



Genetic Divergence on Chickpea (*Cicer arietinum* L.) Genotypes Grown under Late Sown Conditions

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

In the current experiment, 102 chickpea germplasm showed wide range of variation for various characters were evaluated during Rabi 2017-18 along with BG 372, Udai and Pant G 186 as checks varieties in Augmented Block Design at Agronomy Research Farm of Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Ayodhya (U.P.). The observations were recorded on 11 quantitative characters viz., days to 50 per cent flowering, days to maturity, primary branches per plant, secondary branches per plant, plant height (cm), pods per plant, seeds per pod, biological yield per plant (g), seed yield per plant (g), harvest index (%) and 100-seed weight (g). A statistical investigation of each character's genetics yielded a number of

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results. Higher seed yield per plant was generated by genotypes GJG 1416, followed by BG 256, GJG 1416, PhuleG0819. Seed yield per plant had positive and extremely significant associations with secondary branches per plant, pods per plant, seeds per pod, biological yield per plant, harvest index, and 100-seed weight. Primary branches per plant were shown to have positive significant associations with seed output per plant, where as plant height was determined to be non-significant. It showed a poor, non-significant correlation with the number of days until 50% blooming and the number of days till maturity. Biological yield per plant (g) and the Harvest index were found to be significant direct components of seed yield per plant by path analysis. The traits mentioned above that were significant direct and indirect components ought to be taken into account when creating a chickpea selection strategy that would produce high yielding varieties. The 11 clusters formed in divergence analysis contained genotypes of heterogeneous origin there by indicating no parallelism between genetic and geographic diversity. In this context, the maximum inter-cluster distance was recorded between cluster X and XI (12.201) followed by cluster III and XI (11.254), cluster VI and XI (11.125) and cluster VII and XI (10.875). Therefore, crosses between members of cluster separated by high inter-cluster distances are likely to throw desirable segregants.

Keywords: *Cicer arietinum* L; genetic divergence; grain yield; quantitative characters.

1. INTRODUCTION

Chickpea is the third leading grain legume in the world and first in the South Asia. A pulse, also known as a "grain legume," is an annual leguminous crop that produces one to twelve seeds inside of a pod that can vary in size, shape and colour. With a 30% total area coverage and 40% of India's pulse output, chickpeas are a significant cool-season food legume pulse crop. It is a highly self-pollinated crop with an incidence of less than 1% outcrossing. The family *Cicer* consists of 42 species of wild plants and one cultivated species (*Cicer arietinum* L.). More than 90% of the country's total land used for chickpea production is spread over Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Karnataka, Andhra Pradesh, and Gujarat. Pulses were grown in India on a total area of 31.11 mha, yielding 24.51 million tonnes at a productivity of 788 kg/ha. 2018 (Anonymous) "Based on the hypothesis that crosses involving divergent parents give higher chance of obtaining desirable segregants in the segregating generation, genetically diverse potential parents are chosen for use in hybridization programmes. To produce superior genotypes in the segregating generations, many researchers have stressed the need for parental diversity of the ideal magnitude" [1-5]. As a result, efforts should be undertaken to increase the utilisation of variety that has already been created via the collection of germplasm. Although there haven't been many genetic research on chickpea's germplasm assessment, variability, and correlation, the majority of them have relied on examining a small number of germplasm lines. Furthermore, it is impossible to generalise the

findings of past research of these elements since they are only applicable to the specific materials and surroundings used in the study.

2. METHODS AND MATERIALS

Three well-known check varieties, Udai, Pant G186, and BG 372, were used in the experiment to assess the 105 different chickpea strains and varieties, including elite lines and land races. During Rabi 2017–18, the trial material was assessed at the Acharya Narendra Deva University of Agriculture and Technology's Agronomy Research Farm in Narendra Nagar, Kumarganj, Ayodhya (U.P.). The meteorological data were recorded during the experimental period with temperatures of 4.9c to 39.0c. Six equal-sized blocks were placed around the experimental area. In each block, there were twenty entries total, including checks. With an inter-row spacing of 30 cm and an intra-row spacing of 10 cm for each treatment, the plants were planted in a single row of 4 m length.. On five randomly selected plants from each genotype in each replication we recorded data on eleven different quantitative characteristics, including plant height (cm), number of primary and secondary branches and pods and seeds per pod, the weight of 100 seeds (g), the number of days until 50% flowering, the number of days until maturity, biological yield per plant(g), harvest index(%) and seed yield per plant(g).

