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RESEARCH PAPER

Genetic diversity for yield and yield attributing traits in chickpea (*Cicer arietinum* L.) under different moisture regimes

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Abstract: The study was carried out during *Rabi* 2017-18 at College of Agriculture, Vijayapur using 61 chickpea genotypes, involving Multiparent Advanced Generation Intercross (MAGIC) population derived lines and advanced breeding lines to analyse the genetic diversity under well watered and moisture stress conditions. Based on D^2 analysis, the sixty one genotypes were grouped into ten and two clusters under well-watered (E1) and moisture stress conditions (E2) respectively. Among the ten clusters formed under E1, Cluster I was the largest with 51 genotypes, while the largest cluster under E2 had 60 genotypes. The highest ranking was recorded for Cluster I under both the environments. The inter cluster distance varied from 5.20 to 49.68and 89.34 to 544.95 under E1 and E2 respectively. The contribution of 100 seed weight and number of pods per plant was found to be maximum for genetic divergence.

Key words: Chickpea, Genetic diversity, Moisture stress, Population

Introduction

Pulses acquire a unique position in Indian agriculture system because of their distinct features of maintaining and restoring soil fertility along with their high nutritive value. Among the pulses, chickpea is a part of the everyday diet in most of the Indian population and continues to be the largest consumed pulse. Chickpea shares 45-50 per cent contribution to total pluses production in India and in world, it is cultivated in 17.09 million hectares with a production of 17.02 million tonnes with an average yield of 956.1 kg per ha (Anon., 2019). In India, chickpea is cultivated in 9.5 million hectares with a production of 9.9 million tonnes and productivity of 1,041 kg per ha (Anon., 2019a). Karnataka ranks fifth in the cultivation of chickpea with an area of 13.75 lakh hectares, production of 8.25 lakh tonnes and productivity of 479 kg per ha (Anon., 2018b).

About 90 per cent of chickpea crop is grown in rainfed condition. Because of erratic rainfall crop suffers from moisture stress which is the second major constraint in chickpea productivity after diseases. Global economic losses in chickpea due to drought is about 40-50 per cent (Millan *et al.,* 2006), which limit crop production in different parts of the world particularly, in India.

The diversity present in crop genetic resources provide an assurance for future genetic progress and insurance against unforeseen threat to agricultural production. Assessment of genetic diversity in a set of genotypes or population is required for choosing divergent genotypes as parents in a various breeding applications. Thus, genetic diversity analysis is of utmost importance in breeding not only for yield improvement but also for enhanced resistance to both abiotic and biotic stresses. D^2 statistic is a useful tool to measure genetic divergence among genotypes in any crop (Mahalanobis, 1936). In the present study, an attempt was made to identify genetically divergent lines, so as to select the potential parents for a breeding programme to attain the anticipated improvement in grain yield.

Material and methods

A field experiment was conducted during *Rabi* 2017-18 at G block, Regional Agricultural Research Station (RARS), College of Agriculture, Vijayapur campus which is situated in Northern dry zone of Karnataka between 16°49' N latitude, 75°43' E longitude and at 593 m elevation above mean sea level (MSL).The experiment was laid out in randomised complete block design under two moisture regimes, which are Environment 1 (E1) - well watered (No water stress) and Environment 2 (E2) - moisture stress (Moisture stress from flowering onwards) with two replications having plot size of 1.2 m^2 each. The genetic material was consisting of 61 chickpea genotypes from Multiparent Advanced Generation Intercross (MAGIC) population and other advanced breeding lines. Observations on various yield and yield attributing traits was recorded on five randomly selected plants from each genotype *viz.,* days to first flowering, days to 50 per cent flowering, days to first pod initiation, SPAD Chlorophyll meter readings(SCMR) at both 30 and 60 DAS, plant height (cm), number of primary branches per plant, number of secondary branches, number of pods per plant, number of seeds per pod, hundred seed weight (g), dry weight (g), seed yield per plant (g),harvest index (%). Genetic divergence was estimated using Mahalanobis (1936) D^2statistics and clustering was done according to Tocher's method as described by Rao (1952).

