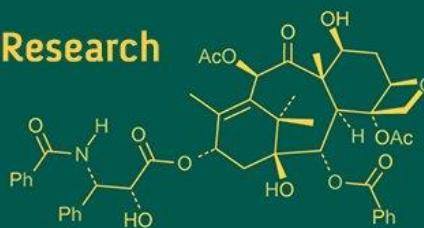


## International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693  
ISSN Online: 2617-4707  
NAAS Rating (2026): 5.29  
IJABR 2026; SP-10(6): 666-671  
[www.biochemjournal.com](http://www.biochemjournal.com)  
Received: 26-03-2026  
Accepted: 29-04-2026

**Deepak Bijarniya**  
Stress Physiology Lab,  
Division of Genetics & Plant  
Breeding, SKUAST-Kashmir,  
Wadura, Jammu & Kashmir,  
India

**Neha Yadav**  
CSA University of Agriculture  
and Technology, Kanpur,  
Uttar Pradesh, India

**Chandragupt Maurya**  
CSA University of Agriculture  
and Technology, Kanpur,  
Uttar Pradesh, India

**Nikhil Kumar**  
CSA University of Agriculture  
and Technology, Kanpur,  
Uttar Pradesh, India

**Vikash Tyagi**  
Sardar Vallabhbhai Patel  
University of Agriculture &  
Technology, Meerut, Uttar  
Pradesh, India

**Rishabh Singh**  
CSA University of Agriculture  
and Technology, Kanpur,  
Uttar Pradesh, India

**Dharmendra Bahadur Singh**  
CSA University of Agriculture  
and Technology, Kanpur,  
Uttar Pradesh, India

**Anurag**  
CSA University of Agriculture  
and Technology, Kanpur,  
Uttar Pradesh, India

**Corresponding Author:**  
**Deepak Bijarniya**  
Stress Physiology Lab,  
Division of Genetics & Plant  
Breeding, SKUAST-Kashmir,  
Wadura, Jammu & Kashmir,  
India

## Characterization and association studies of cowpea (*Vigna unguiculata* L.) core set germplasm for agro-morphological traits under Western Himalayan conditions

**Deepak Bijarniya, Neha Yadav, Chandragupt Maurya, Nikhil Kumar, Vikash Tyagi, Rishabh Singh, Dharmendra Bahadur Singh and Anurag**

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i6Sh.8688>

### Abstract

The present study was conducted to assess the extent of genetic variability and character association among 254 cowpea genotypes using twelve important agro-morphological traits. Significant variability was observed for all traits, indicating genetic diversity within the germplasm. Days to 50% flowering and days to maturity ranged from 52-93 and 73-140 days, respectively, while plant height varied widely from 33 to 370 cm. Considerable variation was also recorded for pod length (8.00-31.67 cm), pod breadth (4.23-12.20 mm), pod width (4.10-9.67 mm), pods per plant (7-45), seeds per pod (7-21), and 100-seed weight (3.80-30.82 g). High coefficients of variation were observed for seed yield per plant, pods per plant, plant height, and 100-seed weight, suggesting greater scope for effective selection. Early flowering and early maturing genotypes such as EC-738159 and IC-259075 were identified as promising lines. Raincloud plots effectively depicted trait distribution and variability among genotypes. Pearson's correlation analysis revealed positive associations of seed yield per plant with number of pods per plant and 100-seed weight, indicating their importance in yield improvement. PCA biplot analysis explained 42.1% of the total variation through the first two principal components and highlighted major traits contributing to diversity. The study identified diverse and promising cowpea genotypes that can be effectively utilised in future breeding programmes aimed at developing high-yielding and early-maturing cultivars.

