**Evaluation of Genetic Variability, Heritability and Genetic Advance in Cauliflower [*Brassica oleracea* var. botrytis L.] Genotypes**

**ABSTRACT**

Exploring genetic variability within the available germplasm is a fundamental prerequisite in any plant breeding program, as it facilitates the selection of superior genotypes. Key genetic parameters such as heritability and genetic advance are valuable tools for breeders in identifying genotypes that exhibit desirable characteristics. To enhance the genetic potential of cauliflower, a comprehensive assessment of genetic variability, heritability, and genetic advance was undertaken using the existing germplasm. The investigation was conducted during the winter season of 2024–2025 at the Main Experiment Station, Department of Vegetable Science, ANDUAT, Kumarganj, Ayodhya (U.P.). Thirty-two cauliflower genotypes were evaluated in a Randomized Block Design with three replications to estimate the extent of genetic variability, heritability and genetic advance for nineteen quantitative and qualitative traits. The analysis of variance revealed significant differences among genotypes for all the characters studied, indicating substantial genetic variability in the germplasm. The phenotypic coefficient of variation (PCV) was found to be higher than the genotypic coefficient of variation (GCV) for all traits, suggesting environmental influence on trait expression. High PCV and GCV were observed for traits such as leaf width, stalk width, curd yield per plot and net curd weight, indicating potential for effective selection. Genetic advance in per cent of mean were found to be high (>20%) for several traits, particularly leaf width (24.10), curd yield per plot (22.28) and stalk width (21.29). Moderate genetic advance in percent of mean (10 to 20%) were observed for traits such as net curd weight (16.65), total soluble solids (16.13), ascorbic acid (15.79), gross plant weight (15.75), days to curd initiation (14.24), stalk length (13.42), curd polar diameter (12.76), leaf length (11.90), days to curd maturity (11.78), curd equatorial diameter (11.50), number of leaves per plant (10.88) and dry matter content (10.58). The high heritability coupled with high genetic advance as a percentage of the mean was recorded for ascorbic acid, curd yield per plot, leaf width and total soluble solids, suggesting additive gene action and effectiveness of direct selection. Among the genotypes, NDC-23-21 and NDC-23-16 were identified as superior based on curd yield per plot. Traits including net curd weight, gross plant weight, days to curd initiation, and curd yield per plot exhibited high heritability coupled with high genetic advance as a percentage of the mean. The combination suggests that the inheritance of these traits is primarily controlled by additive gene effects, and hence, direct selection for these traits is likely to result in significant genetic improvement. The findings highlight the potential for genetic improvement through targeted selection.

**Keywords:** Genetic variability, Heritability, Genetic advance, cauliflower, cross-pollinated crop

**INTRODUCTION**

Development of high yielding genotypes is the ultimate goal in any crop improvement programme. To achieve this target, it is essential to generate information on the available genetic variability and its heritable quotient is very essential (Rana et al., 2024). The degree of genetic diversity in the germplasm is roughly equal to the crop's development potential and offers the chance to increase production and quality via the planned breeding program. Given that phenotypic diversity is determined by interactions between genotype and environment, the phenotype is often not an accurate predictor of its genotype (Singh et al., 2022a). Cauliflower is a widely cultivated cruciferous vegetable, often known as “Phoolgobhi” [Brassica oleracea var. botrytis L.] and belongs to the family Brassicaceae (**Meena et. al. 2012**). It is also known as the “Aristocrat of Cole crops” (**Nimkar and Korla, 2014**).  It is a monogenomic species belonging to the ‘C’ genome and possesses a basic chromosome number of n=9 (**Thamburaj and Singh, 2001**). It was domesticated in the Mediterranean region. It was introduced into India in 1822 by a botanist Dr. Jemson from Kew Gardens, London to Saharanpur (U.P.). The original introductions were the Cornish type, which was originated in England, followed by temperate types that originated from Germany and Netherlands in 18th century. India is the second largest producer of cauliflower in the world after China. The major growing states are West Bengal, Bihar, Odisha, Gujarat, Uttar Pradesh and Haryana. The cultivated area for cauliflower in India is 507.30 thousand hectares and the production of 9794.36 thousand metric tons. West Bengal is the leading state with a production 1997.17 thousand metric tons **(Anonymous 2023-2024)**. Cauliflower is also an important source of human nutrition that contains a good amount of dietary fibres, vitamins and minerals. Additionally, it contains sulforaphane, an anti-cancer substance that lowers the risk of prostate cance. Brassica vegetables are also a rich source of many phytochemicals and bioactive substances (Singh & Kalia, 2021; Singh et al., 2022b).

