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Research Article

GENETIC DIVERGENCE OF CHICKPEA (*CICER ARIETINUM*) CULTIVARS FOR THE TRAITS RELATED TO MECHANICAL HARVESTING AND YIELD AND YIELD COMPONENTS

MASTAMARADI S.B.*, NAIK R.V., BIRADAR S.B., GIRITAMMANAVAR V.A. AND ONTAGODI T.P.
Department of Genetics and Plant Breeding, University of Agricultural Sciences, Dharwad, 560065, India
*Corresponding Author: Email - bmshree.4795@gmail.com

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Abstract: Genetic diversity was assessed through Mahalanobis's D^2 statistics in 58 genetically diverse chickpea genotypes. The study revealed that 58 genotypes were grouped into six distinct clusters. Cluster I was largest consisting of 39 genotypes followed by, cluster II with 8, cluster IV with 4, and cluster V with 5, while remaining clusters III and VI were solitary. Number of seeds per plant contributed maximum (32.43 %) to the divergence of genotypes. This was followed by days to maturity (18.51%), yield per plant (13.25%) and harvest index (12.70%). Based on inter cluster distance, Cluster VI was superior for early maturity habit, number of secondary branches, number of tertiary branches, lowest internodal length and seeds per plant, cluster III for seed yield per plant and harvest index, while cluster IV for seed yield per plant, number of seeds per plant and lower branch angle. Whereas, cluster II for plant height, higher height at first podding, highest number of internodes per plant and lowest branch angle. The genotypes from these clusters may therefore be selected as parents in crossing programmes to incorporate the characters related to mechanical harvesting and yield components.

Keywords: *Genetic diversity, Genotypes, Clusters, Mechanical harvesting*

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Introduction

Chickpea (*Cicer arietinum* L.), also known as Bengal gram or Garbanzo, is one of the earliest food legumes cultivated by man and plays an important role in human diet and agricultural systems. It is the largest produced food legume in South Asia and is currently the second most important food legume in the world after common bean. India is the largest chickpea producing country accounting for 65.4% of the global chickpea production. It occupies 14.8 million hectare of chickpea area with production of 14.23 million tonnes seeds, with productivity of 950 kg ha^{-1} [1].

With continuously increasing labor cost, manual harvesting has become an expensive field operation for any crop in India and farmers are increasingly opting for mechanical harvesting wherever it is feasible. Also, untimely availability of labor causes delay in harvesting which can result in yield losses through pod drop and shattering, while seed quality also deteriorates. Chickpea is harvested by hand in India because the existing popular chickpea varieties grown in India have inadequate height, semi-spreading growth habit and height of lower pods is about 15-20 cm from the ground that means branches are close to ground due to semi-spreading growth habit and therefore these cultivars are not suitable for mechanical harvesting. This necessitates the development of cultivars suited to mechanical harvesting. Cultivars with tall plant height, erect growth habit, acceptable branch angle with higher first pod height, a greater number of internodes and short internodal length are required for mechanical harvesting which need to be developed through intensive breeding programs. The knowledge of genetic diversity is required in the formation of successful breeding programmes. For further crop improvement with desired character combinations, it is required to use diverse parents for hybridization programme so that superior segregants are obtained. So, the present experiment was formulated to study the genetic divergence for selection of suitable parents for utilizing in hybridization programme aimed at combining characters related to mechanical harvesting and yield and yield attributes.

Materials and methods

The base material for the present investigation consisted of 58 genetically diverse genotypes of chickpea obtained from AICRP on chickpea, UAS, Dharwad and ICRISAT, Hyderabad. The chickpea genotypes are listed in [Table-1]. The experiment was conducted at Botany Garden, Department of Genetics and Plant Breeding, Dharwad during rabi 2011. Geographically, Dharwad is situated at 15 º 12 N' latitude and 70º 26' E longitude at an altitude of 678 m above sea level and receives an average annual rainfall of 720 mm. Data were recorded on five randomly tagged plants for *viz*., days to maturity, plant height, number of secondary branches, number of tertiary branches, height at first podding, internodal length, number of internodes per plant, branch angle, seeds per plant, seed yield per plant and harvest index. Mahalanobis (1936) [2] D^2 statistics was used for assessing the genetic divergence among 58 genotypes. On the basis of magnitude of D^2 value the genotypes were grouped into number of clusters as suggested by Tocher described by Rao (1952) [3]. Statistical analyses for experimental observations were carried out by 'windostat' software.

