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**Narendra Padra**
Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

**GM Lal**
Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

**Corresponding Author:**
**Narendra Padra**
Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

# Genetic variability and Heritability for morphological and physiological traits in Indian mustard genotype under heat stress condition

**Narendra Padra and GM Lal**

**Abstract**

Indian mustard to have greater tolerance to heat and water stress than the canola quality Indian mustard. But high temperature prevailing at the time of sowing reduces seed germination and causes seedling mortality, resulting in poor crop stand and reduced seed yield. To estimated genetic variability, heritability in broad sense and genetic advance of Indian mustard genotypes, eighteen genotypes including one check, were sown in the field under heat stress conditions in CRBD (Complete Randomize Block Design) with three replications at ICAR-Directorate of Rapeseed–Mustard Research, Sewar, Bharatpur, (Rajasthan) during *rabi* 2020-2021. It is situated at 77° 30' E of longitude, 27° 15' N latitude and at altitude of 178.37 m above mean sea level. Mean performance of days to 50% flowering earliest for DRMRHT-18-134 (33.5 days), genotype DRMRHT-18-142 (30.00gm) recorded maximum seed yield per plant, the maximum membrane stability index was found in DRMRHT -17-21 (36.58%) and the maximum relative water content was recorded in genotype DRMRHT-17-50. The phenotypic coefficient of variation (PCV) highest for membrane stability index (44.42%) and the Genotypic coefficient of variation (GCV) also highest for membrane stability index (44.25%). The estimates of heritability in broad sense were high for membrane stability index (99.48%). High estimates of heritability coupled with high genetic advance were observed for membrane stability index (%), secondary branches per plant, seed yield per plant (g). High heritability coupled with medium genetic advance for days to 50% flowering, chlorophyll b (mg/g FW). Low heritability with medium genetic advance for chlorophyll a (mg/g FW).

**Keywords:** Heritability, PCV, GCV, chlorophyll, mg/g FW, membrane stability index, excised leaf water loss, water retension capacity of leaf and relative water content

## Introduction

The term mustard is believed to be derived from the early European practice of mixing the sweet "must" of old wine with the crushed seeds to form a hot paste "hot must" or "mustum ardens" hence the modern term (Hemingway, 1976) [19]. Mustard belongs to family *Crucifereae* (Syn. *Brassicacae*) and genus *Brassica*. Indian mustard or brown mustard is natural amphidiploid having chromosome number (2n=36). It is self-pollinated but certain amount of cross pollination (2-15%) occurs due to insects and other factors. The place of origin of mustard is China and from there it was introduced to India (Prain, 1898 and Bailey, 1922) [20, 3]. The presently cultivated Indian varieties contain high levels of erucic acid which, based on studies conducted in birds and animals, is believed to be harmful for the heart (Gopalan *et al*., 1974, Gurr 1992) [11, 13].

Each degree centigrade increases in average growing season temperature reduce crop yield 17% (lobal and asner, 2003) [13]. Transitory and constantly high temperature cause an array of morphological, physiological and biochemical changes in plant (Serraj *et al.* 1999, Moradshahi *et al.* 2004) [23, 18]. Heat stress affects plant growth throughout its ontogeny, through heat–threshold level varies considerably at different developmental stages. For instance, during seed germination, high temperature may slow down or totally inhibit germination and at later stages, high temperature may adversely affect photosynthesis, respiration, water relation and membrane stability, enhanced expression of a variety of heat stock proteins and production of reactive oxygen species (ROS) constitute major plant response to heat stress (Wahid *et al.* 2007, Camejo *et al.* 2006) [26, 8]. Indian mustard to have greater tolerance to heat and water stress than the canola quality Indian mustard. The cultivation of Indian mustard is largely carried out under the rainfed farming systems where sowing commences after south–west monsoon rains (Venkateswarlu and parsad 2012) [25].

Early rains may cause the farmers to sow the crop early in the season to take advantage of the conserved moisture in the soil. But high temperature prevailing at the time of sowing reduces seed germination and causes seedling mortality, resulting in poor crop stand and reduced seed yield (Azharudheen *et al.* 2013) [2].