**Keywords:** Cowpea, genetic variability, character association, agro-morphological traits

### 1. Introduction

Cowpea (*Vigna unguiculata* (L.) Walp.) is an annual leguminous plant, which belongs to the family Leguminosae and subfamily Papilionioideae. It is a diploid with  $2n = 2x = 22$ , genome size of about 620 million base pairs (Abraha *et al.* 2024) [1] and native plant from Africa that is now widespread and cultivated worldwide (Herniter *et al.* 2020) [8]. Among legumes, cowpea has emerged as a promising crop for food security and nutrition (Da Silva *et al.* 2018) [4], its grains consist of up to 33% protein, 63% carbohydrates, and 4.6% lipids (Jayatilake *et al.*, 2018) [11]. They are low in fats (<2%) and salt (16 mg/100 g), but high in potassium (1112 mg/100 g) and dietary fiber (~11%) (U.S. Department of Agriculture [USDA], 2021). Cowpea protein is rich in essential amino acids, except for cysteine and methionine. It is grown as a multipurpose crop (seed, fodder and vegetable) throughout the tropics and subtropics, especially in India grown in arid and semi-arid regions in both summer and rainy seasons. According to the Food and Agriculture Organization (FAO), the global cowpea production in 2021 was approximately 8.99 million metric tons harvested from an area of around 14.91 million hectares (FAOSTAT, 2024) [7]. In India, it is cultivated mainly in Rajasthan, Maharashtra, Karnataka, Gujarat, Tamil Nadu, Andhra Pradesh, Madhya Pradesh and area under this crop was 55,800 hectares with a production of 35,600 tonnes with productivity of 638.6 kg per ha (INDIASTAT, 2024) [10]. Cowpea is a drought tolerant and warm weather crop. The drought hardy nature of cowpea crop enables it to maintain some growth under moisture stress conditions (Bijarniya *et al.*, 2024) [2]. This trait is also extended by deep rooting habits of some varieties and accounts for the crop's ability to grow and yield under semi desert conditions (Soni *et al.*, 2018) [20].

Cowpea cultivation is primarily carried out by small-scale farmers in various regions worldwide, under arid conditions due to its natural resistance to drought and capability to fix atmospheric nitrogen, thereby improving soil fertility (B. B. Singh *et al.*, 1997; B. B. Singh, 2014; Boukar *et al.*, 2019; Horn & Shimelis, 2020) <sup>[17, 18, 3, 8]</sup>. Any crop improvement program depends on the utilization of germplasm stock available in different research organisations/institutes. The germplasm is valuable as they possess a huge treasure of genetic material which may prove valuable in future crop development and improvement programs. Agro-morphological characterisation of germplasm is fundamental in order to provide information for plant breeding programs (Das and Ghosh., 2011) <sup>[5]</sup>. The main objective of the present study was to characterise 254 genotypes of cowpea using twelve agro-morphological characters to provide useful information to facilitate the choice of genitors for cowpea plant breeding programs.

## 2. Materials and Methods

**2.1 Site of the experiment:** The experiment was undertaken during 2023 at research field and Stress physiology laboratory of the Division of Genetics and Plant Breeding, Faculty of Agriculture, Wadura, SKUAST-K (34° 17' North and 74° 33' East at an altitude of 1594 masl). The soil of the experimental site is typical incept soil with clay loam texture. The pH was almost neutral (7.2), with organic carbon 0.65%, electrical conductivity of 0.18 dS/m and CEC of 16 meq/kg. The mean minimum and maximum 0 temperatures (May-September) were 10.63 °C and 22.48 °C, with the lowest (16.43 °C) and highest (25.61 °C) maximum recorded in May and July respectively.

**2.2 Experimental material:** A set of 254 genotypes of cowpea representing a diverse set of national core set NBPGR (National Bureau of Plant Genetic Resources), New Delhi, including four checks (SHCP-1, SHCP-2, WCP-1, WCP-2) which were released by SKUAST-Kashmir.

**2.3 Experimental design:** All the accessions were grown as four rows of four-meter length, with 15 cm x 40 cm spacing, in an augmented block design (ABD) with four checks.

**2.4 Crop management:** The management practices were uniform and homogeneous and comprised of seed treatment with the fungicide (Captan 50WP) and the insecticide (Imidacloprid 17.8%) at the rate of 2 ml/kg seed. Application of the pre-emergent herbicide Pendimethalin at a dose of 1.25l/ha was done along with timely manual weeding. The recommended dose of fertilizers (NPK) comprising a basal dose and a top dressing of urea at the V3 stage (first open trifoliate leaf) was applied. The crop was irrigated intermittently to avoid drought stress that would have confounded the results.

## 3. Agro-morphological traits recorded in the present study

Phenotypic characterization was carried out based on 12 agro-morphological traits using the ICAR-NBPGR plant descriptors for cowpea.

**3.1 Days to 50% flowering:** The number of days from sowing to the date when 50% of plants in each plot-initiated

flowering was recorded and the average number of days for 50% flowering was calculated.

