361 | -0.0664 | 0.0306 | 0.0122 | 0.055 | 0.3874 | 0.0701 | 0.0459 | 0.1108 | -0.0021 | 0.0301 | 0.65 |
| FSC | -0.0028 | -0.0621 | -0.0363 | 0.1607 | 0.0611 | 0.0647 | 0.0091 | 0.0035 | -0.4439 | 0.0175 | 0.0014 | 0.2593 | 0.0461 | 0.0034 | -0.0446 | -0.0702 | -0.0199 | -0.0496 | 0.0766 | 0.0137 | 0.0918 | 0.561 | 0.0513 | 0.0627 | 0.1463 | -0.0037 | 0.0035 | 0.9007 |
| DSC | -0.0027 | -0.0619 | -0.035 | 0.206 | 0.0663 | 0.0585 | -0.0023 | 0.0014 | -0.509 | -0.0166 | 0.0088 | 0.2939 | 0.0452 | 0.0076 | -0.051 | -0.0921 | 0.0445 | -0.0491 | 0.0698 | 0.0145 | 0.0955 | 0.5632 | 0.0517 | 0.061 | 0.1503 | -0.0067 | 0.0018 | 0.9134 |
| HFW | -0.0018 | -0.0321 | -0.0159 | 0.0668 | 0.0362 | 0.0265 | -0.0106 | -0.0008 | -0.3848 | 0.0916 | 0.0014 | 0.2394 | 0.0226 | -0.1426 | -0.0484 | -0.0885 | 0.1761 | -0.0184 | 0.0659 | 0.0075 | 0.0684 | 0.245 | 0.0097 | 0.0155 | 0.067 | -0.0151 | -0.0287 | 0.3521 |
| HDW | -0.0006 | -0.0047 | -0.0054 | -0.0434 | 0.0167 | 0.0011 | -0.008 | -0.0012 | -0.1474 | 0.124 | 0.0003 | 0.1133 | -0.0207 | -0.1427 | -0.0055 | -0.0464 | 0.0963 | 0.054 | 0.0562 | -0.001 | 0.0273 | 0.0296 | -0.0436 | -0.0046 | -0.0057 | -0.0089 | -0.0484 | -0.0195 |
| RESIDUE= 0.2885 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