"The standard statistical procedure were used for estimation of genetic parameters of variability, correlation, path and Genetic divergence among 144 genotypes including checks planted in augmented design was studied through

Non-hierarchical Euclidean cluster analysis” [6,7].

3. RESULTS AND DISCUSSION

In path coefficient analysis using simple correlations, estimates of the direct and indirect effects of various traits on seed yield per plant are provided in Table 1. The table's examination found that biological yield per plant (0.618), harvest index (0.512), and pods per plant (0.098) had the strongest positive and significant direct effects on seed output per plant. A substantially favourable direct contribution to seed yield per plant was shown by biological yield per plant (g), followed by harvest index (%), pods per plant, secondary branch per plant, seeds per pod, and 100 seed weight (g). “The available literatures have also identified these characters as major direct contributors to seed yield per plant in chickpea” [8-12] (Yucel et al. 2010). Highly indirect effects/indirect contributing characters for seed yield by the biological yield per plant (0.363) and harvest index(0.308) via pods per plant; biological yield per plant(0.203), harvest index (0.210) and pods per plant (0.045) via secondary branches per plant ; biological yield per plant(0.106) and harvest index (0.167) via pods per plant; biological yield per plant(0.250) and harvest index (0.254) via 100 seed weight.

The indirect effects of pods per plant (0.363), 100 seed weight (0.250), harvest index (0.138), secondary branches per plant (0.203) and seeds per pod (0.106) via biological yield per plant; pods per plant (0.308), secondary branches per plant (0.210), 100-seed weight (0.254) and biological yield per plant (0.114), seeds per pod (0.167) and primary branches per plant (0.183) via harvest index; harvest index (0.059), biological yield per plant (0.057), primary branches per plant (0.037) and secondary branches per plant (0.045) via pods per plant showed high order positive indirect effects on seed yield . Other rest showed very less or negative indirect effects for seed yield The above finding are broadly in agreement with report of [13-15,8,16,10,11,17] (Yucel et al. 2010). Whereas, harvest index (-0.038) via days to 50 per cent flowering; harvest index (-0.065) and biological yield per plant (-0.017) via days to maturity; primary branches per plant (-0.025) via secondary branches per plant; primary branches per plant (-0.018) via pods per plant; primary branches per plant (-0.017) via harvest index showed highly negative indirect effects on seed yield per plant. The estimates of indirect effects

on the path coefficient were too low to be considered important. The residual factor effects (0.1696) were recorded positive.

“The genetic divergence existing in 105 chickpea germplasm collections was studied by employing Non-hierarchical Euclidean cluster analysis for 11 quantitative characters. These genotypes were grouped in 11 different clusters. The pseudo F-test revealed that eleven clusters arrangement was the most appropriate for this material. Therefore, the 105 genotypes were accepted to be grouped in 11 different non-overlapping clusters” [18-26]. The distribution of 105 chickpea accessions in to 11 clusters is given in Table 1.

The highest number of genotypes appeared in cluster IV, which contains 37 genotypes. Cluster I and cluster III, cluster VI each with 21 and 15 genotypes respectively. The estimates of intra and inter-cluster distance for eleven clusters are presented in Table 2.

The highest intra-cluster value was found for cluster V (3.011) followed by cluster VII (2.651), cluster IV (2.631), cluster VI (2.602), cluster II (2.448) cluster I (2.364) and cluster IX (2.043) while the lowest value was recorded in cluster XI (0.000) and cluster VIII (0.000) followed by cluster X (1.589) and cluster III (1.998). The maximum inter-cluster distance was recorded between cluster X and XI (12.201) followed by cluster III and XI (11.254), cluster VI and cluster XI (11.125). Inter-cluster distances between cluster VII and XI (10.875), cluster II and XI (10.805), cluster IX and XI (10.640), cluster VIII and cluster XI (10.505) were also of high order. The minimum inter-cluster distance was observed between cluster I and II (3.304) followed by cluster III and VI (3.387), cluster I and IV (3.657), cluster II and cluster VI (3.678) and cluster II and cluster VII (3.698) [27-29,22,30-32,23,24,33,25,26,11,34] (Kumar et al. 2013).

The mean performance of clusters for 11 characters is presented in Table 3.