**3.2 Days to maturity:** The number of days taken from the day of sowing to the physiological maturity of the crop was recorded as days to maturity.

**3.3 Plant height (cm):** The plant height was measured as length of the shoot from the base of the stem to the tip of canopy and measured after completion of flowering.

**3.4 Number of primary branches:** Branches arising from main stem were considered as basal or primary branches which were counted and recorded at the time of harvest.

**3.5 Number of internodes:** Number of internodes counted and recorded at the time of harvest.

**3.6 Pods per plant:** The total number of pods per plant was counted and recorded, when the flowering was completed.

**3.7 Pod length (cm):** The pod length was measured as the average length of pods cm using a scale.

**3.8 Pod breadth (mm):** Pod breadth was measured as the average breadth of pods in mm using vernier caliper.

**3.9 Pod thickness (mm):** The pod thickness was measured as the average thickness of pods in mm using vernier caliper.

**3.10 Seeds per pods:** The number of seeds was counted from randomly selected pods in each tagged plant and average was calculated.

**3.11 100 seed weight (gm):** 100-seed weight of three randomly drawn samples of sun-dried seeds from each experimental plot was weighed in grams and averaged.

**3.12 Seed yield per plant (gm):** The yield of seed obtained from selected plants from each experimental plot was weighed and averaged to single plant basis in grams.

## 4. Results

**4.1 Variability for Agro-morphological traits:** There was substantial variability in twelve agro-morphological traits in 254 genotypes of cowpea core collection indicating significant diversity of the material in respect of agro-morpho traits (Table 1).

### 4.1.1 Days to 50% flowering

Days to 50% flowering had a mean value of 71.29±0.40 with a range of 52.00 to 93.00 and CV of 9.10. Among genotypes, EC-738159 (52), IC-590841 (56), EC-8969 (60) EC-100034 (60) and EC-738091 (60) were earliest to flower whereas the genotypes IC-199702 (93) took highest number of days to flower.

### 4.1.2 Days to maturity

Days to maturity had a mean value of 105.04±0.66 with a range of 75.00 to 140.00 and CV of 10.00. Among genotypes, EC-738159 (73), IC-259075 (75), IC-385869 (77), IC-447797 (78) and IC-687886 (88) were earliest to

maturity whereas the genotype IC-199702 (140) took height number of days maturity.

#### 4.1.3 Plant height (cm)

Plant height had a mean value of  $156.38 \pm 3.57$  with a range of 33.00 to 370.00 and CV of 36.40. Among genotypes, EC-738233 (370), IC-978007 (315), IC-331106 (310), IC-58905 (305) and EC-390280 (302) were tall whereas the genotype IC-415416 (33) was short in height.

#### 4.1.4 Pod length (cm)

Pod length had a mean value of  $15.56 \pm 0.21$  with a range of 8.00 to 31.67 and CV of 21.80. Highest pod length was recorded in IC471926 (31.67cm), IC58905 (28.40), WFC-3 (23.67), EC107192 (22.60) and EC109493-1047-1 (22.60) while as lowest value for pod length was recorded in IC202710 (8 cm).

#### 4.1.5 Pod breadth (mm)

Pod breadth had a mean value of  $7.44 \pm 0.08$  with a range of 4.23 to 12.2 and CV of 18.9. Highest pod breadth was recorded in EC724805 (12.20), EC723822 (10.97), EC724239 (10.80), EC100034 (10.77), and EC725103 (10.70) while as lowest value for pod breadth was recorded in IC397618 (4.23).

#### 4.1.6 Pod width (mm)

Pod width had a mean value of  $6.06 \pm 0.06$  with a range of 4.10 to 9.67 and CV of 18.20. The highest pod width was recorded in IC413324 (9.67), EC244130 (9.20), EC724805 (9.10) and EC107163 (8.53) while as lowest value for pod width was recorded in IC383461 (4.10).

#### 4.1.7 Pods per plant

Pods per plant had a mean value of  $22.16 \pm 0.53$  with a range of 7 to 45 and CV of 38.30. Among genotypes, EC-724160 (45) EC-738091 (44) IC-515708 (43) EC-738277 (41) and EC-738089 (41) had a greater number of pods per plant whereas the genotype EC-4221 (7) had lesser number of pods per plant.