## Material and Method

To estimated genetic variability of Indian mustard genotypes, eighteen genotypes including one check, were sown in the field under heat stress conditions in CRBD (Complete Randomize Block Design) with three replications at ICAR-Directorate of Rapeseed–Mustard Research, Sewar, Bharatpur, (Rajasthan) during *rabi* 2020-2021. It is situated at 77° 30' E of longitude, 27° 15' N latitude and at altitude of 178.37 m above mean sea level. The climate of Bharatpur region sub-tropical and semi-arid. Summer season is quite hot with mean maximum daily temperature from 12 to 19 ℃. It receives near about 700mm of rainfall. The crop was raised strictly under conserved moisture condition. Row to row and Plant to Plant spacing was maintained at 45 and 15 cm, respectively. Recommended package and practices were followed to raise a good crop.

Observation were recorded on different seed yield and yield contributing traits *i.e.* days to 50% flowering, days to maturity, plant height (cm), primary branches per plant, secondary branches per plant, main shoot length (cm), siliqua on MSL, siliqua per plant, siliqua length (cm), seeds per siliqua, seed yield per plant (g), 1000-seed weight (gm), membrane stability index (%), relative water content (%), excised leaf water loss (%), water retension capacity of leaf (%), total phenol (mg/g) and chlorophyll contain (mg/g FW). All characters were recorded from five randomly selected plants of each genotype.

### Membrane stability index (%)

Leaf stripes (0.2g) of uniform size were placed in test tubes containing 10 ml of double distilled water in two sets. Test tubes in one set were kept at 40 ℃ in a water bath for 30 min and electrical conductivity of the water containing the sample was measured ($C_1$) using a conductivity bridge. Test tubes in the other set were incubated at 100 ℃ in boiling water in water bath for 15 min and electrical conductivity was measured as above ($C_2$) (Premachandra *et al.*, 1990), Sairam, (1994) [21, 22] Leaf membrane stability index (MSI) was calculated using the following formula:

$$MSI= [1- C_1/ C_2] \times 100$$

### Relative water content (%)

The samples for RWC were also weighed immediately to obtain fresh weight (FW); 2 cm leaf sections were floated in distilled water for 4 h, blot -dried and weighed to obtain turgid weight (TW); The 2 cm leaf sections were oven dried at 60 ℃ for 24 h and weighed to obtain dry weight (DW). The RWC was calculated using the formula of Barrs (1968).

$$RWC (\%) = [FW – DW] / (TW- DW] \times 100$$

### Excised leaf water loss (%)

For determining excised- leaf water loss (ELWL) the leaves were weighed at three stages *viz.* immediately after sampling (fresh weight); after drying in an incubator at 28℃ and 50% R.H. for 6 h; and after oven drying for 24 h at 70℃ as suggested by Clarke, (1987): ELWL was calculated using the following formula:

ELWL= [Fresh weight – Weight after 6 h) / (Fresh weight-Dry weight] x 100

### Water Retension Capacity of leaf (%)

Water retension capacity of leaf was estimated by the method proposed by Ashraf and Ahmed (1998) [1].

WRCL =Wt. of excised leaf each hours/Wt. of turgid excised leaf x 100

Total Phenol (mg/g):

Total phenol of leaf was estimated by method proposed by Bray and Thorpe (2006).

Chlorophyll contain (mg/g FW):

Chlorophyll estimation was done in fresh leaf by a common method (Hiscox and Israelstam 1979) [15] with the following formula for deriving Chlorophyll *a* (Chl *a*), Chlorophyll *b* (Chl *b*), Total chlorophyll (Chl total) and Total carotenoids content.

$$\text{Chl a (mg/g FW)} = [(12.7 \times A663) – (2.69 \times A645)] \times V/1000 \times W$$

$$\text{Chl b (mg/g FW)} = [(22.9 \times A645) – (4.68 \times A663)] \times V/1000 \times W$$

$$\text{Carotenoids (mg/g FW)} = [(1000 \times A470) – (3.29 \times \text{Chl a}) – (104 \times \text{Chl b})]/198$$

Where,
V-volume of DMSO added
W-weight of sample taken
FW- fresh weight

### Statistical analysis

The data obtained for different genotypes with respect to various parameters under consideration were subjected to Analysis of Variance (ANOVA). ANOVA was calculated according to the formula described by Panse and Sukhatme (1957) and critical differences (CD) were determined at 5 and 1% probability level. Estimation of phenotypic and genotypic coefficient variation, heritability in broad sense and genetic advance processed by Windostat Version 9.1 software. The studies on genotype coefficient of variation (GCV) and phenotypic coefficient of variation(PCV) values higher to 20 percent are considered as high while values less than 10 percent are considered as low and values between 10 to 20 per cent considered intermediate (Deshmukh *et al*. 1986) [10].