The edible portion of cauliflower is the pre-floral, fleshy apical meristem, commonly known as the "curd", which serves as the economic part of the plant and is a rich source of vitamins and minerals. The curd represents an intermediate developmental stage between the vegetative and reproductive phases **(Singh *et al*., 2013).** Its formation is controlled by two mutant genes: BoAP1-a and BoCA-L-a. Cauliflower is a cross-pollinated crop due to the presence of protogyny and sporophytic self-incompatibility mechanisms. The type of fruit is a siliqua and the inflorescence is racemose. The flower exhibits tetradynamous stamens, consisting of six stamens four long and two short. It is a thermo-sensitive crop. The ideal temperature for the growth of young plants is around 23 °C, while 17–20 °C is most favourable during curd development and later growth stages. Cauliflower is also sensitive to highly acidic soil conditions, which can lead to molybdenum deficiency **(Kanwar, 2023).** The portion of the curd that is consumed by humans can grow to be more than twenty centimetres in diameter. When it comes to the development of curd, this crop requires a particular climate in contrast to other vegetables in the brassicaceous family. Extreme temperatures and droughts, for example, might cause cauliflower to react negatively and produce pre-mature curd, which can have a negative economic impact (Singh & Kalia, 2021).

It can immensely improve human health and has been recognized as ‘Super food’ owing to its oxidative defense systems **(Gopalan *et al.* 2011)** and consumption of cauliflower reduces the incidence of cancer, as it contains an anti-cancerous property, sulphoraphane. It is also an excellent source of ascorbic acid, folic acid, dietary fiber and rich in vitamin-A through the incorporation of ‘or’ gene in the curd, which will make curd colour orange and rich in beta carotene **(Xiangjun *et al*. 2006).**

Exploring genetic variability within the available germplasm is a fundamental prerequisite in any plant breeding program, as it facilitates the selection of superior genotypes. The nature and extent of variability present in the gene pool for different traits, as well as the interrelationships among these traits, play a critical role in determining the success of genetic improvement efforts. Key genetic parameters such as heritability and genetic advance are valuable tools for breeders in identifying genotypes that exhibit desirable characteristics. Heritability refers to the proportion of observed variation in a trait that is attributable to genetic factors, indicating the potential for successful transmission of traits from parents to offspring. Genetic advance, on the other hand, quantifies the expected improvement in a trait under selection pressure. High estimates of both heritability and genetic advance suggest the presence of additive gene action and offer promising prospects for improvement in subsequent generations. To enhance the genetic potential of cauliflower, a comprehensive assessment of genetic variability, heritability, and genetic advance was undertaken using the existing germplasm.

**MATERIALS AND METHODS**

The present experiment was conducted at the Main Experiment Station, Department of Vegetable Science, Acharya Narendra Deva University of Agriculture & Technology, Narendra Nagar (Kumarganj), Ayodhya (U.P.), during the winter season of 2024–2025. A total of thirty-two morphologically diverse cauliflower genotypes were evaluated. The experiment was laid out in a Randomized Block Design (RBD) with three replications. Each plot measured 3 m × 1.2 m, with a spacing of 60 cm between rows and 45 cm between plants, thereby accommodating 12 plants per plot. All recommended agronomic practices and plant protection measures were followed to ensure a healthy crop. Five randomly selected plants per plot were observed , namely: days to curd initiation, days to curd maturity, plant height (cm), leaf length (cm), leaf width (cm), number of leaves per plant, stalk length (cm), stalk width (cm), curd polar diameter (cm), curd equatorial diameter (cm), gross plant weight (g), harvest index (%), total soluble solids (TSS, °Brix), ascorbic acid content (mg/100g), dry matter content (%), moisture content (%), chlorophyll content (mg/g), net curd weight (g), and curd yield per plot (kg). The analysis of variance (ANOVA) for the experimental design was carried out following the procedure outlined by Panse and Sukhatme (2000). The phenotypic and genotypic coefficients of variation (PCV and GCV) were computed using the method proposed by Burton and DeVane (1953). Broad-sense heritability was estimated following the approach of Hanson *et al.* (1956), and the genetic advance (GA) was calculated using the formula suggested by Johnson *et al*. (1955).

**Table.1 List of genotypes and their source of origin**

|  |  |  |
| --- | --- | --- |
| **S.No.** | **Genotype** | **Source of origin** |
| **1.** | NDC-23-1 | ANDUAT, Ayodhya |
| **2.** | NDC-23-2 | ANDUAT, Ayodhya |
| **3.** | NDC-23-3 | ANDUAT, Ayodhya |
| **4.** | NDC-23-4 | ANDUAT, Ayodhya |
| **5.** | NDC-23-5 | ANDUAT, Ayodhya |
| **6.** | NDC-23-6 | ANDUAT, Ayodhya |
| **7.** | NDC-23-7 | ANDUAT, Ayodhya |
| **8.** | NDC-23-8 | ANDUAT, Ayodhya |
| **9.** | NDC-23-9 | ANDUAT, Ayodhya |
| **10.** | NDC-23-10 | ANDUAT, Ayodhya |
| **11.** | NDC-23-11 | ANDUAT, Ayodhya |
| **12.** | NDC-23-12 | ANDUAT, Ayodhya |
| **13.** | NDC-23-13 | ANDUAT, Ayodhya |
| **14.** | NDC-23-14 | ANDUAT, Ayodhya |
| **15.** | NDC-23-15 | ANDUAT, Ayodhya |
| **16.** | NDC-23-16 | ANDUAT, Ayodhya |
| **17.** | NDC-23-17 | ANDUAT, Ayodhya |
| **18.** | NDC-23-18 | ANDUAT, Ayodhya |
| **19.** | NDC-23-19 | ANDUAT, Ayodhya |
| **20.** | NDC-23-20 | ANDUAT, Ayodhya |
| **21.** | NDC-23-21 | ANDUAT, Ayodhya |
| **22.** | NDC-23-22 | ANDUAT, Ayodhya |
| **23.** | NDC-23-23 | ANDUAT, Ayodhya |
| **24.** | NDC-23-24 | ANDUAT, Ayodhya |
| **25.** | NDC-23-25 | ANDUAT, Ayodhya |
| **26.** | NDC-23-26 | ANDUAT, Ayodhya |
| **27.** | NDC-23-27 | ANDUAT, Ayodhya |
| **28.** | NDC-23-28 | ANDUAT, Ayodhya |
| **29.** | NDC-23-29 | ANDUAT, Ayodhya |
| **30.** | NDC-23-30 | ANDUAT, Ayodhya |
| **31.** | NDC-23-31 | ANDUAT, Ayodhya |
| **32.** | Pusa Himjyoti | IARI, New delhi |