#### 4.1.8 Number of seeds per pod

Seeds per pod had a mean value of  $13.75 \pm 0.15$  with a range of 7.00 to 21.00 and CV of 18.20. Among genotypes, EC-98661 (21), EC-98678 (21), IC-97807 (20), EC-244071 (20)

and EC-18734 (19) had maximum number of seeds per pods whereas genotypes IC-372722 (7), EC-16205 (8), IC-372726 (9), EC-738092 (9) and IC-202710 (9) had minimum number of seeds per pod.

#### 4.1.9 100 seed weight (g)

The 100 seed weight had a mean value of  $15.15 \pm 0.32$  (g) with a range of 3.80 to 30.82 and CV 52.90. Among genotypes, seed weight in genotypes EC-244130 (26.58 g), EC-724805 (27.3 g), IC-91446 (28.15 g), IC-337287 (28.15 g) and IC-319513 (30.82 g) was maximum whereas genotype IC-337287 (3.8 g) had minimum seed weight.

#### 4.2 Raincloud plots for agro-morphological traits

A raincloud plot is a hybrid of a dot plot, box plot and kernel density plot, which shows peaks in data. It is used to visualise the distribution of numerical data. They show in data the overall shape of the distribution, the location of center (median), how spread out the data and the presence of any outliers. The variation pattern for 12 agro-morphological traits is presented inform of raincloud plots (figure 1).

#### 4.3 Pearson's correlation among agro-morphological traits

A heat map of 12 agro-morphological traits shows trait correlation in terms of colour and intensity was also created based on the different trait associations. Positive correlation is represented with the colour grey, negative correlation with the colour red, and no correlation with the colour orange. Figure 2 presents a heat map of 12 agro-morphological traits.

#### 4.4 PCA biplot for agro-morphological traits

The biplot was constructed based on 1<sup>st</sup> two PCs that accounted for 42.1 percent of variation in order to capture the most significant trait contribution towards the total variation as well as their relationship with the trait of interest. PC relation of the 1<sup>st</sup> two PCs that were used to construct the biplot (Figure 3). In terms of the biplot the relationship and the variance contribution are depicted in terms of the angle between the traits and length of arrow respectively. In terms of biplot seed yield per plant was significantly positively correlated with 100 seed weight and number of pods per.

**Table 1:** Descriptive statistics of agro-morphological traits

| Statistic | Minimum | Maximum | Mean   | + SE | Sd    | CV (%) |
|-----------|---------|---------|--------|------|-------|--------|
| DF        | 52      | 93      | 71.29  | 0.4  | 6.5   | 9.1    |
| DM        | 75      | 140     | 105.04 | 0.66 | 10.53 | 10     |
| PH        | 33      | 370     | 156.38 | 3.57 | 56.95 | 36.4   |
| NPB       | 0       | 13      | 4.01   | 0.13 | 2.17  | 54.3   |
| NI        | 4       | 32      | 14.63  | 0.28 | 4.49  | 30.07  |
| PPP       | 7       | 45      | 22.16  | 0.53 | 8.48  | 38.3   |
| PL        | 8       | 31.67   | 15.56  | 0.21 | 3.39  | 21.8   |
| PB        | 4.23    | 12.2    | 7.44   | 0.08 | 1.4   | 18.9   |
| PT        | 4.1     | 9.67    | 6.06   | 0.06 | 0.95  | 18.2   |
| SPP       | 7       | 21      | 13.75  | 0.15 | 2.49  | 18.2   |
| 100SW     | 3.8     | 30.82   | 15.15  | 0.32 | 5.12  | 33.8   |
| SYPP      | 7.17    | 143.83  | 40.46  | 1.35 | 21.5  | 52.9   |

Trait legends: DF-Days to 50% flowering, DM-Days to maturity, PH-Plant height (cm), NPB-Number of primary branches, NI-Number of internodes, PPP-Pods per plant,

PL-Pod length (cm), PB-Pod breadth (mm), PT-Pod thickness (mm), SPP-Seeds per pod, 100SW-Seed weight (gm), SYPP-Seed yield per plant (gm).