Results and discussion

Based on D^2 values, 61 genotypes were grouped into ten and two clusters under E1 and E2 respectively. Among ten

Table 1a. Distribution of chickpea genotypes into different clusters under E1

Clusters	No. Of genotypes	Genotypes
I	51	MAGIC 41, MAGIC 85, MAGIC 53, MAGIC 42, DIBG 209, MAGIC 83, MAGIC 84, MAGIC 79, DIBG 204, ICC 1132, MAGIC 54, BGD 528, MAGIC 21, MAGIC 24, ICC 4567, MAGIC 113, MAGIC 35, MAGIC 50, MAGIC 112, MAGIC 72, MAGIC 34, MAGIC 70, MAGIC 76, JG-11, MAGIC 2, GJG 0205, MAGIC 110, BG 2024, BGD 111-1, DIBG 208, BGD 103, MAGIC 68, MAGIC 75, MAGIC 97, MAGIC 29, MAGIC 77, MAGIC 65, JKG 2004-334, MAGIC 107, ICCV 4111, JG 2004-23, MAGIC 82, MABC WR SA-1, DIBG 207, MAGIC 111, MAGIC 71, MAGIC 108, DIBG 206, DIBG 205, MAGIC 43, MAGIC 105
II	1	ICCC 37
III	1	MAGIC 103
IV	1	JAKI 9218
V	1	DIBG 203
VI	1	MAGIC 58
VII	1	ANNIGERI 1
VIII	1	MAGIC 62
IX	2	JG - 16, ICC 4958
X	1	RKD 1

Table 1b. Distribution of chickpea genotypes into different clusters under E2

Clusters	No. of genotypes	Genotypes
I	60	MAGIC 2, MAGIC 34, MAGIC 107, MAGIC 62, MAGIC 21, MAGIC 41, MAGIC 24, MAGIC 79, MAGIC 112, MAGIC 97, MAGIC 43, MAGIC 77, MAGIC 83,BGD 528, MAGIC 68, MAGIC 54, MAGIC 77, MAGIC 35, MAGIC 42, MAGIC 108, MAGIC 85, JG – 16, ANNIGERI 1, MAGIC 53, MAGIC 76, MABC WR SA-1, MAGIC 110, MAGIC 71, GJG 0205, MAGIC 105, MAGIC 84, BG 2024, MAGIC 50, MAGIC 29, DIBG 207, MAGIC 103, JG – 11, DIBG 208, MAGIC 72, RKD 1, ICC 1132, JAKI 9218, BGD 111-1, MAGIC 70, MAGIC 111, MAGIC 113, BGD 103, ICCC 37, DIBG 204, DIBG 203, JKG 2004-334, ICC 4567, JG 2004-23, DIBG 206, DIBG 205, MAGIC 58, MAGIC 83, DIBG 209, ICC 4958, ICCV 4111
II	1	MAGIC 65

Table 2a. Per cent contribution of fourteen characters towards divergence under E1

Sl.No.	Characters	Times ranked 1st	Per cent (%) contribution
1	DFF	104	5.68
2	DFPF	91	4.97
3	DFPD	26	1.42
4	SPAD 30	55	3.01
5	SPAD 60	96	5.25
6	PH	76	4.15
7	NPB	75	4.1
8	NSB	159	8.69
9	NPPP	377	20.6
10	NSPP	92	5.03
11	SYPP	253	13.83
12	DMW	223	12.19
13	100 SW	120	6.56
14	HI	83	4.54

DFF: Days to first flowering, DFPF: Days to fifty per cent flowering, DFPD: Days to pod initiation, SPAD: SPAD chlorophyll meter readings at 30 and60, PH: Plant height (cm), NPB: Number of primary branches, NSB: Number of secondary branches, NPPP: No. of pods per plant, NSPP: Number of seeds per pod, SYPP: Seed yield per plant (g), DMW: Dry matter weight, HSW: Hundred seed weight (g) and HI: Harvest index.

Table 2b. Per cent contribution of fourteen characters towards divergence of E2

Sl.No.	Characters	Times ranked 1st	Per cent (%) contribution
1	DFF	324	17.7
2	DFPF	31	1.69
3	DFPD	6	0.33
4	SPAD 30	0	0.00
5	SPAD 60	50	2.73
6	PH	12	0.66
7	NPB	3	0.16
8	NSB	2	0.11
9	NPPP	191	10.44
10	NSPP	0	0.00
11	SYPP	236	12.9
12	DMW	106	5.79
13	100 SW	701	38.31
14	HI	168	9.18

DFF: Days to first flowering, DFPF: Days to fifty per cent flowering, DFPD: Days to pod initiation, SPAD: SPAD chlorophyll meter readings at 30 and60, PH: Plant height (cm), NPB: Number of primary branches, NSB: Number of secondary branches, NPPP: No. of pods per plant, NSPP: Number of seeds per pod, SYPP: Seed yield per plant (g), DMW: Dry matter weight, HSW: Hundred seed weight (g) and HI: Harvest index.

