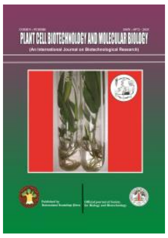

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Characterization of Chickpea Genotypes for Qualitative and Quantitative Traits in the Bundelkhand Region

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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

About 550 germplasm accessions of chickpea were undertaken to evaluate 20 morphological traits using DUS guidelines given by PPV & FRA. And they are used to determine the relationships among yield and yield attributes using direct and indirect selection parameters. Out of 20 DUS traits, seven traits were dimorphic, 10 traits were found trimorphic and the remaining three traits showed polymorphism. Significant genetic variations were observed among the genotypes for days to 50% flowering, days to maturity, leaf-let size, number of pods per plant, number of seeds per pod, primary branches, peduncle length, plant height, secondary branches, 100 seed weight, seed yield per plant. High PCV, GCV, heritability and genetic advance are obtained for secondary

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branches, pods per plant, seeds per pod, 100 seed weight and seed yield. Correlation studies revealed that seed yield was positively and significantly correlated with leaf-let size, number of pods per plant, number of seeds per pod, primary branches, peduncle length, plant height, secondary branches, 100 seed weight. The path coefficient analysis based on seed yield, as a dependent variable, showed that the number of pods per plant had the greatest direct effect on seed yield (0.68) followed by 100 seed weight (0.561) and the number of seeds per pod (0.42). Both correlation and path analysis indicated that pods per plant and the 100 seed weight were the major direct contributors to seed yield.

Keywords: Chickpea; qualitative traits; quantitative traits; correlation; path analysis.

1. INTRODUCTION

Chickpea (*Cicer arietinum* L.) is generally known as Gram, Bengal gram, or Chola, has been under the practice of cultivation since ancient times. It is mainly grown in rainfed and is highly valued for its ability to improve and sustain soil fertility and productivity [1]. The production of chickpea has been estimated to be about 12.61 million tonnes during 2020-21 in our country [2]. In India, chickpea is grown on about 10.56 million hectares while, Bundelkhand region is one of the mini pulse-hub of India it consists of seven districts of Uttar Pradesh (Jhansi, Jalaun, Lalitpur, Mahoba, Hamirpur, Banda and Chitrakoot) and seven districts of Madhya Pradesh (Datia, Tikamgarh, Niwari, Chhatarpur, Panna, Damoh and Sagar) [3]. The area under chickpea cultivation in Bundelkhand is about 0.79 million hectares with a production of 1.08 million tonnes and whose productivity is 1320 kg per hectare which is higher than the national average productivity (1077 Kg/ha). Bundelkhand contributes 9.49 % of chickpea production to the total chickpea production in India [4]. Datia district of Bundelkhand shows the highest productivity of chickpea (2.07 tonnes per hectare) which is 67.66 % higher than average national productivity [5]. Characterization of plant genetic resources helps in the identification of trait-specific donors for their utilization in breeding programs. Similarly, the characterization of varieties for morphological traits helps in establishing the distinctness of the variety during quality seed production. The knowledge of genetic variability present in targeted material is essential for better understanding the worth of the germplasm material introduced and its utilization in the crop improvement program. Out of the several promising donors/genotypes, one should identify the genotype/donor having the combination of useful traits (agronomically superior) for use in a breeding programme.

2. MATERIALS AND METHODS

550 germplasms of chickpea received from NBPGR, New Delhi was undertaken for evaluation of qualitative traits, assessment of direct and indirect selection parameters. This investigation was carried out at Rani Lakshmi Bai Central Agricultural University Jhansi (Uttar Pradesh) in augmented design with 11 blocks (50 germplasms per block) using four checks (RVG 202, RVG 203, JG 14 and Ujjawal) and observations were recorded for 20 DUS traits and quantitative traits. Seeds of each genotype were sown at 4m long with a spacing of 30 x 10 cm. The analysis of variance for augmented design was done using the method given by Federer [6]. Genotypic and phenotypic coefficients of variability for all traits are assessed by using a method proposed by Burton and Devane [7]. Heritability in a broad sense was calculated by using the formula suggested by Allard, (1960). Simple correlations were computed by using the formula given by Singh and Narayanan [8]. The method of path coefficient is calculated by using method developed by Wright (1921) and modified by Dewey and Lu [9].