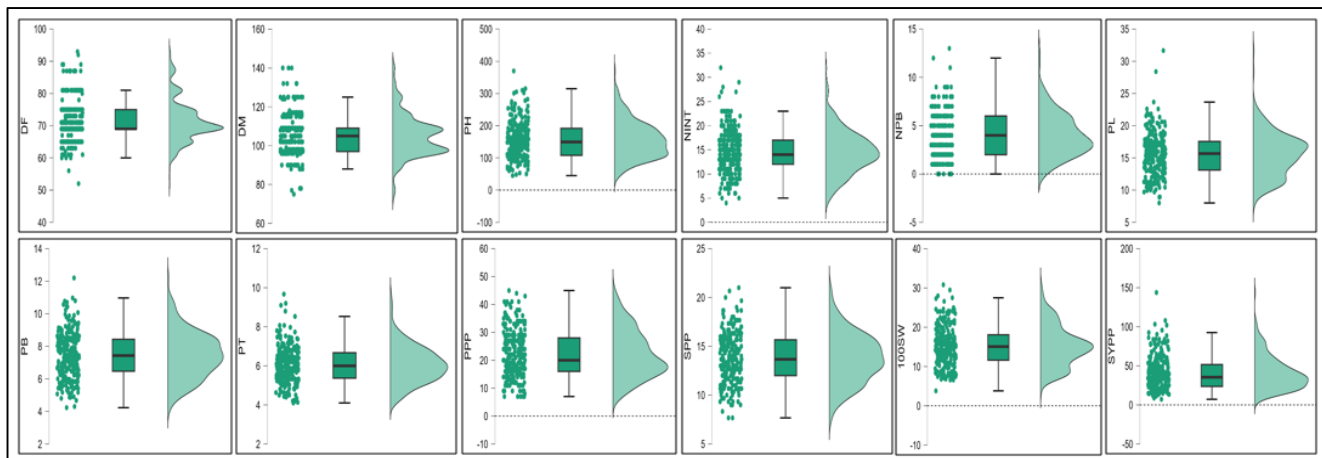


**Fig 1:** Raincloud plots of distribution of agro-morphological traits, Where DF-Number of days to 50% flowering, DM-Number of days to maturity, PH-Plant height (cm), PL-Pod length (cm), PB-Pod breadth (mm), PT-Pod thickness (mm). PPP-Number of pods per plant, SPP-Number of seeds per pod, 100SW-Seed weight (gm), SYPP-Seed yield per plant (gm).

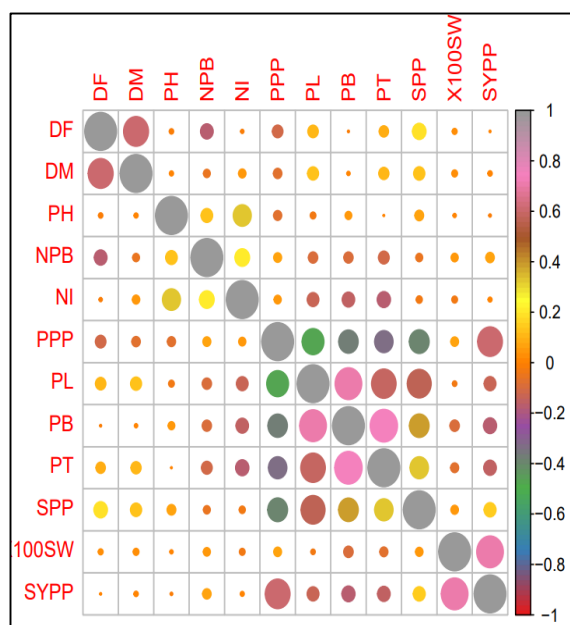


**Fig 2:** Heat map of agro-morphological traits, Where, DF-Number of days to 50% flowering, DM-Number of days to maturity, PH-Plant height (cm), NPB-Number of primary branches, NI-Number of internodes, PPP-Number of pods per plant, PL-Pod length (cm), PB-Pod breadth (mm), PT-Pod thickness (mm), SPP-Number of seeds per pod, 100SW-Seed weight (gm), SYPP-Seed yield per plant (gm).