**RESULTS AND DISCUSSION**

The analysis of variance of nineteen characters under study was carried out for thirty-two genotypes. Mean sum of squares due to treatments were highly significant for all the traits, indicating significant differences among the genotypes with respect to traits under study. Days to curd initiation ranged from 75.57 (NDC-23-21) to 104.33 (NDC-23-17) with a mean value of 87.42. Days to curd maturity ranged from 91.7 (NDC-23-10) to 121.93 (NDC-23-20) with a mean value of 105.06. Plant height at the time of curd initiation ranged from 46.73 cm (**NDC-23-5**) to 57.50 cm (**NDC-23-1)** with a mean value of52.22 cm. Leaf length at the time of curd initiation ranged from 23.30 cm (NDC-23-9) to 33.00 cm (NDC-23-1) with a mean value of 28.28 cm. Leaf width at the time of curd initiation ranged from 11.30 cm (NDC-23-18) to 20.47cm (NDC-23-1) with a mean value of 15.67 cm. Number of leaves per plant ranged from 12.67 (NDC-23-14) to 22.23 (NDC-23-23) with a mean value of 19.28. Stalk length ranged from 5.67 cm (NDC-23-5) to 9.13 cm (NDC-23-1) with a mean value of 7.33 cm. Stalk width ranged from 2.43 cm (NDC-23-8) to 4.33 cm (NDC-23-30) with a mean value of 3.50 cm. Curd polar diameter ranged from 5.87 cm (NDC-23-14) to 8.53 cm (NDC-23-20) with a mean value of 7.05 cm. Curd equatorial diameter ranged from 7.80 cm (NDC-23-14) to 11.33 cm (NDC-23-24) with a mean value of 9.53 cm. Gross plant weight ranged from 871.67 g (NDC-23-9) to 1466.73 g (NDC-23-2) with a mean value of 1088.32 g. Harvest index ranged from 21.69 % (NDC-23-31) to 32.93 % (NDC-23-27) with a mean value of 25.53 %. TSS ranged from 4.97 0Brix (NDC-23-16) to 7.37 0Brix (NDC-23-12) with a mean value of 6.10 0Brix. Ascorbic acid ranged from 35.3 mg/100g (NDC-23-30) to 50.17mg/100g (NDC-23-27) with a mean value of 40.66mg/100g. Dry matter ranged from 10.33 % (NDC-23-12) to 14.70 % (NDC-23-28) with a mean value of 12.48 %. Moisture content ranged from 85.30 % (NDC-23-28) to 89.67 % (NDC-23-12) with a mean value of 87.53 %. Chlorophyll content ranged from 0.97 mg/g (NDC-23-25) to 1.13mg/g (NDC-23-28) with a mean value of 1.06 mg/g. Net curd weight ranged from 204.73 g (NDC-23-28) to 363.67 g (NDC-23-21) with a mean value of 276.34 g. Curd yield per plot ranged from 2.55 kg (NDC-23-28) to 4.90 kg (NDC-23-21) with a mean value of 3.39 kg.

The estimates of coefficients of variation revealed that magnitude of phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for all characters. Traits such as leaf width (14.32), stalk width (14.30), curd yield per plot (12.42) and net curd weight (11.38) recorded comparatively high PCV values, indicating a greater scope for selection based on phenotypic performance. Conversely, traits like moisture content (1.08) and chlorophyll content (4.13) exhibited low PCV, suggesting limited phenotypic variation. High GCV values were recorded for traits such as leaf width (12.95), stalk width (12.16), curd yield per plot (11.59) and net curd weight (9.59), suggesting strong genetic influence and the potential for effective improvement through selection. Traits like moisture content (1.14) and chlorophyll content (4.20) exhibited low GCV values, indicating limited genetic variability.