3. RESULTS AND DISCUSSION

3.1 Morphological Characterization

For morphological characterization, twenty qualitative characters were considered by following DUS guidelines given by PPV & FRA. All the 550 accessions were classified into different groups concerning each qualitative trait under study. Out of twenty DUS traits, seven traits were dimorphic, ten traits were found trimorphic and the remaining three traits showed polymorphism. The accessions were categorized into different groups as (i) Anthocyanin pigmentation: absent (11) and present (539). Desi chickpeas generally shows anthocyanin pigmentation while kabuli type do not shows anthocyanin pigmentation in their foliage; (ii) Stem height at initiation of first flower: low (4), medium (490) and high (55). This trait will shows position of first cob from the ground level ; (iii) Days to 50% flowering: medium (144) and long (406) this trait will helps to know the flowering time and biomass accumulation; (iv) Growth habit: erect (58), semi erect (468) and spreading (24). Erect growth habit plants are most suitable for mechanical harvesting; (v) Plant: foliage colour: light green (13), medium green (96), dark green (423) and greenish purple (17). Darker the foliage darker the seed coat colour; (vi) Leaf-let size: small (22), medium (490) and large (38). Broader the leaflet size higher the area of photosynthesis; (vii) Leaf pattern: simple (1) and compound (549). Broder the leaf area higher the seed size; (viii) Flower number per peduncle: single (542) and twin (8). Two or more flower per peduncle causes the small seed size; (ix) Flower colour: white (11), pink (530) and blue. Generally Kabuli type of chickpea shows white coloured flowers while desi chickpea shows pink and blue colour flower. (x) Flower stripes on standard petal: absent (9) and present (541); (xi) Peduncle length: short (5), medium (254) and long (291); (xii) Plant height: short (118), medium (421) and tall (11). Tall plant type susceptible to lodging; (xiii) Pod size: small (72), medium (431) and large (47). Pod size may have influence on seed size, generally greater the pod size higher the seed size; (xiv) Seeds per pod: one (168) and more than one (382). Higher the seeds per pod increases seed yield per plant; (xv) Seed colour: beige (7), creamy beige (28), green (2), yellow (95), orange (6), brown (244), dark brown (77), grey (75) and black (16). Kabuli types will shows beige to creamy beige colour while Desi types shows other coloured seeds; (xvi) Seed size: very small (443), small (52), medium (34), large (18), very large (3). Higher the seed size greater the seed yield per plant; (xvii) Seed shape: pea-shaped (16), owl's head (84) and angular (450), pea shaped and owl's head shaped seeds generally have good seed weight than angular shaped seeds; (xviii) Seed testa texture: rough (153), smooth (305), tuberculated (92); (xix) Seed ribbing: absent (372) and present (178); (xx) Seed type: Desi (538) and Kabuli (12). All these seed traits will have influence on seed appearance and storability. Similar wide variations for morphological traits are also reported by Upadhyaya et al. [10], Johanson et al. [11], Qureshi et al. [12], Ramanappa et al. [13], Choudhury et al. [14], Solanki et al. [15]. All the above mentioned DUS traits will helps in identifying better doner parents for crop improvement programme, and also helps in conducting grow out test to identify specific varieties. Out of 550 accessions, 6 accessions namely viz., EC267309, IC267381, IC255447, IC244331, IC328106 and IC269082 had erect plant architecture therefore may be suitable for mechanical harvesting.