## Result and Discussion

The genetic variability analysis was done considering 21 characters of 18 genotypes in the study. Their performance in respect of genetic analysis of variance, heritability and genetic advance. A wide range of variability present in any crop always provides the better chances of selecting desired types (Vavilov, 1951).

Mean performance of different genotypes for Morpho-physiological traits of Indian mustard presented in Table No. 1. Influential variation was recorded among the genotypes. The days to 50% flowering ranged from 33.5 days in DRMRHT-18-134 to 46.5 days in DRMRHT-18-40 with a grand mean of 40.5 days. Among all the genotypes about 19 days variation was observed at the maximum in respect of maturity. DRMRHT-18-142 was the earliest genotypes for harvesting (109) and the genotypes DRMRHT-17-23 took maximum number of days (128) for maturity with grand mean

119.58. The maximum plant height was obtained from the DRMRHT-18-141 had the lowest plant height (185.5) with mean plant height (164.86). It is revealed from Table No. 1 that the mean number of primary branches per plant was 5.52 and ranged from 4.7 to 6.7. The maximum number of primary branches was recorded in genotypes DRMRHT-18-89 whereas; DRMRHT-17-74 recorded minimum primary branches per plant. The maximum secondary branches per plant were recorded in the genotype DRMRHT-18-65 (16.9) while genotype DRMRHT-18-123 had lowest number of primary branches per plant (5.7) with 12.11 grand mean. The mean of main shoot length was 71.11 and ranged from 56.70 to 84.6. The maximum main shoot length was recorded in genotype DRMRHT-17-83 and lowest in genotype DRMRHT-17-23. The maximum number of siliqua on main shoot was recorded in genotype in DRMRHT-17-83(48.1) while minimum of number of siliqua on main shoot was recorded in genotype DRMRHT-17-21(35.1) with grand mean of 41.89. The maximum number of siliqua per plant was recorded in the genotype DRMRHT-18-142(385.9) while genotype DRMRHT-18-123 (152.1) had lowest number of siliqua per plant with a grand mean of 274.36. The maximum siliqua length was recorded in the genotype DRMRHT-18-134 (5.60) and lowest siliqua length in DRMRHT-18-40 (4.62) with grand mean 5.16. The maximum number of seeds per siliqua was found in the genotype DRMRHT-17-74 (16.56) while least number of seeds per siliqua was found in genotype DRMRHT -18-40 (12.48) with a grand mean of 14.60. With respect to seed yield per plant, genotype DRMRHT-18-142 (30.00gm) recorded maximum seed yield per plant whereas, the genotype DRMRHT-17-40 (14.5gm) genotype DRMRHT-18-91 (185.5) and the genotypes attained minimum seed yield per plant with grand mean (20.52gm). The 1000-seed weight ranged from 4.02gm (DRMRHT-18-140) to 6.43gm (DRMRHT-18-123) whereas mean 1000-seed weight was 5.36gm. The maximum membrane stability index was found in DRMRHT -17-21 (36.58%) whereas the minimum in genotype DRMRHT-18-40 (4.84%) with a grand mean 19.77%. The mean of relative water content 76.67% and ranged from 71.86% to 79.87%. The maximum relative water content was recorded in genotype DRMRHT-17-50 and minimum in genotype in DRMRHT-18-40. The highest excised leaf water loss was found in DRMRHT-17-40 (24.08%) whereas, the lowest in genotype DRMRHT-18-65(13.59%) with a grand mean 18.89%. The maximum water retension capacity of leaf was found in DRMRHT-17-2(72.30%) whereas, the minimum in genotype DRMRHT-18-134 (46.16%) with a grand mean 60.74%. The mean of total phenol 5.17 and ranged from 3.59 to 5.87. The maximum total phenol was recorded in genotype DRMRHT-18-91 and minimum in genotype in DRMRHT-17-40. The highest chlorophyll a was found in DRMRHT-18-65(4.80) whereas the lowest in genotype DRMRHT-18-91 (3.49) with a grand mean 4.033. The mean of chlorophyll b 0.695 and ranged from 0.54 to 0.98. The maximum Chlorophyll b was recorded in genotype DRMRHT-18-123 and minimum in genotype in DRMRHT-18-88. The highest total chlorophyll was found in DRMRHT-18-123 (5.70) whereas, the lowest in genotype DRMRHT-18-88 (4.07) with a grand mean 4.72. The maximum carotenoid was found in DRMRHT-18-123 (16.58) whereas the minimum in genotype DRMRHT-18-88 (10.34) with a grand mean 12.65.