The genotypes of cluster IX were earlier flowering (\bar{X} = 58 days) followed by cluster V (\bar{X} = 65 days). While, genotypes of cluster II were late in flowering (\bar{X} = 79 days) followed by cluster III (\bar{X} = 78 days) and cluster I (76 days).

Table 1. Clustering pattern of 105 chickpea genotypes on the basis of Non-hierarchical Euclidean cluster analysis of eleven character

| Cluster number | Number of genotypes | Genotypes |
|----------------|---------------------|--|
| I | 21 | RSG 881,BG 3003, H 11- 41, JG 36, PhuleG0819, IPC 2012-98, RVIG 34, RVSSG 4, IPC 2008-92, RVSSG 10, RVSSG 42, JG 2016-43, RS2011-16, RAG 888, H 11-58, PhuleG13116, BG256, BG3021, JG 37, RVSSG 2, RVSSG 9. |
| II | 2 | IPC 2008-69, H 07-157. |
| III | 15 | IPC 2010-69, IPC 2011-138, H 12-36, IPC 2010-134, H 09-90, H 08-75, H 09-19, Vijay, PBC 570, H 08-13, H 08-18, BG 3027, RG 2011-02, JG 2016-45, RKG 13-380. |
| IV | 37 | RVSSG 5, PhuleG0818, RVSSG45, H 08-18,IPC 97-72, GJG 08820, PhuleG0408, KDG 94-4, RVSSG 41, H 04-09, RSG 957, PhuleG0151, IPC 2004-5, H 06-62, IPC2007-28, IPC 2013-33, IPC 1014, H 08-25, GJG 1209, IPC 2011-141, IPC 0907, GJG0921, GJG 1001, PhuleG0609-15, HIR 55, PhuleG21207, IPC 2006-126, PhuleG12110, GJG 0810, BG 3031, GJG 1403, PhuleG625-6, IPC 07-56, H 04-49, PhuleG0405. |
| V | 2 | H 13-03,GJG 0809 |
| VI | 15 | PhuleG0805, H 10-05, IPC 07-56, H 09-9, IPC 2010-62, DC 16-1, H 12-29, H 12-36, EC 442406, H 13-36, JG 2016-9605, JG 2016-44, GJG 1010, H 10-22, UDAI. |
| VII | 3 | IPC 2006-127, H 06-6, GJG 1114 |
| VIII | 1 | PANT G 186 |
| IX | 2 | IPC 2010-127, GJG 1416 |
| X | 6 | RVSSG 1, JG 38, IPC 2013-21,BG 372,PDG 84-16,H 12-1 |
| XI | 1 | GJG 1208 |

Table 2. Estimates of average intra and inter cluster distance for 11clusters in chickpea germplasm

| Cluster number | I | II | III | IV | V | VI | VII | VIII | IX | X | XI |
|----------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| I | 2.364 | 3.304 | 3.504 | 3.657 | 4.693 | 4.411 | 4.597 | 4.101 | 5.545 | 7.187 | 10.445 |
| II | | 2.448 | 4.045 | 3.678 | 5.190 | 5.168 | 3.698 | 4.948 | 5.552 | 7.301 | 10.805 |
| III | | | 1.998 | 3.885 | 4.547 | 3.387 | 6.349 | 5.459 | 6.683 | 8.645 | 11.254 |
| IV | | | | 2.631 | 3.952 | 3.789 | 4.840 | 4.363 | 4.356 | 7.723 | 10.811 |
| V | | | | | 3.011 | 4.324 | 6.083 | 4.130 | 4.074 | 7.727 | 10.792 |
| VI | | | | | | 2.602 | 6.459 | 4.633 | 5.991 | 8.873 | 11.125 |
| VII | | | | | | | 2.651 | 4.084 | 4.547 | 6.248 | 10.875 |
| VIII | | | | | | | | 0.000 | 3.940 | 6.624 | 10.505 |
| IX | | | | | | | | | 2.043 | 6.147 | 10.640 |
| X | | | | | | | | | | 1.589 | 12.201 |
| XI | | | | | | | | | | | 0.000 |

Note: Bold figures indicate intra cluster distance.