3.2 Variability Studies

The estimates of the phenotypic and (PCV) and genotypic coefficient of variation (GCV) for twelve characters of chickpea have been represented in Table (3). The magnitude of the phenotypic coefficient of variation (PCV) was higher than that of the corresponding genotypic coefficient of variation for all the traits which might be due to the environmental influence. The genetic parameters estimated are represented as follows, the highest phenotypic (PCV) and genotypic (GCV) coefficients of variation were recorded for seed yield per plant (PCV=34.2, GCV=32.28) followed by the number of pods per plant (PCV=42.92, GCV=42.16), 100 seed weight (PCV=34.99, GCV=32.56), secondary branches (PCV=28.45, GCV=27.85) and the number of seeds per pod (PCV=26.02, GCV=24.21) can be considered as high because of being very close to 20%. All the above mentioned traits are highly influenced by genetic and environmental factors. The presence of high GCV and PCV for 100 seed weight, seed yield per plant, was earlier reported by Banik et al. [16], Jain et al. [3] and Kishor et al. (2018) high GCV and PCV for 100 seed weight, seed yield per plant and biological yield per plant were also reported earlier by Mohan et al. [17]. The moderate value estimate (<20% to >10%) of PCV and GCV were recorded for primary branches (PCV=19.7, GCV=16.88) followed by plant height (PCV=15.09, GCV=13.84) and leaf-let size (PCV=14.28, GCV=13.88), whereas, the lowest values estimate of phenotypic and genotypic coefficient of variation had observed for days to maturity (PCV=7.65, GCV=7.56) and days to 50% flowering (PCV=5.79, GCV=5.67). These traits are less influenced by environment and genetic factors. Selection of germplasm can be done directly for the traits like seed yield, number of pods per plant, 100 seed weight, number of secondary branches and number of seeds per pods. And the same results are obtained by Babbar et al. [18] and Ali et al. [19].

Table 1. Analysis of variance for yield and yield attribute traits in chickpea germplasm

Sources of variation	DF	Days to 50% flowering	Days to maturity	Leaf-let size	No. of pods per plant	No. of seeds per pod	Primary branches	Peduncle length	Plant hight	Pod length	Secondary branches	100 seed weight	Seed yield per plant
		Mean sum of square											
Block (adjusted)	10	1.65	**0.74**	**0.78****	**65.18****	**0.03**	**0.04**	**4.64**	**16.76**	**2.73**	**2.9****	**3.65**	**25.85**
Entries (adjusted)	553	20.3 **	101.61 **	3.17 **	748.96 **	0.12 **	0.33 **	7.92 **	54.4 **	8.8 ns	11.43 **	43.13 **	105.8 **
Check	3	375.42 **	105.78 **	0.54 *	1260.55 **	0.88 **	1.68 **	48.08 **	456.32 **	198.67 **	9.53 **	185.73 **	333.38 **
Verities	549	22.96 **	101.62 **	3.32 **	827.43 **	0.12 **	0.4 **	6.74 *	56.46 **	6.95 ns	16.59 **	40.34 **	107.48 **
Check vs. Varieties	1	1.63 ns	2331.28 **	10.59 **	139.93 *	0.18 **	13.83 **	711.99 **	2008.92 **	974.89 **	146.6 **	2112.85 **	2744.41 **
Error	30	0.94	2.28	0.18	28.88	0.02	0.11	3.87	8.94	5.86	0.73	5.41	9.56

and indicate 5% and 1% level of significance*

Table 2. Estimation of mean performance and range of accession

Sl.No	Character	Mean	Range		Co-efficient of variance
			Minimum	Maximum	
1	DF50	82.7	54.5	93.75	1.17
2	DM	131.81	106.3	140.3	1.15
3	PB	3.21	1.78	5.21	10.05
4	SB	14.3	6.86	29.23	5.91
5	NPPP	67.03	16.77	174.67	8
6	NSPP	1.35	0.89	2.54	9.5
7	PH	49.79	25.47	75.17	5.95
8	SW100	18.15	6.51	55.71	12.48
9	SYPP	16.15	0.43	122.31	18.51
10	LS	12.76	6.26	18.86	3.32
11	PL	17.14	10.19	27.36	13.86
12	PDL	10.26	2.31	22.39	18.67

Table 3. Estimation of PCV and GCV, heritability, genetic advance and genetic advance as per mean for twelve characters in chickpea (2019-20)

	Character	Coefficient of variance		Heritability	Genetic advance	Genetic advance as per mean
		PCV	GCV			
1	DF50	5.79	5.67	95.9	9.48	11.46
2	DM	7.65	7.56	97.76	20.33	15.42
3	PB	19.7	16.88	73.36	0.96	29.82
4	SB	28.48	27.85	95.62	8.03	56.19
5	NPPP	42.92	42.16	96.51	57.27	85.45
6	NSPP	26.02	24.21	86.57	0.63	46.48
7	PH	15.09	13.84	84.16	13.05	26.2
8	SW100	34.99	32.56	86.59	11.35	62.51
9	SYPP	34.2	32.28	71.11	19.49	89.67
10	LS	14.28	13.88	94.57	3.55	27.85
11	PL	15.38	6.1	15.73	0.86	4.99
12	PDL	25.29	16.49	42.51	2.28	22.18