**Table 1:** Mean performance of different genotypes for Morpho-physiological traits of Indian mustard

| S. No. | Genotype | Days to 50% flowering | Days to Maturity | Plant Height (cm) | Primary Branches | Secondary branches | Main shoot Length(cm) | Siliqua on MSL | Siliqua Per plant | Siliqua Length (cm) | Seeds per siliqua | Seed yield Per plant (g) | 1000 Seed Weight (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | DRMR HT-18-40 | 46.5 | 123 | 171.8 | 4.7 | 9.1 | 66.85 | 39.5 | 230.3 | 4.62 | 12.48 | 19 | 6.337 |
| 2 | DRMR HT-18-65 | 44.5 | 113 | 169.4 | 6.4 | 16.9 | 79.25 | 45.6 | 353.1 | 5.52 | 13.96 | 25 | 5.644 |
| 3 | DRMRHT-18-88 | 39.5 | 116.5 | 164.3 | 6.1 | 15 | 75.75 | 46.8 | 280.4 | 5.335 | 15.42 | 17.5 | 4.794 |
| 4 | DRMRHT-18-89 | 39.5 | 120 | 164.2 | 6.7 | 14.5 | 71.8 | 44 | 294.1 | 5.53 | 13.92 | 20.5 | 5.137 |
| 5 | DRMRHT-18-91 | 42 | 120.5 | 185.5 | 6.6 | 14.7 | 75.65 | 43.8 | 284.5 | 5.005 | 13.08 | 21.5 | 5.249 |
| 6 | DRMRHT-18-97 | 37 | 120 | 166.8 | 5.3 | 12.6 | 73.7 | 43.9 | 254.6 | 4.81 | 14.6 | 19 | 4.513 |
| 7 | DRMRHT-18-123 | 40.5 | 121 | 169 | 4.8 | 5.7 | 63.95 | 35.7 | 152.1 | 5.105 | 14.4 | 15.5 | 6.433 |
| 8 | DRMRHT-18-126 | 42 | 123.5 | 172.7 | 5 | 8.9 | 68.9 | 44.6 | 206.1 | 4.92 | 14.5 | 18.5 | 6.2115 |
| 9 | DRMRHT-18-134 | 33.5 | 115 | 152.7 | 4.9 | 14.8 | 71.25 | 36.4 | 296.6 | 5.605 | 15.4 | 25 | 5.671 |
| 10 | DRMRHT-18-141 | 35 | 109.5 | 141.9 | 5.4 | 15.8 | 69.95 | 37.3 | 341.4 | 4.965 | 14.98 | 17.5 | 4.0215 |
| 11 | DRMRHT-18-142 | 37 | 109 | 152.3 | 5.6 | 14.9 | 75.8 | 39.3 | 385.9 | 5.445 | 16.54 | 26 | 4.3055 |
| 12 | DRMRHT-17-83 | 39.5 | 120.5 | 172.9 | 5.3 | 14.6 | 84.6 | 48.1 | 334.2 | 5.32 | 16.22 | 30 | 5.643 |
| 13 | DRMRHT-17-74 | 41 | 126.5 | 153.7 | 4.7 | 14.7 | 75.05 | 47.4 | 324.1 | 4.87 | 16.56 | 23.5 | 4.685 |
| 14 | DRMRHT-17-50 | 42.5 | 125.5 | 181.6 | 5.7 | 9.8 | 74.7 | 38.8 | 270.1 | 5.18 | 14.04 | 18.5 | 4.7995 |
| 15 | DRMRHT-17-23 | 41.5 | 128 | 167.2 | 5.6 | 6 | 56.7 | 41.2 | 199.5 | 5.005 | 13.42 | 17.5 | 6.107 |
| 16 | DRMRHT-17-40 | 42.5 | 123.5 | 164.8 | 5.3 | 6.9 | 66.9 | 41.8 | 208.4 | 5.295 | 14.06 | 14.5 | 5.0795 |
| 17 | DRMRHT-17-21 | 43.5 | 121 | 157.5 | 5.7 | 8.9 | 57.85 | 35.1 | 227.7 | 5.31 | 13.8 | 15.5 | 5.941 |
| 18 | CHECK NPJ-112 | 41.5 | 116.5 | 159.3 | 5.6 | 14.2 | 71.35 | 44.8 | 295.4 | 5.075 | 15.54 | 25 | 5.931 |
| | Mean | 40.5 | 119.58 | 164.86 | 5.52 | 12.11 | 71.11 | 41.89 | 274.36 | 5.16 | 14.60 | 20.52 | 5.36 |
| | Range | 33.5-46.5 | 109-128 | 141.9-185.5 | 4.7-6.7 | 5.7-16.9 | 56.70-84.6 | 35.1-48.1 | 152.1-385.9 | 4.62-5.60 | 12.48-16.56 | 14.5-30.00 | 4.02-6.43 |
| | SE(d) | 0.24 | 0.979 | 3.8646 | 0.2248 | 0.4703 | 2.6286 | 1.8084 | 29.676 | 0.1291 | 0.4187 | 0.9555 | 0.2265 |
| | C.D. | 0.690 | 2.8143 | 11.107 | 0.6461 | 1.3515 | 7.5546 | 5.1974 | 85.290 | 0.3711 | 1.2033 | 2.746 | 0.651 |
| | C.V. | 1.027 | 1.4183 | 4.0601 | 7.0515 | 6.7253 | 6.4024 | 7.4766 | 18.734 | 4.3332 | 4.9645 | 8.0618 | 7.318 |