The estimates of heritability in the broad sense (h²) for the nineteen traits studied in cauliflower exhibited a wide range, reflecting the varying degrees of genetic control over these characters. High estimates of heritability (>80%) were observed for traits such as ascorbic acid content (92.10) followed by curd yield per plot (87.12), total soluble solids (84.77) and leaf width (81.70) suggesting that the phenotypic expression of these traits is largely governed by genetic factors with minimal environmental influence. Moderate heritability (>60% to <80%) was recorded for traits like days to curd initiation (74.41) followed by gross plant weight (73.40), net curd weight (71.02), days to curd maturity (69.91), dry matter content (68.35), moisture content (67.46), curd polar diameter (67.25), leaf length (66.42), and chlorophyll content (62.50), stalk length (62.35) and curd equatorial diameter (60.76). Low heritability (<60%) was recorded for traits like number of leaves per plant (55.35) followed by plant height (54.01) and harvest index (41.39). In a similar study, **Sharma *et al.* (2018)** also found similar results; high heritability estimates were observed for ascorbic acid (98.91%), harvest index (97.23%), and gross weight per plant (73.12%).

Genetic advance in per cent of mean was found to be high (>20%) for several traits, particularly leaf width (24.10), curd yield per plot (22.28) and stalk width (21.29). Moderate genetic advance in percent of mean (10 to 20%) were observed for traits such as net curd weight (16.65), total soluble solids (16.13), ascorbic acid (15.79), gross plant weight (15.75), days to curd initiation (14.24), stalk length (13.42), curd polar diameter (12.76), leaf length (11.90), days to curd maturity (11.78), curd equatorial diameter (11.50), number of leaves per plant (10.88) and dry matter content (10.58). This association of high heritability with high genetic advance suggests that the inheritance of these traits is predominantly due to additive gene effects, and that improvement through direct selection would be highly effective. Lowest genetic advance (<10%) as percent of the mean were observed for traits such as harvest index (9.32), plant height (5.41), chlorophyll content (5.32) and moisture content (1.50). Similar results were obtained by **Manaware *et al.* (2017),** genetic advance as percentage of mean ranged between 13.84% for stalk length at 45 DAT to 103.65% for curd length. The highest estimate of genetic advance as percentage of the mean was recorded for curd length, curd circumference, core length, curd width, curd yield per hectare, curd yield per plot, marketable curd yield, net curd weight, curd weight and total plant weight.

**Table 2. Analysis of variance (mean squares) for nineteen characters in cauliflower**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S.**  **No.** | **Traits** | **Source of variation** | | |
| **D.F** | **Replication** | **Treatments** | **Error** |
| **2** | **31** | **62** |
| 1. | Days to curd initiation | 23.59 | 262.11\*\* | 16.87 |
| 2. | Days to curd maturity | 15.87 | 280.45\*\* | 22.23 |
| 3. | Plant height(cm) | 1.79 | 20.36\*\* | 2.96 |
| 4. | Leaf length (cm) | 6.43 | 22.14\*\* | 2.03 |
| 5. | Leaf width (cm) | 1.06 | 21.49\*\* | 0.92 |
| 6. | Number of leaves per plant | 2.15 | 10.87\*\* | 1.51 |
| 7. | Stalk length (cm) | 2.435 | 2.049\*\* | 0.221 |
| 8. | Stalk width (cm) | 0.010 | 0.977\*\* | 0.070 |
| 9. | Curd polar diameter(cm) | 0.109 | 1.553\*\* | 0.138 |
| 10. | Curd equatorial diameter (cm) | 0.83 | 2.63\*\* | 0.30 |
| 11. | Gross plant weight (g) | 1016.61 | 50594.35\*\* | 3418.66 |
| 12. | Harvest index (%) | 0.68 | 20.68\*\* | 4.56 |
| 13. | Total soluble solids (0 Brix) | 0.16 | 1.39\*\* | 0.05 |
| 14. | Ascorbic acid (mg/100g) | 0.48 | 53.66\*\* | 0.91 |
| 15. | Dry matter content (%) | 0.44 | 3.28\*\* | 0.28 |
| 16. | Moisture content (%) | 0.12 | 3.28\*\* | 0.29 |
| 17. | Chlorophyll content (mg/g) | 0.0005 | 0.0068\*\* | 0.0007 |
| 18. | Net curd weight (g) | 356.77 | 3799.41\*\* | 286.64 |
| 19. | Curd yield per plot (kg) | 0.033 | 0.795\*\* | 0.023 |