Results and discussion

The 58 genotypes tested were grouped into six distinct clusters. Cluster pattern revealed that, cluster I is largest consisting of 39 genotypes followed by, cluster II with 8, cluster IV with 4, and cluster V with 5, while remaining clusters III and VI were solitary [Table-2] and [Fig-1].

Maximum difference among the genotypes within same cluster was shown by cluster V (D^2=175.55) followed by cluster I (D^2 =145.89). The minimum intra cluster distance was observed for cluster II (113.83). Since cluster III and VI had only one genotype each the intra cluster distance was zero. When diversity among the clusters was studied, it showed a range of 141.84 to 3028.12. Cluster VI and II showed maximum inter cluster distances of 3028.12, followed by that between cluster VI and III (2164.75).

Table-1 *List of chickpea genotypes used in the study*

No.	Genotype	Source	No.	Genotype	Source
1	PG 0105	UAS, DWD	30	IARI-367	UAS, DWD
2	JG 23	UAS, DWD	31	BUSHY MUT	UAS, DWD
3	H 08-13	UAS, DWD	32	AT-2-3	UAS, DWD
4	PG 081	UAS, DWD	33	AT-3-4	UAS, DWD
5	GJG 0907	UAS, DWD	34	ICCV 03112	ICRISAT, HYD
6	RKG 153	UAS, DWD	35	ICCX-040111-F3-P14-BP	ICRISAT, HYD
7	Phule G 0215-2	UAS, DWD	36	ICCV 03108	ICRISAT, HYD
8	CSJ 564	UAS, DWD	37	ICCX-040177-F3-BP-P44-BP	ICRISAT, HYD
9	Phule G 0204-4	UAS, DWD	38	JG 11	UAS, DWD
10	IPC 07-19	UAS, DWD	39	ICCV 98501	ICRISAT, HYD
11	JG 24	UAS, DWD	40	ICCX-040183-F3-BP-P38-BP	ICRISAT, HYD
12	IPC 08-11	UAS, DWD	41	ICCX-040123-F3-P24-BP	ICRISAT, HYD
13	AKG 1001	UAS, DWD	42	ICCX-040111-F3-P13-BP	ICRISAT, HYD
14	BGD 1068	UAS, DWD	43	ICCX-040130-F4-BP-P8-BP-BP	ICRISAT, HYD
15	RVSSG-9	UAS, DWD	44	ICCX-040138-F3-BP-P4-BP	ICRISAT, HYD
16	GJG 0906	UAS, DWD	45	ICCX-040183-F3-BP-P15-BP	ICRISAT, HYD
17	RVSSG-10	UAS, DWD	46	ICCX-040166-F4-P18-BP-BP	ICRISAT, HYD
18	H 08-71	UAS, DWD	47	ICCX-040183-F3-BP-P13-BP	ICRISAT, HYD
19	BCP60	UAS, DWD	48	ICCV 04103	ICRISAT, HYD
20	IPC 07-09	UAS, DWD	49	ICCV 03104	ICRISAT, HYD
21	BGD 1070	UAS, DWD	50	ICCX-060058-F4-P10-BP	ICRISAT, HYD
22	BGM 572	UAS, DWD	51	ICCX-040118-F3-P4-BP	ICRISAT, HYD
23	BG 3029	UAS, DWD	52	ICCX-040166-F4-P5-BP-BP	ICRISAT, HYD
24	GJG 0904	UAS, DWD	53	ICCX-040155-F4-P9-BP-BP	ICRISAT, HYD
25	BGD 1061	UAS, DWD	54	ICCX-040121-F3-P34-BP	ICRISAT, HYD
26	Phule G 09103	UAS, DWD	55	JAKI 9218	UAS, DWD
27	Phule G 07101	UAS, DWD	56	BGD-103	UAS, DWD
28	DBGV-02	UAS, DWD	57	A-1	UAS, DWD
29	DBGV 04	UAS, DWD	58	BG-256	UAS, DWD