**Table 1:** Cont….

| S. No. | Genotype | Membrane Stability Index (%) | Relative Water Content (%) | Excised Leaf Water Loss (%) | Water Retension Capacity of Leaf (%) | Total Phenol (mg/g) | Chlorophyll a (mg/g FW) | Chlorophyll b (mg/g FW) | Total Chlorophyll (mg/g FW) | Carotenoids (mg/g FW) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | DRMR HT-18-40 | 4.845 | 71.86 | 17.275 | 63.615 | 5.0433 | 4.09 | 0.78 | 4.87 | 13.85 |
| 2 | DRMR HT-18-65 | 14.47 | 75.69 | 13.595 | 47.56 | 5.0267 | 4.8033 | 0.7 | 5.5033 | 13.08 |
| 3 | DRMRHT-18-88 | 8.2767 | 74.95 | 15.99 | 57.445 | 5.7867 | 3.53 | 0.54 | 4.07 | 10.3467 |
| 4 | DRMRHT-18-89 | 23.0567 | 75.09 | 18.945 | 64.695 | 5.5067 | 4.31 | 0.62 | 4.93 | 11.88 |
| 5 | DRMRHT-18-91 | 18.925 | 74.3 | 18.77 | 59.625 | 5.8767 | 3.49 | 0.62 | 4.11 | 11.3567 |
| 6 | DRMRHT-18-97 | 20.7667 | 74.34 | 17.74 | 59.775 | 5.3433 | 4.39 | 0.74 | 5.13 | 13.7333 |
| 7 | DRMRHT-18-123 | 18.51 | 78.395 | 24.05 | 67.63 | 5.1567 | 4.72 | 0.98 | 5.7 | 16.5867 |
| 8 | DRMRHT-18-126 | 13.1167 | 77.415 | 20.515 | 68.545 | 4.8033 | 3.75 | 0.57 | 4.32 | 11.9133 |
| 9 | DRMRHT-18-134 | 29.6683 | 79.08 | 15.915 | 46.16 | 5.5367 | 4.0333 | 0.76 | 4.7933 | 12.9 |
| 10 | DRMRHT-18-141 | 36.2467 | 78.53 | 17.515 | 55.835 | 4.6033 | 4.17 | 0.6 | 4.77 | 12.14 |
| 11 | DRMRHT-18-142 | 29.8633 | 79.59 | 16.68 | 56.935 | 4.8367 | 4.1167 | 0.72 | 4.8367 | 13.08 |
| 12 | DRMRHT-17-83 | 17.2533 | 79.145 | 18.86 | 58.05 | 5.1067 | 3.9433 | 0.62 | 4.5633 | 12.1567 |
| 13 | DRMRHT-17-74 | 19.7217 | 75.205 | 18.23 | 60.92 | 5.6233 | 3.5467 | 0.66 | 4.2067 | 12.3467 |
| 14 | DRMRHT-17-50 | 18.4583 | 79.87 | 23.105 | 62.83 | 5.4633 | 4.4867 | 0.71 | 5.1967 | 13.2067 |
| 15 | DRMRHT-17-23 | 15.95 | 79.83 | 18.41 | 72.3 | 5.2167 | 3.7567 | 0.76 | 4.5167 | 12.79 |
| 16 | DRMRHT-17-40 | 19.8617 | 75.89 | 24.085 | 70.065 | 3.59 | 4.01 | 0.67 | 4.68 | 11.7267 |
| 17 | DRMRHT-17-21 | 36.58 | 76.745 | 19.55 | 68.075 | 5.09 | 3.59 | 0.8 | 4.39 | 13.09 |
| 18 | CHECK NPJ-112 | 10.4117 | 74.31 | 20.87 | 53.32 | 5.4967 | 3.8733 | 0.66 | 4.5333 | 11.5867 |
| | Mean | 19.7768 | 76.6797 | 18.8944 | 60.7433 | 5.1726 | 4.0339 | 0.695 | 4.7289 | 12.6539 |