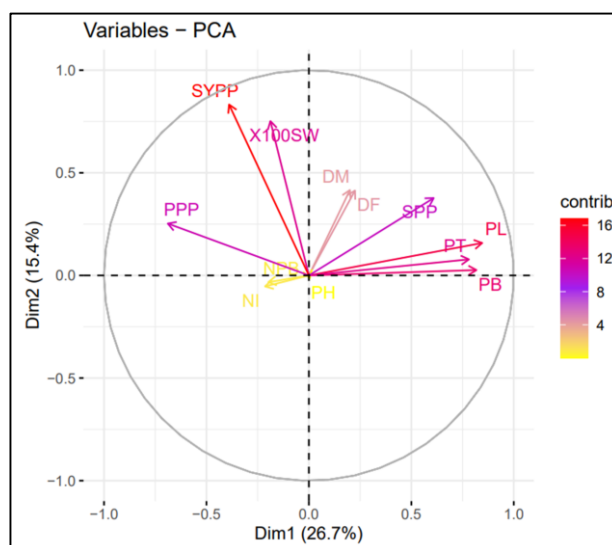


**Fig 3:** PCA Biplot of various agro-morphological traits, where, DF-Number of days to 50% flowering, DM-Number of days to maturity, PH-Plant height (cm), NPB-Number of primary branches, NI-Number of internodes, PPP-Number of pods per plant, PL-Pod length (cm), PB-Pod breadth (mm), PT-Pod thickness (mm), SPP-Number of seeds per pod, X100SW-Seed weight (gm), SYPP-Seed yield per plant (gm).

## 5. Discussion

The success of any crop improvement program relies heavily on the magnitude and nature of genetic variability present within the germplasm. In this study, the evaluation of 254 genotypes belonging to the cowpea (*Vigna unguiculata* (L.) Walp.) core collection revealed phenotypic diversity across all twelve agro-morphological traits. This high degree of variation indicates that the core collection represents a robust gene pool capable of providing valuable parents for direct selection and hybridization. Wide morphological diversity within expansive cowpea germplasm lines is highly advantageous, offering rich genetic resource pools required to improve yields and climate resilience (Digrado *et al.*, 2022) <sup>[6]</sup>.

The present study documented the presence of wide genetic variability among the cowpea genotypes for days to 50% flowering, days to maturity, plant height, number of primary branches per plant, number of pods per plant, pod length, number of seeds per pod, 100 seed weight and seed yield per plant. These findings were in line with the findings of Kiran *et al.* (2020) <sup>[12]</sup> and Hulsure *et al.* (2022) <sup>[9]</sup>.

Two distinct groups could be identified for plant height that fall into bush and pole types. The importance of plant height is largely based on the ability of a plant to produce substantial biomass that could support a better pod and seed load, especially by influencing the number of branches and flowers. The considerable amount of variation recorded for pod length (cm), pod breadth (mm) and pod width (mm) traits have also been reported by several earlier workers, (Tiware and Bhatia, 1995) <sup>[21]</sup> and (Krisnawati *et al.*, 2017) <sup>[13]</sup>.

Among 12 agro-morphological traits, seed yield per plant was positively correlated with pods per plant and 100-seed weight. The number of days to maturity positively correlated with days to 50 percent flowering. Similar results have also been reported by (Manggoel *et al.*, 2013) <sup>[14]</sup> (Rana *et al.*, 2015) <sup>[16]</sup> and (Sofi *et al.*, 2022) <sup>[19]</sup>. The number of pods per plant, plant height, and principal and secondary branches all showed a significant correlation. Plant height, 100-seed weight, and primary and secondary branches were also significantly correlated, surpassing previously reported by (Owusu *et al.*, 2021) <sup>[15]</sup>.

## 6. Conclusion

The study found significant variability for agro-morphological traits with a broad range of trait values, indicating the presence of wide genetic variability in the cowpea genotypes for days to 50 percent flowering, days to maturity, plant height, number of primary branches per plant, number of pods per plant, pod length, number of seeds per pod, 100 seed weight and seed yield per plant. A number of genotypes were found to have significantly better performance as compared to checks for maturity and yield parameters. The large group of genotypes exhibited desirable performance with respect to maturity and yield parameters.