**Table 3. Mean performance of 32 genotypes for nineteen characters in cauliflower**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Genotypes** | **Days to curd initiation** | **Days to curd maturity** | **Plant height (cm)** | **Leaf length (cm)** | **Leaf width (cm)** | **Number of leaves per plant** | **Stalk length (cm)** | **Stalk width (cm)** | **Curd polar diameter (cm)** | **Curd equatorial diameter (cm)** | **Gross plant weight (g)** | **Harvest index (%)** | **TSS (0 Brix)** | **Ascorbic acid (mg/100g)** | **Dry matter content (%)** | **Moisture content (%)** | **Chlorophyll content (mg/g)** | **Net curd weight (g)** | **Curd yield /plot (kg)** |
| **NDC-23-1** | 87.70 | 104.67 | 57.50 | 33.00 | 20.47 | 18.30 | 9.13 | 4.23 | 6.73 | 10.10 | 1105.60 | 25.10 | 6.50 | 36.50 | 13.90 | 86.10 | 0.97 | 277.67 | 3.47 |
| **NDC-23-2** | 76.90 | 95.20 | 49.73 | 28.33 | 20.43 | 19.40 | 7.17 | 3.60 | 7.60 | 10.57 | 1466.73 | 23.50 | 5.47 | 40.57 | 14.23 | 85.77 | 1.02 | 344.27 | 4.41 |
| **NDC-23-3** | 99.60 | 117.67 | 55.00 | 27.83 | 20.30 | 21.40 | 7.50 | 4.17 | 7.13 | 8.60 | 1226.70 | 21.69 | 5.47 | 37.03 | 12.00 | 88.00 | 1.04 | 266.03 | 3.28 |
| **NDC-23-4** | 76.10 | 94.70 | 52.43 | 29.90 | 19.70 | 18.50 | 6.70 | 3.90 | 8.50 | 10.87 | 1382.30 | 23.12 | 5.63 | 38.00 | 11.83 | 88.17 | 1.01 | 318.89 | 3.99 |
| **NDC-23-5** | 87.77 | 104.07 | 46.73 | 23.83 | 16.57 | 18.93 | 5.67 | 3.30 | 7.63 | 9.00 | 1152.07 | 23.60 | 6.03 | 42.53 | 11.27 | 88.73 | 1.04 | 271.44 | 3.15 |
| **NDC-23-6** | 87.90 | 105.27 | 49.43 | 25.60 | 15.83 | 19.03 | 6.83 | 2.67 | 6.90 | 10.50 | 1190.83 | 24.74 | 7.03 | 45.97 | 13.67 | 86.33 | 1.10 | 294.65 | 3.61 |
| **NDC-23-7** | 76.10 | 94.90 | 51.20 | 27.23 | 14.47 | 19.20 | 6.27 | 3.67 | 6.80 | 9.43 | 1067.03 | 23.23 | 6.60 | 41.07 | 13.03 | 86.97 | 1.13 | 247.70 | 3.00 |
| **NDC-23-8** | 79.30 | 95.00 | 51.23 | 25.13 | 16.73 | 19.20 | 7.90 | 2.43 | 6.93 | 10.27 | 935.20 | 26.88 | 6.23 | 38.30 | 12.10 | 87.90 | 1.01 | 250.51 | 3.16 |
| **NDC-23-9** | 77.23 | 95.27 | 52.73 | 23.30 | 13.90 | 17.93 | 8.10 | 3.50 | 6.30 | 8.17 | 871.67 | 24.14 | 5.77 | 41.00 | 12.03 | 87.97 | 1.10 | 210.10 | 2.55 |
| **NDC-23-10** | 76.60 | 91.70 | 51.20 | 31.07 | 16.44 | 17.97 | 7.93 | 4.00 | 7.03 | 9.90 | 973.13 | 26.01 | 7.07 | 45.40 | 12.77 | 87.23 | 1.07 | 252.37 | 2.92 |
| **NDC-23-11** | 90.97 | 107.47 | 47.33 | 25.51 | 18.71 | 18.57 | 7.00 | 3.57 | 6.50 | 8.87 | 1069.13 | 26.69 | 6.33 | 37.90 | 12.60 | 87.40 | 1.12 | 285.30 | 3.54 |
| **NDC-23-12** | 76.10 | 93.30 | 48.80 | 26.38 | 16.44 | 22.00 | 8.65 | 2.83 | 6.87 | 8.27 | 1078.73 | 26.38 | 7.37 | 36.27 | 10.33 | 89.67 | 1.10 | 284.83 | 3.39 |
| **NDC-23-13** | 90.67 | 107.33 | 56.13 | 29.67 | 19.33 | 16.47 | 8.86 | 4.13 | 6.30 | 9.83 | 1127.50 | 25.19 | 6.77 | 41.37 | 11.67 | 88.33 | 1.12 | 283.30 | 3.44 |
| **NDC-23-14** | 91.17 | 107.33 | 52.17 | 30.74 | 18.50 | 12.67 | 6.27 | 2.50 | 5.87 | 7.80 | 934.57 | 26.52 | 6.47 | 36.90 | 12.90 | 87.10 | 1.03 | 246.55 | 2.94 |
| **NDC-23-15** | 90.37 | 108.33 | 54.33 | 28.67 | 14.52 | 17.57 | 7.00 | 2.93 | 5.93 | 9.77 | 1125.33 | 25.78 | 5.43 | 39.57 | 14.00 | 86.00 | 1.04 | 290.17 | 3.57 |
| **NDC-23-16** | 76.10 | 95.40 | 53.40 | 29.19 | 13.94 | 18.47 | 6.48 | 2.77 | 7.23 | 10.70 | 1169.03 | 30.25 | 4.97 | 35.77 | 12.07 | 87.93 | 1.08 | 352.73 | 4.30 |
| **NDC-23-17** | 104.33 | 121.27 | 53.67 | 27.84 | 12.97 | 20.60 | 6.49 | 3.37 | 6.63 | 8.67 | 923.87 | 27.36 | 6.30 | 37.30 | 11.73 | 88.27 | 1.11 | 252.37 | 3.06 |