Table 4. Estimation of the simple correlation coefficient between twelve characters in chickpea

	Augmented Design Correlations 2019-20											
	DF50	**DM**	**PB**	**SB**	**NPPP**	**NSPP**	**PH**	**SW100**	**LS**	**PL**	**PDL**	**SYPP**
DF50	1											
DM	.358**	1										
PB	-.204**	-.152**	1									
SB	-.190**	-.148**	.845**	1								
NPPP	-.082*	-.074	.365**	.474**	1							
NSPP	-.138**	-.035	.087*	.102*	.008	1						
PH	-.270**	-.118**	.280**	.210**	.188**	-.003	1					
SW100	.034	-.057	.046	-.006	-.081*	-.105*	.189**	1				
LS	-.005	-.010	.191**	.161**	.134**	.057	.381**	.174**	1			
PL	-.093*	-.086*	.238**	.207**	.010	-.021	.313**	.396**	.235**	1		
PDL	-.242**	-.172**	.142**	.085*	.048	.071	.226**	.155**	.141**	.213**	1	
SYPP	-.118**	-.114**	.303**	.349**	.642**	.371**	.221**	.437**	.185**	.181**	.151**	1

***. Correlation is significant at the 0.01 level (2-tailed)*
**. Correlation is significant at the 0.05 level (2-tailed).*

Table 5. Path matrix; direct and indirect effects of various characters on seed yield

	DF50	DM	PB	SB	NPPP	NSPP	PH	SW100	LS	PL	PDL
DF50	**-0.023**	-0.004	0.007	-0.005	-0.054	-0.059	0.001	0.017	0.000	0.004	-0.002
DM	-0.008	**-0.011**	0.005	-0.004	-0.048	-0.013	0.000	-0.034	0.000	0.004	-0.001
PB	0.005	0.002	**-0.035**	0.024	0.252	0.038	-0.001	0.028	-0.004	-0.010	0.001
SB	0.004	0.002	-0.030	**0.028**	0.320	0.042	0.000	-0.006	-0.003	-0.008	0.001
NPPP	0.002	0.001	-0.013	0.013	**0.681**	0.004	0.000	-0.045	-0.002	0.000	0.000
NSPP	0.003	0.000	-0.003	0.003	0.007	**0.421**	0.000	-0.062	-0.001	0.001	0.001
PH	0.006	0.001	-0.010	0.006	0.129	0.000	**-0.002**	0.107	-0.007	-0.013	0.002
SW100	-0.001	0.001	-0.002	0.000	-0.054	-0.046	0.000	**0.561**	-0.003	-0.016	0.001
LS	0.000	0.000	-0.007	0.005	0.088	0.025	-0.001	0.095	**-0.018**	-0.009	0.001
PL	0.002	0.001	-0.008	0.006	0.007	-0.008	-0.001	0.225	-0.004	**-0.040**	0.002
PDL	0.006	0.002	-0.005	0.003	0.034	0.029	0.000	0.084	-0.003	-0.008	**0.009**

Residualeffect:0.167

The highest heritability (broad sense) was noted for days to maturity (97.76%) followed by the number of pods per plant (96.51%), days to 50% flowering (95.9%), secondary branches (95.62%), leaf-let size (94.57), seed yield per plant (71.11%), 100 seed weight (86.59%) number of seeds per pod (86.57%), plant height (84.16%) and primary branches (73.36%) indicating that desired improvement through the exploitation of traits having high heritability can be achieved in chickpea results to a certain extent are in accordance with the findings of Kuldeep et al. [20]; Banik et al. [16]. Traits like days to maturity, number of pods per plant, days to 50% flowering, secondary branches, leaf-let size, seed yield per plant, 100 seed weight, number of seeds per pods, plant height and primary branches are easily heritable to next generation selection among these traits will give better results. And moderate heritability is recorded for pod length (42.51%) and low heritability is observed for peduncle length (15.73%).