Table 3. Cluster means for 11 clusters in chickpea germplasm

| Number of cluster | Days to 50% flowering | Days to maturity | Plant height (cm) | Primary branches per plant | Secondary branches per plant | Pods per plant | Seeds Per Pod | 100-seed weight (g) | Biological yield per plant (g) | Harvest index (%) | Seed yield per plant (g) |
|--------------------------|------------------------------|-------------------------|--------------------------|-----------------------------------|-------------------------------------|-----------------------|----------------------|----------------------------|---------------------------------------|--------------------------|---------------------------------|
| I | 76.333 | 133.714 | 38.852 | 1.562 | 4.652 | 27.471 | 1.219 | 16.442 | 12.655 | 36.397 | 4.579 |
| II | 78.500 | 134.500 | 41.300 | 1.200 | 3.800 | 25.800 | 1.100 | 22.355 | 16.940 | 35.345 | 5.955 |
| III | 77.467 | 134.267 | 34.547 | 1.227 | 4.013 | 14.787 | 1.087 | 16.031 | 11.816 | 26.623 | 3.146 |
| IV | 67.595 | 123.892 | 34.303 | 1.335 | 4.286 | 19.538 | 1.162 | 20.741 | 12.237 | 36.433 | 4.436 |
| V | 64.500 | 122.500 | 37.300 | 1.200 | 3.500 | 15.400 | 1.700 | 16.745 | 14.210 | 31.415 | 4.455 |
| VI | 65.867 | 121.800 | 35.520 | 1.293 | 3.953 | 17.640 | 1.027 | 15.001 | 11.557 | 24.723 | 2.877 |
| VII | 70.667 | 126.667 | 34.867 | 1.400 | 4.733 | 35.467 | 1.133 | 21.160 | 20.750 | 41.067 | 8.417 |
| VII | 64.000 | 119.000 | 27.800 | 1.400 | 4.600 | 33.600 | 1.400 | 12.910 | 17.870 | 33.460 | 5.980 |
| IX | 58.000 | 115.000 | 42.300 | 1.400 | 5.500 | 22.000 | 1.600 | 20.995 | 17.315 | 41.805 | 7.250 |
| X | 73.333 | 126.000 | 44.167 | 3.117 | 8.133 | 26.500 | 1.700 | 20.620 | 26.773 | 32.508 | 8.682 |
| XI | 67.000 | 125.000 | 345.00 | 1.200 | 4.600 | 32.200 | 1.400 | 13.240 | 13.110 | 42.940 | 5.630 |

Table 4. Direct and indirect effects of ten characters on seed yield per plant in chickpea germplasm

| Characters | Days to 50% Flowering | Days to Maturity | Plant height (cm) | primary branches per Plant | Secondary branches per plant | Pods per Plant | seeds per Pod | Biological yield per Plant (g) | Harvest index (%) | 100-seed weight (g) | Correlation with seed yield per plant |
|--------------------------------|-----------------------|------------------|-------------------|----------------------------|------------------------------|----------------|---------------|--------------------------------|-------------------|---------------------|---------------------------------------|
| Days to 50% flowering | 0.007 | -0.002 | 0.000 | 0.004 | 0.000 | 0.007 | -0.005 | 0.005 | -0.038 | -0.001 | -0.02 |
| Days to maturity | 0.007 | -0.002 | -0.001 | 0.009 | -0.002 | 0.001 | -0.006 | -0.017 | -0.065 | -0.002 | -0.08 |
| Plant height (cm) | 0.000 | 0.000 | -0.028 | 0.004 | 0.002 | 0.020 | 0.003 | 0.009 | 0.072 | -0.003 | 0.08 |
| Primary branches per plant | -0.001 | 0.000 | 0.002 | -0.047 | 0.023 | 0.037 | 0.001 | 0.071 | 0.183 | 0.004 | 0.28 |
| Secondary branches per plant | 0.000 | 0.000 | -0.002 | -0.025 | 0.043 | 0.045 | 0.001 | 0.203 | 0.210 | 0.004 | 0.48 |
| Pods per plant | 0.000 | 0.000 | -0.006 | -0.018 | 0.020 | 0.098 | -0.001 | 0.363 | 0.308 | 0.004 | 0.77 |
| Seeds per pod | -0.002 | 0.001 | -0.003 | -0.001 | 0.002 | -0.006 | 0.023 | 0.106 | 0.167 | 0.002 | 0.29 |
| Biological yield per plant (g) | 0.000 | 0.000 | 0.000 | -0.005 | 0.014 | 0.057 | 0.004 | 0.618 | 0.114 | 0.009 | 0.81 |
| Harvest index (%) | -0.001 | 0.000 | -0.004 | -0.017 | 0.018 | 0.059 | 0.008 | 0.138 | 0.512 | 0.011 | 0.72 |
| 100-seed weight | 0.000 | 0.000 | 0.004 | -0.009 | 0.008 | 0.019 | 0.002 | 0.250 | 0.254 | 0.022 | 0.55 |