| **NDC-23-18** | 89.10 | 107.03 | 53.05 | 25.22 | 11.30 | 20.30 | 6.80 | 2.53 | 7.80 | 9.23 | 1034.03 | 26.96 | 5.23 | 40.63 | 11.27 | 88.73 | 1.06 | 278.00 | 3.33 |
| **NDC-23-19** | 102.33 | 121.70 | 52.94 | 30.87 | 14.33 | 18.70 | 7.97 | 3.30 | 5.90 | 9.10 | 1098.43 | 24.53 | 5.53 | 36.10 | 10.63 | 89.37 | 0.99 | 269.27 | 3.27 |
| **NDC-23-20** | 102.30 | 121.93 | 52.85 | 29.40 | 15.75 | 20.43 | 7.97 | 2.97 | 6.77 | 9.50 | 1107.60 | 24.43 | 5.10 | 36.00 | 12.73 | 87.27 | 1.11 | 270.70 | 3.20 |
| **NDC-23-21** | 75.57 | 94.40 | 52.40 | 27.33 | 13.85 | 20.43 | 7.47 | 3.90 | 8.53 | 10.50 | 1205.60 | 30.17 | 6.27 | 41.37 | 12.80 | 87.20 | 1.01 | 363.67 | 4.90 |
| **NDC-23-22** | 87.60 | 105.47 | 53.50 | 30.90 | 13.40 | 20.97 | 8.56 | 3.53 | 7.37 | 11.30 | 1016.40 | 30.41 | 5.53 | 47.43 | 10.77 | 89.23 | 1.10 | 307.57 | 3.77 |
| **NDC-23-23** | 90.23 | 105.73 | 53.52 | 27.23 | 13.99 | 22.23 | 7.03 | 3.97 | 6.37 | 8.73 | 1132.13 | 23.64 | 5.50 | 49.03 | 13.30 | 86.70 | 1.10 | 267.30 | 3.17 |
| **NDC-23-24** | 76.93 | 94.30 | 52.73 | 27.55 | 14.61 | 21.40 | 6.03 | 3.57 | 7.53 | 8.73 | 1137.53 | 22.73 | 6.97 | 45.43 | 12.10 | 87.90 | 1.02 | 258.53 | 3.14 |
| **NDC-23-25** | 86.73 | 103.10 | 48.38 | 27.33 | 12.56 | 21.60 | 7.20 | 4.27 | 8.40 | 11.33 | 1116.00 | 26.61 | 6.43 | 41.30 | 12.83 | 87.17 | 0.97 | 293.80 | 4.08 |
| **NDC-23-26** | 99.23 | 118.67 | 48.19 | 29.07 | 13.69 | 18.60 | 7.27 | 4.30 | 6.27 | 10.17 | 1012.03 | 27.01 | 5.83 | 47.27 | 13.87 | 86.13 | 1.04 | 272.57 | 3.29 |
| **NDC-23-27** | 88.23 | 104.37 | 50.29 | 29.37 | 14.79 | 19.87 | 7.90 | 3.27 | 7.53 | 10.07 | 903.17 | 32.93 | 6.80 | 50.17 | 12.70 | 87.30 | 1.07 | 297.07 | 3.47 |
| **NDC-23-28** | 76.97 | 95.10 | 52.93 | 31.70 | 13.29 | 21.50 | 7.37 | 3.53 | 6.90 | 8.83 | 888.67 | 23.20 | 5.27 | 36.37 | 14.70 | 85.30 | 1.13 | 204.73 | 2.56 |
| **NDC-23-29** | 100.10 | 118.97 | 51.90 | 25.03 | 11.89 | 19.37 | 6.83 | 4.07 | 8.00 | 8.33 | 1116.83 | 25.15 | 6.83 | 38.90 | 12.37 | 87.63 | 1.12 | 280.93 | 3.41 |
| **NDC-23-30** | 101.57 | 121.03 | 55.53 | 31.47 | 14.59 | 17.23 | 7.63 | 4.33 | 7.40 | 9.40 | 1145.30 | 23.65 | 6.87 | 35.30 | 12.03 | 87.97 | 1.10 | 270.70 | 3.17 |
| **NDC-23-31** | 88.73 | 105.77 | 53.93 | 24.83 | 14.17 | 18.00 | 7.50 | 3.77 | 6.73 | 9.73 | 1034.00 | 21.70 | 5.17 | 40.20 | 12.60 | 87.40 | 1.08 | 223.61 | 2.68 |
| **Pusa Himjyoti** | 86.93 | 105.50 | 55.97 | 34.53 | 19.87 | 20.03 | 7.03 | 3.27 | 7.07 | 8.80 | 1079.03 | 23.65 | 6.47 | 44.17 | 12.37 | 87.63 | 1.06 | 255.47 | 3.23 |
| **Mean** | **87.42** | **105.06** | **52.22** | **28.28** | **15.67** | **19.28** | **7.33** | **3.50** | **7.05** | **9.53** | **1088.32** | **25.53** | **6.10** | **40.66** | **12.48** | **87.53** | **1.06** | **276.34** | **3.39** |
| **Min** | 75.57 | 91.70 | 46.73 | 23.30 | 11.30 | 12.67 | 5.67 | 2.43 | 5.87 | 7.80 | 871.67 | 21.69 | 4.97 | 35.30 | 10.33 | 85.30 | 0.97 | 204.73 | 2.55 |
| **Max** | 104.33 | 121.93 | 57.50 | 34.53 | 20.47 | 22.23 | 9.13 | 4.33 | 8.53 | 11.33 | 1466.73 | 32.93 | 7.37 | 50.17 | 14.70 | 89.67 | 1.13 | 363.67 | 4.90 |
| **SE(d) ±** | 3.35 | 3.85 | 1.41 | 1.16 | 0.78 | 1.00 | 0.38 | 0.22 | 0.30 | 0.45 | 47.74 | 1.74 | 0.18 | 0.78 | 0.43 | 0.44 | 0.02 | 13.82 | 0.12 |
| **C.D. at 5%** | 6.72 | 7.71 | 2.82 | 2.33 | 1.57 | 2.01 | 0.77 | 0.43 | 0.61 | 0.90 | 95.66 | 3.50 | 0.36 | 1.56 | 0.86 | 0.88 | 0.04 | 27.70 | 0.25 |
| **C.V. (%)** | 4.70 | 4.49 | 3.30 | 5.04 | 6.13 | 6.37 | 6.41 | 7.53 | 5.27 | 5.75 | 5.37 | 8.37 | 3.60 | 2.34 | 4.23 | 0.61 | 2.54 | 6.13 | 4.46 |