| | Range | 4.84-36.58 | 71.86-79.87 | 13.59-24.08 | 46.16-72.30 | 3.59-5.87 | 3.49-4.80 | 0.54-0.98 | 4.07-5.70 | 10.34-16.58 |
| | SE(d) | 0.4479 | 0.8068 | 0.9226 | 2.9877 | 0.2661 | 0.2358 | 0.0246 | 0.2379 | 0.4762 |
| | C.D. | 1.2873 | 2.3187 | 2.6515 | 8.5867 | 0.7649 | 0.6776 | 0.0707 | 0.6837 | 1.3687 |
| | C.V. | 3.9227 | 1.8224 | 8.4573 | 8.5192 | 8.912 | 10.1239 | 6.1272 | 8.7133 | 6.5184 |

The phenotypic and genotypic coefficient of variation, Heritability in broad sense and genetic advance in 21 characters in 18 genotypes of Indian mustard is presented in Table No. 2.

It was revealed that the phenotypic coefficient of variation (PCV) highest for membrane stability index (44.42%), secondary branches per plant (30.89), siliqua per plant (27.20), seed yield per plant (22.03gm), excised leaf water loss (16.43%), chlorophyll b (15.60mg/g FW). The lowest PCV were observed for days to maturity (4.67), relative water content (3.44%). The Genotypic coefficient of variation (GCV) highest for membrane stability index (44.25%), secondary branches per plant (30.15), seed yield per plant (20.50gm), siliqua per plant (19.72). The lowest GCV were observed for siliqua length (4.72cm), days to maturity (4.45) and relative water content (2.92%).

Genotypic coefficient of variation (GCV) was less as compared to that of phenotypic coefficient of variation (PCV) for all the characters and these findings are in close to the observations. The GCV and PCV values were found to be very distant to each other for most of the characters. The distant relationship between GCV and PCV indicated that characters are much influenced by environmental factors. The studies showed that the PCV was higher than the GCV for all the traits, representing the effect of environmental variance in the rest of variance studied. Similar findings were reported by Ram *et al.* (2017), Yadav and Panday (2018), Gupta *et al.* (2019), Thapa *et al.* (2020) and Ram *et al.* (2021) [6, 27, 12, 24, 5]. The character membrane stability index (%) with higher values of PCV has been reported by Ram *et al.* (2017) [6]. The highest GCV and PVC values were observed for membrane stability index (%) expressing the presence of the wide extent of variability of this character. (Ram *et al.* 2021) [5].