Table 3a. Average intra - cluster and inter – cluster D^2 values of sixty one genotypes observed under E1

	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI	Cluster VII	Cluster VIII	Cluster IX	Cluster X
Cluster I	7.24	10.69	10.01	11.73	16.48	18.30	16.17	14.02	33.45	15.98
Cluster II	10.69	0.00	5.20	11.28	9.62	7.93	23.91	10.42	34.40	14.91
Cluster III	10.01	5.20	0.00	13.38	13.89	10.36	23.96	11.94	39.41	15.53
Cluster IV	11.73	11.28	13.38	0.00	9.21	13.85	7.84	22.58	18.28	23.68
Cluster V	16.48	9.62	13.89	9.21	0.00	9.95	20.68	28.22	26.57	27.70
Cluster VI	18.30	7.93	10.36	13.85	9.95	0.00	26.23	20.84	44.28	28.35
Cluster VII	16.17	23.91	23.96	7.84	20.68	26.23	0.00	29.24	25.06	26.91
Cluster VIII	14.02	10.42	11.94	22.58	28.22	20.84	29.4	0.00	49.68	19.11
Cluster IX	33.45	34.40	39.41	18.28	26.57	44.28	25.06	49.68	9.11	40.82
Cluster X	15.98	14.91	15.53	23.68	27.70	28.35	26.91	19.11	40.82	0.00

Table 3b. Average intra - cluster and inter - cluster D^2 values of sixty one genotypes observed under E2

	Cluster I	Cluster II
Cluster I	89.34	544.95
Cluster II	544.95	0.00

clusters of well watered condition (E1), Cluster I was the largest with 51 genotypes, followed by Cluster IX with 2 genotypes and remaining clusters being solitary (with only one genotype) in nature. There were two clusters formed under moisture stress condition (E2), with 60 genotypes in Cluster-I and Cluster-II with one genotype (Table 1a and 1b). The classifying of genotypes would be of practical value to chickpea breeders to identify the genotype with desired trait for utilization in breeding program for genetic improvement (Sharifi *et al.*, 2018). Though in general number of clusters under stress condition are expected to be more due to differenrtial expression for various traits, in the present study it is not so, attributing to the fact that the genotypes used for the present study were the lines selected based on the screening for drought tolerance in previous experiments.

Maximum contribution towards divergence was attributed by number of pods per plant (20.6%) and least was by days to first pod initiation under well watered (E1) condition whereas, in moisture stress (E2)100 seed weight (38.31%) was found to have maximum contribution towards divergence and least contribution was from SPAD chlorophyll meter reading and number of seeds per pod. The data on per cent contribution towards divergence is given in Table 2a and 2b. The results emphasize the presence of differential G x E interaction pattern for the traits under different moisture regimes. The characters contributing maximum divergence needs greater emphasis for deciding on the clusters for the purpose of selection of parents in the respective cluster for hybridization aimed at developing genotypes suitable for particular environment Parameshwarappa *et al*. (2011).

Maximum distance among the genotypes within the same cluster was observed in Cluster IX (9.11) followed by Cluster I (7.24). As indicated by inter cluster D^2 values, the inter cluster distance varied from 5.20 to 49.68. Among 2 clusters under E2, there was only one genotype in Cluster II where the intra cluster divergence was zero. Maximum distance among the genotypes within the same clusters was observed in Cluster I (89.34), while the inter cluster distance varied from 89.34 to 544.95. Inter cluster distances were higher than the intra cluster distances in both well watered and moisture stress conditions (Table 3a and 3b) indicating precise grouping of genotypes and presence of diversity among the genotypes. The lines belonging to the distant clusters could be used in hybridization programme for obtaining a wider range of variability Parameshwarappa *et al*. (2011).

Cluster means of 14 characters and overall score of the characters is presented in Table 4a and 4b. Based on the scores of individual trait means across clusters, highest ranking was recorded by Cluster I (Rank 1) followed by Cluster VIII (Rank 2) and least ranking was observed in Cluster III (Rank 10) followed by Cluster IX (Rank 9) under E1. Whereas under E2, Cluster I (Rank 1) followed by Cluster II (Rank 2).