**Table 4. Estimates of grand mean, range, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability in broad sense and Genetic advance in percent of mean for nineteen characters in cauliflower germplasm**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Characters** | **Mean** | **Min.** | **Max**. | **Heritability (%)** | **GA% mean** | **GCV (%)** | **PCV (%)** |
| **Days to curd initiation** | 87.42 | 75.57 | 104.33 | 74.41 | 14.24 | 8.01 | 9.29 |
| **Days to curd maturity** | 105.06 | 91.70 | 121.93 | 69.91 | 11.78 | 6.84 | 8.18 |
| **Plant height (cm)** | 52.22 | 46.73 | 57.50 | 54.01 | 5.41 | 3.57 | 4.86 |
| **Leaf length (cm)** | 28.28 | 23.30 | 34.53 | 66.42 | 11.90 | 7.09 | 8.70 |
| **Leaf width (cm)** | 15.67 | 11.30 | 20.47 | 81.70 | 24.10 | 12.95 | 14.32 |
| **Number of leaves per plant** | 19.28 | 12.67 | 22.23 | 55.35 | 10.88 | 7.10 | 9.54 |
| **Stalk length (cm)** | 7.33 | 5.67 | 9.13 | 62.35 | 13.42 | 8.25 | 10.45 |
| **Stalk width (cm)** | 3.50 | 2.43 | 4.33 | 72.28 | 21.29 | 12.16 | 14.30 |
| **Curd polar diameter (cm)** | 7.05 | 5.87 | 8.53 | 67.25 | 12.76 | 7.55 | 9.21 |
| **Curd equatorial diameter (cm)** | 9.53 | 7.80 | 11.33 | 60.76 | 11.50 | 7.16 | 9.19 |
| **Gross plant weight (g)** | 1088.32 | 871.67 | 1466.73 | 73.40 | 15.75 | 8.93 | 10.42 |
| **Harvest index (%)** | 25.53 | 21.69 | 32.93 | 41.39 | 9.32 | 7.03 | 10.93 |
| **Total soluble solids ( 0Brix)** | 6.10 | 4.97 | 7.37 | 84.77 | 16.13 | 8.50 | 9.24 |
| **Ascorbic acid (mg/100g)** | 40.66 | 35.30 | 50.17 | 92.10 | 15.79 | 7.99 | 8.32 |
| **Dry matter content (%)** | 12.48 | 10.33 | 14.70 | 68.35 | 10.58 | 6.21 | 7.52 |
| **Moisture content (%)** | 87.53 | 85.30 | 89.67 | 67.46 | 1.50 | 0.88 | 1.08 |
| **Chlorophyll content (mg/g)** | 1.06 | 0.97 | 1.13 | 62.50 | 5.32 | 3.27 | 4.13 |
| **Net curd weight (g)** | 276.34 | 204.73 | 363.67 | 71.02 | 16.65 | 9.59 | 11.38 |
| **Curd yield per plot (kg)** | 3.39 | 2.55 | 4.90 | 87.12 | 22.28 | 11.59 | 12.42 |