Residual effect=0.169607 Bold values shows direct and normal values shows indirect effects

The entries represented in cluster IX (\bar{X} = 115 days) was comparatively early maturing followed by cluster VIII (\bar{X} = 119 days), while genotypes in cluster II were late in maturity (\bar{X} = 135 days) followed by cluster III (\bar{X} = 134 days) and cluster I (\bar{X} = 134 days).

The highest and lowest cluster means for plant height at maturity was observed for cluster XI (\bar{X} = 345 cm) and cluster VIII (\bar{X} = 27.28 cm), respectively. Cluster X (\bar{X} = 44.16 cm) and cluster IX (\bar{X} = 42.30 cm) was another clusters which contained mostly tall stature genotypes.

The highest number of primary branches per plant was found in cluster X (\bar{X} = 3.117). Cluster II (\bar{X} = 1.200), Cluster V (\bar{X} = 1.200) and Cluster XI (\bar{X} = 1.200) appears to possess genotypes having very low number of primary branches per plant.

The genotypes with high number of secondary branches per plant was concentrated in cluster X (\bar{X} = 8.133) followed by cluster IX (\bar{X} = 5.500). Cluster V (\bar{X} = 3.500) appears to possess genotypes having very low number of secondary branches per plant.

The highest cluster mean for number of pods per plant was observed for cluster VII (\bar{X} = 35.467) followed by cluster VIII (\bar{X} = 33.600) and cluster XI (\bar{X} = 32.200) while genotypes for lowest number of pods per plant was concentrated in cluster III (\bar{X} = 14.787).

The genotypes representing the maximum cluster mean for number of seeds per pod was present in cluster V (\bar{X} = 1.700) and cluster X (\bar{X} = 1.700). while lowest number of seeds per pod were observed in cluster VI (\bar{X} = 1.027).

The genotypes with highest 100-seed weight was found in cluster II (\bar{X} = 22.355 g) followed by cluster VII (\bar{X} = 21.160 g), cluster IX (\bar{X} = 20.995) and cluster IV (\bar{X} = 20.741). Lowest 100 seed weight was observed in cluster VIII (\bar{X} = 12.910 g) followed by cluster XI (\bar{X} = 13.24 g). The biological yield per plant was highest among the genotypes of cluster II (\bar{X} = 81.456 g)

followed by cluster X (\bar{X} = 80.459 g). The lowest biological yield was observed in cluster IV (\bar{X} = 53.711 g).

The highest cluster mean for harvest index was observed for cluster XI (\bar{X} = 42.940%) followed by cluster IX (\bar{X} = 41.805 %) and cluster VII (\bar{X} = 41.067 %), while lowest harvest index was observed in cluster VI (\bar{X} = 24.723 %).

The highest cluster mean for seed yield per plant was observed in case of cluster X (\bar{X} = 8.682 g) followed by cluster VII (\bar{X} = 8.417 g).

4. CONCLUSION

Path analysis identified biological yield per plant (g) and harvest index important direct components for seed yield per plant. The characters identified above as important direct and indirect components merit due to consideration in the formulation of effective selection strategy in chickpea for developing high yielding varieties. The Non-hierarchical Euclidean cluster analysis grouped 105 genotypes included checks into eleven clusters. This indicated presence of substantial genetic diversity in the evaluated germplasms. The highest intra-cluster distance which was observed in case of cluster V (3.011), followed by cluster VII (2.651), while the lowest value was recorded in case of cluster XI (0.000) and cluster VI (6.520) followed by cluster X (1.589). The maximum inter cluster distance was found between cluster I and XI (10.445) followed by VIII and XI (10.505). The minimum inter-cluster distance was observed between I and II (3.304) followed by cluster III and VI (3.387). The eleven clusters formed in divergence analysis contained genotypes of heterogenic origin there by indicating no parallelism between genetic and geographic diversity. Therefore, crosses between the members of cluster separated by high inter cluster distance, are likely to throw desirable segregants. In this context, cluster XI had very high inter-cluster distance from remaining ten clusters, but cluster XI have moderate to poor mean performance for some characters.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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