Table-2 *Inter (bold) - and intra- cluster distances (D^2) in 58 chickpea genotypes*

Clusters	I	II	III	IV	V	VI	No. of genotypes
I	145.89	268.1	227.57	350.91	337.38	2891.2	39
II		113.83	327.06	500.76	407.62	3028.12	8
III			0	141.84	403.88	2164.75	1
IV				123.43	694.17	1827.7	4
V					175.55	2948	5
VI						0	1

Table-3 *Percent contribution of different traits related to yield and mechanical harvesting in 58 chickpea genotypes towards total diversity*

Characters	Times ranked first	Percent contribution
Days to maturity	306	18.51%
Plant height	3	0.18%
Number of secondary branches per plant	38	2.30%
Number of tertiary branches per plant	19	1.15%
Height at first podding	148	8.95%
Internodal length	56	3.39%
Number internodes per plant	6	0.36%
Branch angle	112	6.78%
Seeds per plant	536	32.43%
Yield per plant	219	13.25%
Harvest index	210	12.70%

Table-4 *Cluster means for 11 different traits related to yield and mechanical harvesting in 58 chickpea genotypes*

Cluster	DM	PH (cm)	NSB	NTB	HAFP (cm)	INL (cm)	NIPP	BA	SPP	YPP (g)	HI (%)
I	106.05	48.75	8.44	12.14	26.97	1.61	27.3	34.24	64.69	16.06	49.83
II	121.81	52.59	6.8	10.4	38.51	1.69	29.1	31.39	46.35	10.36	48.44
III	113.5	44.36	14.55	26.5	24.6	1.74	28.01	32.93	132.73	32.93	53.56
IV	106.63	45.92	10.01	16.7	21	1.59	26.27	34.61	143.44	28.73	53.37
V	111.1	47.93	17.7	22.44	22.73	1.93	26.77	43.58	47.7	11.67	35.53
VI	89	28.7	42.75	50.45	11.25	1.08	25.5	48.25	261	28.05	38.4

The lowest inter cluster distance was noticed between clusters IV and III (141.84), followed by between clusters I and III (227.57) [Table-2]. Researcher found considerable genetic diversity in chickpea where in inter cluster distance ranged from 55.59 to 400.99 [4]. Whereas, little divergence in chickpea where the inter cluster distance ranged from 11.92 to 31.59 [5]. Similarly, Vishnu, *et al*., (2018) [6] found D^2 values varying from 8.64 to 28 under irrigated condition in chickpea. This indicated that substantial diversity existed in the germplasm collections evaluated in the present study. This is also in agreement with earlier reports indicating substantial diversity in chickpea materials [7,8]. Number of seeds per plant (ranked first 536 times out of 1653 total number of combinations) contributed 32.43 percent to divergence of genotypes. This was followed by days to maturity (18.51%), yield per plant (13.25%), harvest index (12.70%), height at first podding (8.95%), branch angle (6.78%), internodal length (3.39 %) number of secondary branches per plant (2.30 %) and number of tertiary branches per plant (1.15 %). On the other hand, number of internodes per plant and plant height had negligible contribution towards divergence.

Vijayakumar, *et al*., (2017) [10] observed highest contribution of seed yield and days to maturity towards the divergence in chickpea. Whereas, number of internodes per plant and plant height had negligible contribution towards divergence. Major contribution of number of pods per plant / seeds per plant towards genetic diversity in chickpea was also reported [9] [Table-3].