**CONCLUSION**

Among the thirty-two genotypes evaluated, NDC-23-21 followed by NDC-23-16, exhibited superior performance in terms of curd yield per plot. For all the traits studied, the phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV), indicating a significant influence of the environment on trait expression. Notably, traits such as leaf width, stalk width, curd yield per plot and net curd weight showed comparatively high values of both PCV and GCV. This suggests substantial genetic variability, indicating that selection for yield improvement based on these traits would be effective. Furthermore, traits including net curd weight, gross plant weight, days to curd initiation, and curd yield per plot exhibited high heritability coupled with high genetic advance as a percentage of the mean. This combination suggests that the inheritance of these traits is primarily controlled by additive gene effects, and hence, direct selection for these traits is likely to result in significant genetic improvement.

**Disclaimer (Artificial intelligence)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, manuscript.

**REFERENCES**

1. **National Horticulture Board.** 2023-2024. Horticultural database. Ministry of Agriculture and Farmers Welfare, Government of India.
2. **Burton, G. W. and DeVane, E. W.** 1953. Estimating heritability in tall fescue (Festuca arundinacea) from replicated clonal material. Agronomy Journal, 45(10): 478–481.
3. **Gopalan, C., Rama Sastri, B. V., Balasubramanian, S. C., Narasinga Rao, B. S., Deosthala, Y. G. and Pant, K. C.** 2011. Nutritive value of Indian foods. Indian Council of Medical Research. 89–91.
4. **Johnson, H. W., Robinson, H. F. and Comstock, R. E.** 1955. Estimates of genetic and environmental variability in soybean. Agronomy Journal, 47(7): 314–318.
5. **Hanson, C. H., Robinson, H. F. and Comstock, R. E.** 1956. Biometrical studies of yield in segregating populations of Korean Lespedeza. Agronomy Journal, 48: 268–272.
6. **Kanwar, M. S.** 2023. Performance and genetic evaluation of some cauliflower genotypes in dry temperate Ladakh region of India. International Journal of Plant and Soil Science, 35(17): 422–427.
7. **Manaware, D., Naidu, A. K. and Lal, N.** 2017. Genetic diversity assessment for growth and yield traits in cauliflower. International Journal of Current Microbiology and Applied Sciences, 6(8): 3016–3027.
8. **Meena, M. L., Ram, R. B., Lata, R. and Sharma, S. R.** 2012. Estimates of genetic variability and correlation studies for some quality traits in cabbage (Brassica oleracea var. capitata). Indian Journal of Agricultural Sciences, 82(4): 370.
9. **Nimkar, S. A. and Korla, B. N.** 2014. Studies on comparison of biparental and F4 progenies in late cauliflower (Brassica oleracea L. var. botrytis). Journal of Farm Sciences, 4: 27–34.
10. **Panse, V. G. and Sukhatme, P. V.** 2000. Statistical methods for agricultural workers (4th ed., p. 328). Indian Council of Agricultural Research.
11. **Thamburaj, T. and Singh, N.** 2001. Textbook of vegetables, tuber crops and spices (p. 327). ICAR Publication.
12. **Singh, S. P. and Dogra, R. K.** 2013. Studies on character association in some genotypes of cauliflower under mid hill conditions of western Himalayas. Asian Journal of Horticulture, 8(1): 29–31.
13. **Sharma, S., Singh, Y., Sharma, S. and Sekhon, B. S.** 2018. Variability studies in cauliflower (Brassica oleracea L. var. botrytis L.) for horticultural traits under mid hill conditions of North-Western Himalayas, India. Journal of Pharmacognosy and Phytochemistry, 7(2): 100–103.
14. **Xiangjun, Z., Joyce, V. E. and Li, L.** 2006. Use of cauliflower Or gene for improving crop nutritional quality. Biotechnology Annual Review, 14: 105–111.
15. Rana, N., Sharma, A., Kumari, V., Lata, H., Kaur, M., & Thakur, A. (2024). Assessment of genetic variability and character association in mid-late/late cauliflower genotypes. Electronic Journal of Plant Breeding, 15(1), 70-79.
16. Singh, S., & Kalia, P. (2021). Advances in cauliflower (Brassica oleracea var. botrytis L.) breeding, with emphasis on India. Advances in Plant Breeding Strategies: Vegetable Crops: Volume 10: Leaves, Flowerheads, Green Pods, Mushrooms and Truffles, 247-301.
17. Singh, Jagmeet, Akhilesh Sharma, Aman Deep Ranga, and Mukesh Kumar Bairwa. 2022a. “Genetic Studies for Selection Parameters in Cauliflower (Brassica Oleracea L. Var. Botrytis): A Review”. International Journal of Plant & Soil Science 34 (24):785-95. <https://doi.org/10.9734/ijpss/2022/v34i242702>.
18. Singh, Vipul Pratap, Surabhi Sharma, Kulveer Singh Yadav, Shubham Gupta, and Munendra Gangwar. 2022b. “Factors Affecting Production of Cauliflower: A Review”. International Journal of Environment and Climate Change 12 (11):2425-31. https://doi.org/10.9734/ijecc/2022/v12i1131235.