Genetic advance as percent of mean has been observed maximum for seed yield per plant (89.67) followed by the number of pods per plant (85.45), 100 seed weight (62.51), secondary branches (56.19), number of seeds per plant (46.48), primary branches (29.82), plant height (26.2), leaf-let size (27.85) and pod length (22.18). Highest genetic gain can be obtained by selecting number of pods per plant, 100 seed weight, secondary branches, number of seeds per plant, primary branches, plant height, leaf-let size and pod length. Kuldeep et al. [20], Hagoes et al. (2015) and Johanson et al. [11] also reported high genetic advances for 100 seeds per plant, primary branches, secondary branches, pods per plant and seed yield per plant. Whereas, moderate values of genetic advance as per mean (5%) were observed for days to maturity (15.42) and days to 50 % flowering (11.46) which is similar to the results of Babbar et al. [18]. While low genetic advance is observed for peduncle length (4.99).

3.3 Character Association Studies

Seed yield is a complex trait and is determined by the interactive effects of many yield attributing traits, which are further influenced by their genetic structures and the environmental effect. Seed yield per plant had a highly significant and positive association with the number of pods per plant (0.642**) followed by 100 seed weight (0.437**), number of seeds per pod (0.371**), secondary branches (0.349**), primary branches (0.303**), plant height (0.221**), leaf-let size (0.185**), peduncle length (0.181**) and pod length (0.151**) (Table 4). Direct selection for above mentioned traits will significantly increases the yield per plant. Positive and significant correlations with these yield contributing traits were also reported by Noor et al. [21]; Arshad et al. [22]; Vaghela et al. [23]; Sohil et al. [24]; Babbar et al. [18]; Bayahi et al. [25]; Tsehaye et al. [26]. While days to 50% flowering (-0.118**) and days to maturity (-0.114*) exhibited a negative and significant association with seed yield per plant. These results are also reported by Babbar et al. [18]; Bayahi et al. [25]; Jain et al. [(3]; Vaghela et al. [23]. And 100 seed weight showed a highly significant and positive association with seed yield (0.437**), peduncle length (0.396**), plant height (0.189**), leaf-let size (0.174**), pod length (0.155**) which is also reported by Kumar et al. [27]. And leaf-let size showed a significant positive correlation with plant height (0.381**). The number of pods per plant showed a significant positive correlation with seed yield (0.642**), secondary branches (0.474**) and primary branches (0.365**) which is similar to the results of Hama et al. (2019).

3.4 Path Coefficient Analysis

Path coefficient analysis is conducted to study the direct and indirect effect of various yield contributing traits, where yield per plant is the dependent variable and other characters are independent variables (Table 5). In the present investigation, the number of pods per plant (0.681) showed the highest positive direct effect on seed yield followed by 100 seed weight (0.561), the number of seeds per pod (0.421), secondary branches (0.028) and pod length (0.009). The traits like number of pods per plant, number of seeds per pods, secondary branches and pod length are having direct effect on seed yield. Similar results are also reported by Noor et al. [21]; Banu et al. [28]; Arshad et al. [22]; Jivani et al. [29]; Khan and Gul [30]. And peduncle length (-0.040), primary branches (-0.035), days to 50% flowering (-0.023), leaf-let size (-0.018), days to maturity (-0.011) and plant height (-0.002) showed a direct negative effect on seed yield. Yucel et al. [31] reported a similar result of a direct negative effect on seed yield. The number of pods per plant showed a positive indirect effect on yield through the number of seeds per plant and secondary branches which is also reported by Yadav et al. [32]. Days to 50% flowering showed an indirect positive effect on yield through plant height and 100 seed weight, a similar result is also reported by Agarwal et al. [33], Sohail et al. [24]. Plant height is positively indirectly dependent on seed yield via days to 50% flowering, secondary branches and the number of pods per plant, which is reported earlier by Noor et al. [21]; Banu et al. [28].

4. CONCLUSION

The genotypes used in the study showed huge variability and association among themselves for various traits under study. From the present study, seed yield, pod length, 100 seed weight and primary branches are more variable characters among these genotypes. To achieve improvement in the seed yield more importance should be given to those characters which are influencing it directly or indirectly on seed yield. For this, correlation and path co-efficient analysis is carried out to find out the relationship among the yield and yield contributing characters. In the present investigation, the characters like the number of pods per plant, 100 seed weight, secondary branches and primary branches were identified as main selection criteria for improving seed yield in chickpea, as these characters recorded strong positive correlation as well as high positive direct effects with seed yield per plant.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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