## References

1. Abbraha R, Badji A, Ozimati A, Mukankusi C, Edema R, Ekwamu A, *et al.* Advancing resilient legume crops for sustainable agriculture and feeding Africa: genetics and genomics studies on cowpea and common bean. *Afr J Rural Dev.* 2024;9(1):16-36.
2. Bijarniya D, Shafi S, Zaffar A, Riyaz I, Fatima S, Zargar SM, *et al.* Identification of resistant sources for pod shattering in a cowpea (*Vigna unguiculata* L.) core collection using a modified screening system based on weighted level scores using random impact method. *Plant Genet Resour.* 2024;22(6):378-384.
3. Boukar O, Togola A, Chamarthi S, Belko N, Ishikawa H, Suzuki K, *et al.* Cowpea [*Vigna unguiculata* (L.) Walp.] breeding. In: Al-Khayri JM, Jain SM, Johnson DV, editors. *Advances in Plant Breeding Strategies: Legumes.* Vol. 7. Cham: Springer; 2019. p. 201-243.
4. Da Silva AC, Da Costa Santos D, Junior DLT, Da Silva PB, Dos Santos RC, Siviero A. Cowpea: a strategic legume species for food security and health. In: *Legume Seed Nutraceutical Research.* London: IntechOpen; 2018.
5. Das S, Ghosh A. Characterization of rice germplasm of West Bengal. *Oryza.* 2011;47(3):201-205.
6. Digrado A, Gonzalez-Escobar E, Owston N, Page R, Mohammed SB, Umar ML, *et al.* Cowpea leaf width correlates with above ground biomass across diverse environments. *Legume Sci.* 2022;4(4):e144.
7. FAOSTAT. FAOSTAT database [Internet]. Rome: Food and Agriculture Organization of the United Nations; 2024 [cited 2026 Jun 11]. Available from: <https://www.fao.org/faostat/en/#home>
8. Herniter IA, Muñoz-Amatriáin M, Close TJ. Genetic, textual, and archeological evidence of the historical global spread of cowpea (*Vigna unguiculata* [L.] Walp.). *Legume Sci.* 2020;2(4):e57.
9. Hulsure P, Thomas B, Arya K, Gayathri G, Nair AS, Varanya A. Genetic analysis in grain cowpea (*Vigna unguiculata* (L.) Walp.) for yield and quality. [Journal details not available].
10. IndiaStat. IndiaStat database [Internet]. 2024 [cited 2026 Jun 11]. Available from: <https://www.indiastat.com/>
11. Jayathilake C, Visvanathan R, Deen A, Bangamuwa R, Jayawardana BC, Nammi S, *et al.* Cowpea: an overview on its nutritional facts and health benefits. *J Sci Food Agric.* 2018;98(13):4793-4806.
12. Kiran SB, Kumar P. Genetic divergence studies in cowpea *Vigna unguiculata* (L.) Walp. *J Pharmacogn Phytochem.* 2020;9(5):2839-2845.
13. Krisnawati A, Adie MM. Characterization and performance of agronomic characters of soybean genotypes resistant to pod shattering. *Biodiversitas.* 2017;18(3):1158-1164.
14. Manggoel W, Uguru MI, Ndam ON, Dasbak MA. Genetic variability, correlation and path coefficient analysis of some yield components of ten cowpea [*Vigna unguiculata* (L.) Walp.] accessions. *J Plant Breed Crop Sci.* 2012;4(5):80-86.
15. Owusu EY, Karikari B, Kusi F, Haruna M, Amoah RA, Attamah P, *et al.* Genetic variability, heritability and correlation analysis among maturity and yield traits in cowpea (*Vigna unguiculata* (L.) Walp.) in Northern Ghana. *Heliyon.* 2021;7(9):e07872.
16. Rana MK, Partap PS, Ranjan R. Character association and path analysis in vegetable cowpea [*Vigna unguiculata* (L.) Walp.]. *Veg Sci.* 2015;42(1):122-123.
17. Singh BB, editor. *Advances in Cowpea Research.* Ibadan: International Institute of Tropical Agriculture; 1997.

18. Singh BB, Timko MP, Aragao FJL. Advances in cowpea improvement and genomics. In: Gupta SK, editor. Legumes in the Omic Era. New York: Springer; 2014. p. 131-153.
19. Sofi PA, Mir RR, Gull M, Shafi S, Zaffar A, Gani S, *et al.* Characterization of cowpea landrace diversity of Kashmir: pattern of variation for morphological and yield traits and resistance to mosaic virus. Range Manag Agrofor. 2022;43(1):25-32.
20. Soni RK, Shekhawat SS, Kumar M. Genetic variability study in cowpea [*Vigna unguiculata* (L.) Walp.] for green fodder yield and related traits. Indian Res J Genet Biotechnol. 2018;10(3):428-435.
21. Tiwari SP, Bhatia VS. Characters of pod anatomy associated with resistance to pod-shattering in soybean. Ann Bot. 1995;76(5):483-485.
22. U.S. Department of Agriculture. USDA [Internet]. Washington (DC): United States Department of Agriculture; 2021 [cited 2026 Jun 11]. Available from: <https://www.usda.gov/>