The estimates of heritability in broad sense were high for membrane stability index (99.48%) followed by days to 50% flowering (98.40%), secondary branches per plant (95.26%), days to maturity (90.80%), seed yield per plant (86.61%), chlorophyll b (84.59%). While, low heritability was observed for chlorophyll a (37.90%). The highest value of expected genetic advance as percentage of mean for membrane stability index (%) (90.80) followed by secondary branches per plant (60.62), seed yield per plant (g) (39.31).

High estimates of heritability coupled with high genetic advance were observed for membrane stability index (%), secondary branches per plant, seed yield per plant (g). High heritability coupled with medium genetic advance for days to 50% flowering, chlorophyll b (mg/g FW). Low heritability with medium genetic advance for chlorophyll a (mg/g FW).

Heritability estimates and genetic advance in a population provides information about the expected genetic gain in the following generations. The most important functions of heritability estimates in the genetic studies of quantitative characters are their predictive role, possible advance through selection based on phenotypic values can be predicted only from knowledge of the degree of correspondence between phenotypic and genotypic values. Heritability estimates revealed the heritable portion of variability present in different characters.

Thus, it is clear that a character with high GCV and high heritability have high genetic advance. The heritability, which is a ratio of genotypic and phenotypic variance, is mainly due to the additive gene effects in narrow sense, but in the broad sense it includes both additive as well as non-additive gene effects. The heritability values estimated in the present study are expressed in broad sense. Broad sense heritability gives only a rough estimate. Moreover, broad sense heritability and narrow sense heritability are generally negatively correlated (Kempthorn, 1957) [16]. If heritability was mainly due to additive effects, it would be associated with high genetic gain and if it is due to non-additive, genetic gain would be low (Panse, 1957) [19].

**Table 2:** Genetic variability for Morpho-physiological and quantitative traits of Indian mustard

| Characters | Genetic Coefficient of variance (%) | Phenotypic Coefficient of variance (%) | Heritability (Broad sense) (%) | Genetic Advance | Genetic Advance value % mean |
|---|---|---|---|---|---|
| Days to 50%Flowring | 8.06 | 8.13 | 98.40 | 6.67 | 16.48 |
| Days to Maturity | 4.45 | 4.67 | 90.80 | 10.46 | 8.74 |
| Plant Height (cm) | 6.09 | 7.32 | 69.27 | 17.22 | 10.45 |
| Primary branches | 10.36 | 12.53 | 68.37 | 0.97 | 17.65 |
| Secondary branches | 30.15 | 30.89 | 95.26 | 7.34 | 60.62 |
| Main Shoot Length(cm) | 9.07 | 11.10 | 66.75 | 10.85 | 15.26 |
| Siliqua on MSL | 8.91 | 11.63 | 58.72 | 5.89 | 14.07 |
| Siliqua Per Plant | 19.72 | 27.20 | 52.57 | 80.81 | 29.45 |
| Siliqua Length (cm) | 4.72 | 6.41 | 54.33 | 0.37 | 7.17 |
| Seeds Per Siliqua | 7.41 | 8.92 | 69.06 | 1.85 | 12.69 |
| Seed Yield Per Plant (g) | 20.50 | 22.03 | 86.61 | 8.07 | 39.31 |
| 1000 Seed wt.(g) | 13.02 | 14.94 | 76.01 | 1.25 | 23.39 |
| Membrane Stability Index (%) | 44.25 | 44.42 | 99.48 | 17.95 | 90.80 |
| Relative Water Content (%) | 2.92 | 3.44 | 72.04 | 3.92 | 5.11 |
| Excised Leaf Water Loss (%) | 14.09 | 16.43 | 73.53 | 4.70 | 24.90 |
| Water Retension Capacity of Leaf (%) | 11.00 | 13.91 | 62.52 | 10.88 | 17.92 |
| Total Phenol (mg/g) | 8.72 | 12.47 | 48.95 | 0.65 | 12.57 |
| Chlorophyll a (mg/g FW) | 7.90 | 12.84 | 37.90 | 0.40 | 10.03 |
| Chlorophyll b(mg/g FW) | 14.35 | 15.60 | 84.59 | 0.18 | 27.19 |
| Total Chlorophyll (mg/g FW) | 8.14 | 11.92 | 46.64 | 0.54 | 11.46 |
| Carotenoids (mg/g FW) | 9.75 | 11.73 | 69.13 | 2.11 | 16.70 |

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