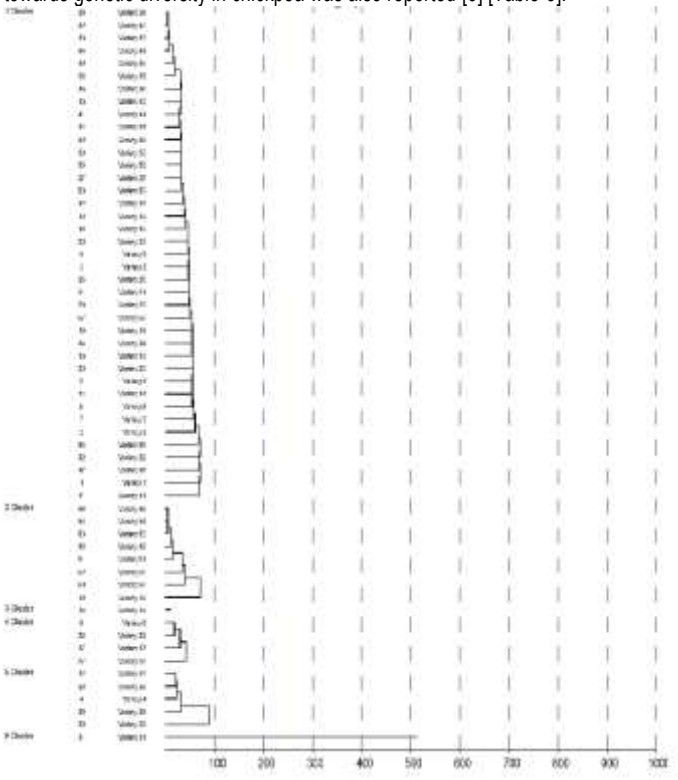

Fig-1 *Dendrogram of 58 chickpea genotypes based on evaluation for 11 different traits*

The mean value showed that the different clusters were superior in respect of different characters. Cluster VI consisting of single genotype exhibited early maturity habit with mean number of days to maturity being 89 days, highest (42.75) mean number of secondary branches per plant, highest (50.45) number of tertiary branches per plant, lowest (1.08 cm) internodal length and highest seeds per plant (261). Cluster III with a single genotype had very high seed yield per plant (32.93 gm) and high harvest index (53.56 %). Also, cluster IV with 4 genotypes represented high seed yield per plant (28.73 g) and a greater number of seeds per plant and lower branch angle. Whereas, cluster II showed higher plant height (52.59 cm), higher height at first podding (38.51cm), highest number of internodes per plant (29.1) and lowest branch angle (31.39 degree) [Table-4]. The genotypes from these clusters may therefore be selected as parents in crossing programmes to incorporate the characters related to mechanical harvesting and yield components.

Conclusion

The results of diversity analysis could be utilized in identifying the best parental combination for generating variability with respect to the traits related to mechanical harvesting and yield and yield attributes. Accordingly, the genotypes from cluster-II ICCX-040183-F3-BP-P15-BP, ICCX-040138-F3-BP-P4-BP and genotypes from cluster-I ICCX-040111-F3-P13-BP, GJG 0907, Phule G 0215-2 exhibited desirable plant height and height at first podding and therefore these could be utilized in breeding programmes aiming at development of lines suitable for machine harvesting. Whereas, the genotypes from cluster-IV RVSSG 10, BGD 1061 and genotype RVSSG-9 of cluster-III with high perse performance could be utilized in breeding programme for improvement of seed yield. In this context genotypes in cluster-I and II could be crossed with genotypes in cluster-IV and aslo, by hybridization of genotypes in cluster-III and IV and subsequent selection from segregating generations, there is an opportunity to breed for high yielding chickpea genotypes which are suitable for mechanical harvesting.

Application of research: Genetic diversity study in chickpea provided the information on amount of variability present for plant height, height at first podding and seed yield and seed yield related traits. This information could be used in developing improved chickpea plant type which is high yielding as well as suitable for mechanical harvesting. Current study aimed at unveiling the available diversity of genotypes suitable for mechanical harvesting.

Research Category: Plant Breeding and Farm Mechanization

Abbreviations: AICRP- All India Coordinated Research Project
ICRISAT- International Crop Research Institute on Semi-Arid Tropics

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****Research Guide or Chairperson of research: Dr R V Naik**
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Study area / Sample Collection: UAS, Dharwad and ICRISAT, Hyderabad

Cultivar / Variety / Breed name: Chickpea (*Cicer arietinum* L.)

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

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