The genotypes in the Cluster I showed more number of secondary branches, Cluster II and VIII recorded higher total plant dry matter weight and hundred seed weight. Cluster IV was consisting of genotypes with higher seed yield per plant along with more number of primary branches whereas, high number of pods per plant and seeds per pod were recorded highest in Cluster VI. Further, Cluster IX consisted of the genotypes with taller plants and high harvest index under E1. Under E2 Cluster I ranked highest in containing more number of secondary branches per plant, total dry matter weight and hundred seed weight whereas Cluster II was found top for containing more number of primary branches per plant, number of pods per plant, number of seeds per pod, seed yield per plant along with plant height and harvest index.

In the present study, the lines DIBG 203 and DIBG 206 were found to be promising for yield under moisture stress condition with seed yield (q/ha) of 22.10 and 22.7, respectively against the popular check variety, JG 11 (21.4q/ha).

Conclusion

From MAGIC population moisture stress tolerant lines were identified.

Table 4a. Cluster means for nine traits in sixty one genotypes of chickpea under E1

Sl. No.	Characters	Clusters I	Clusters II	Cluster III	Cluster IV	Cluster V	Cluster VI	Cluster VII	Cluster VIII	Cluster IX	Cluster X
1	PH	34.47(6)	31.60(3)	30.60(2)	37.00(7)	37.40(8)	34.00(5)	39.00(9)	33.90(4)	39.55(10)	29.70(1)
2	NPB	1.95(5)	1.90(4)	2.00(6)	2.30(9)	2.10(7)	1.40(1)	2.20(8)	1.60(2)	1.85(3)	2.50(10)
3	NSB	5.55(7)	4.30(3)	4.00(2)	4.90(6)	8.00(10)	3.50(1)	4.70(5)	4.40(4)	6.65(9)	5.60(8)
4	NPPP	27.95(2)	46.35(8)	44.15(5)	46.00(7)	64.70(10)	61.65(9)	30.90(4)	29.30(3)	45.30(6)	12.40(1)
5	NSPP	1.08(5)	1.06(2)	1.04(1)	1.08(5)	1.08(5)	1.20(9)	1.38(10)	1.10(7)	1.07(3)	1.14(8)
6	SYPP	4.27(2)	5.90(6)	4.34(3)	8.18(9)	7.27(7)	5.03(5)	8.01(8)	4.41(4)	12.40(10)	3.26(1)
7	DMW	2.02(4)	2.52(8)	2.75(9)	1.79(2)	2.11(5)	1.93(3)	1.64(1)	3.13(10)	2.33(7)	2.12(6)
8	100 SW	22.08(4)	25.70(8)	21.80(3)	23.90(6)	20.55(1)	25.25(7)	21.25(2)	28.55(10)	23.43(5)	26.40(9)
9	HI	67.15(4)	70.07(5)	61.22(3)	82.05(8)	77.49(7)	72.25(6)	83.03(9)	58.49(1)	84.17(10)	60.48(2)
Productivity	Total score	39	47	79	59	60	46	56	45	63	46
traits	Rank	1	5	10	7	8	3.5	6	2	9	3.5

PH: Plant height (cm), NPB: Number of primary branches, NSB: Number of secondary branches, NPPP: No. of pods per plant, NSPP: Number of seeds per pod, SYPP: Seed yield per plant (g), DMW: Dry matter weight, HSW: Hundred seed weight (g) and HI: Harvest index

Table 4b. Cluster means for nine traits in sixty one genotypes of chickpea under E2

Sl. No.	Characters	Clusters I	Clusters II
1	PH	33.61(1)	39.00(2)
2	NPB	2.18(1)	2.20(2)
3	NSB	5.77(2)	4.70(1)
4	NPPP	19.91(1)	30.90(2)
5	NSPP	1.06(1)	1.38(2)
6	SYPP	3.16(1)	8.01(2)
7	DMW	1.75(2)	1.64(1)
8	100 SW	22.55(2)	21.25(1)
9	HI	63.70(1)	83.03(2)
Productivity	Total score	12	15
traits	Rank	1	2

PH: Plant height (cm), NPB: Number of primary branches, NSB: Number of primary branches, NPPP: No. of pods per plant, NSPP: Number of seeds per pod, SYPP: Seed yield per plant (g), DMW: Dry matter weight, HSW: Hundred seed weight (g) and HI: Harvest index

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