**Table 4:** Genotypic correlation coefficient

| | PH | SG | NLP | LL | LW | NBP | DF | DFF | NFP | PL | DPM | FPW | NSP | SD | FSW | DSW | HW | PL | PD | NPP | FPY | FSY | PSP | FSR | DSR | HFSW | HDSW | DSYP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PH | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SG | 0.922** | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| NLP | 0.965** | 0.949** | 1 | | | | | | | | | | | | | | | | | | | | | | | | | |
| LL | 0.568 | 0.728 | 0.661 | 1 | | | | | | | | | | | | | | | | | | | | | | | | |
| LW | 0.408 | 0.741 | 0.548 | 0.933** | 1 | | | | | | | | | | | | | | | | | | | | | | | |
| NBP | 0.888** | 0.031 | 0.955** | 0.646 | 0.675 | 1 | | | | | | | | | | | | | | | | | | | | | | |
| DF | -0.575 | -0.269 | -0.534 | -0.103 | 0.273 | -0.383 | 1 | | | | | | | | | | | | | | | | | | | | | |
| DFF | -0.761 | -0.542 | -0.710 | -0.215 | 0.116 | -0.607 | 0.968** | 1 | | | | | | | | | | | | | | | | | | | | |
| NFP | 0.849** | 0.958** | 0.890** | 0.798 | 0.812 | 0.881** | -0.110 | -0.300 | 1 | | | | | | | | | | | | | | | | | | | |
| PL | -0.034 | -0.128 | 0.023 | 0.388 | -0.178 | -0.116 | -0.320 | -0.176 | -0.123 | 1 | | | | | | | | | | | | | | | | | | |
| DPM | -0.807 | -0.306 | -0.783 | -0.298 | 0.441 | -0.259 | 0.878** | 0.780 | -0.431 | -0.967** | 1 | | | | | | | | | | | | | | | | | |
| FPW | 0.838* | 0.887** | 0.842* | 0.439 | 0.449 | 0.856** | -0.048 | -0.277 | 0.882** | -0.347 | -0.713 | 1 | | | | | | | | | | | | | | | | |
| NSP | 0.692 | 0.873** | 0.678 | 0.511 | 0.425 | 0.844** | -0.183 | -0.403 | 0.665 | 0.064 | -0.117 | 0.726 | 1 | | | | | | | | | | | | | | | |
| SD | 0.190 | 0.215 | 0.079 | -0.385 | 0.116 | 0.028 | 0.363 | 0.351 | 0.289 | -0.271 | 0.324 | 0.429 | -0.130 | 1 | | | | | | | | | | | | | | |
| FSW | 0.943** | 0.011 | 0.909** | 0.741 | 0.678 | 0.939** | -0.062 | -0.233 | 0.029 | -0.176 | -0.493 | 0.964** | 0.890** | 0.487 | 1 | | | | | | | | | | | | | |
| DSW | 0.704 | 0.894** | 0.729 | 0.626 | 0.696 | 0.731 | 0.230 | 0.027 | 0.952** | -0.278 | -0.634 | 0.002 | 0.585 | 0.469 | 0.063 | 1 | | | | | | | | | | | | |
| HW | -0.003 | 0.145 | -0.036 | 0.080 | 0.132 | -0.085 | 0.812 | 0.805** | 0.345 | -0.259 | -0.590 | 0.525 | 0.059 | -0.740 | 0.509 | 0.654 | 1 | | | | | | | | | | | |
| PL | 0.679 | 0.800 | 0.675 | 0.754 | 0.191 | 0.718 | -0.386 | -0.487 | 0.607 | 0.673 | -0.698 | 0.462 | 0.997** | 0.580 | 0.811 | 0.379 | -0.174 | 1 | | | | | | | | | | |
| PD | 0.597 | 0.875** | 0.654 | 0.481 | 0.993** | 0.748 | 0.117 | -0.079 | 0.821 | -0.843* | 0.375 | 0.685 | 0.396 | 0.004 | 0.608 | 0.724 | 0.100 | -0.029 | 1 | | | | | | | | | |
| NPP | 0.783 | 0.979** | 0.838* | 0.870** | 0.860** | 0.931** | -0.139 | -0.349 | 0.925** | 0.008 | -0.131 | 0.739 | 0.824 | 0.122 | 0.956** | 0.792 | 0.108 | 0.809 | 0.752 | 1 | | | | | | | | |
| FPY | 0.981** | 0.900** | 0.947** | 0.716 | 0.576 | 0.838* | -0.437 | -0.616 | 0.917** | 0.016 | -0.863** | 0.795 | 0.602 | 0.025 | 0.887** | 0.799** | 0.099 | 0.654 | 0.605 | 0.822 | 1 | | | | | | | |
| FSY | 0.909** | 0.012 | 0.948** | 0.742 | 0.727 | 0.987** | -0.321 | -0.561 | 0.919** | -0.045 | -0.455 | 0.842* | 0.790 | -0.435 | 0.928** | 0.793 | 0.006 | 0.738 | 0.753 | 0.941** | 0.908** | 1 | | | | | | |
| PSP | 0.436 | 0.711 | 0.470 | 0.728 | 0.618 | 0.684 | -0.125 | -0.276 | 0.528 | 0.265 | 0.308 | 0.301 | 0.849* | -0.025 | 0.616 | 0.314 | -0.185 | 0.941** | 0.315 | 0.809 | 0.437 | 0.656 | 1 | | | | | |
| FSR | 0.749 | 0.976** | 0.843* | 0.653 | 0.753 | 0.989** | -0.233 | -0.486 | 0.800 | -0.114 | -0.047 | 0.770 | 0.832 | -0.056 | 0.834* | 0.669 | -0.102 | 0.704 | 0.790 | 0.910 | 0.730 | 0.949** | 0.732 | 1 | | | | |
| DSR | 0.715 | 0.973** | 0.813 | 0.837* | 0.816 | 0.893** | 0.060 | -0.192 | 0.917** | 0.109 | -0.289 | 0.872** | 0.815 | -0.056 | 0.955** | 0.878** | 0.228 | 0.697 | 0.719 | 0.963** | 0.760 | 0.953** | 0.737 | 0.973** | 1 | | | |
| HFW | 0.485 | 0.505 | 0.370 | 0.271 | 0.445 | 0.404 | 0.272 | 0.112 | 0.693 | -0.599 | -0.045 | 0.711 | 0.408 | 0.053 | 0.905** | 0.843* | 0.900** | 0.260 | 0.680 | 0.500 | 0.544 | 0.415 | 0.139 | 0.247 | 0.446 | 1 | | |
| HDW | 0.164 | 0.074 | 0.127 | -0.176 | 0.206 | 0.017 | 0.206 | 0.168 | 0.266 | -0.811 | -0.009 | 0.336 | -0.374 | 0.054 | 0.104 | 0.442 | 0.492 | -0.766 | 0.579 | -0.068 | 0.217 | 0.050 | -0.622 | -0.073 | -0.038 | 0.593 | 1 | |
| DSYP | 0.824 | 0.001 | 0.884** | 0.757 | 0.764 | 0.961** | -0.151 | -0.412 | 0.907** | -0.012 | -0.365 | 0.856* | 0.819 | -0.006 | 0.929** | 0.826 | 0.092 | 0.724 | 0.749 | 0.949** | 0.833* | 0.985** | 0.698 | 0.978** | 0.991** | 0.410 | 0.004 | 1 |

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