LR-4407
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SHORT COMMUNICATION

Legume Research- An International Journal, Volume Issue :

Genetic Variability and Inter-relationships Among Grain Physical and Hydration Traits in Chickpea

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10.18805/LR-4407

ABSTRACT

Background: Chickpea is the major pulse crop in India accounting for nearly 43% (10.13 MT) of the total pulse production and 80% of total pulse export during 2018-19. It is a good source of carbohydrates and protein and constitutes an important component of diet of largely vegetarian Indian masses. Hydration capacity and volume expansion (after soaking in water) are important cooking quality traits in chickpea, particularly in *kabuli* type which are mostly cooked as 'whole grain' without decortication. Limited information is available on these properties of chickpea. The current study is aimed at assessing the genetic variability and inter-relationships among grain physical and hydration traits in chickpea varieties.

Methods: During the period 2017-2018, a total of fifty-nine chickpea (*Cicer arietinum* L.) varieties including 46 *desi* type and 13 *kabuli* type varieties were evaluated for their grain physical and hydration traits *viz*., 100-seed weight, seed density, hydration capacity, hydration index, swelling capacity and swelling index.

Result: Significant differences were observed for 100 seed weight (Range: 11.00 to 51.50 g/100 seeds; Mean: 21.8 g/100 seeds), seed density (Range: 1.19 to 1.88; Mean: 1.37), hydration capacity (Range: 0.05 to 0.62; Mean: 0.24), hydration index (Range: 0.33 to 1.51; Mean: 1.10), swelling capacity (Range: 0.08 to 0.60; Mean: 0.25) and swelling index (Range: 0.62 to 2.33; Mean: 1.59). The magnitude of PCV was moderately higher than the corresponding GCV values for most of the traits indicating that the influence of the environment on the expression of these traits was not high. High heritability coupled with high genetic advance was recorded for 100-seed weight, hydration capacity and swelling capacity in both *desi* and *kabuli* varieties. These results indicate that high heritability of these traits is predominantly due to additive gene action and hence direct selection for these traits is expected to be effective. 100-seed weight showed significant positive correlations with hydration capacity and swelling capacity and negative correlation with seed density. Seed density showed negative correlation with hydration capacity, hydration index and swelling capacity. Hydration capacity was positively correlated with hydration index, swelling capacity and swelling index. These traits are important for consumers where whole grains are consumed after soaking and cooking. Existence of sufficient variability for these quality traits suggest the scope for breeding chickpea towards improved consumer preferred quality traits.

Key words: Chickpea, Grain physical traits, Hydration capacity, Seed weight, Swelling capacity.

INTRODUCTION

Pulses play a vital role in providing daily protein dietary requirement of largely vegetarian population in the Indian sub-continent. Chickpea, being the major pulse crop, provides bulk of this requirement through *dal* and other preparations. It accounted for nearly 43% (10.13 MT) of the total pulse production and 80% of total pulse export during 2018-19 (Anonymous, 2019). It is a good source of carbohydrates and protein and constitutes an important component of diet of largely vegetarian Indian masses (Chibbar *et al*. 2010). In general, large-seeded *kabuli* chickpeas fetch a higher price and the price premium increases as the seed size increases (Gaur *et al*., 2007). Hydration capacity and volume expansion (after soaking in water) are important cooking quality traits in chickpea, particularly in *kabuli* type which are mostly cooked as 'whole grain' without decortication. Chickpea breeding in India has been focussed on yield improvement along with incorporation of stress resistance and quality improvement has often been neglected (Srivastava *et al*. 2016). Limited information is available on these properties of chickpea based on breeding lines (Tripathi *et al*, 2012), mini-core collection (Sastri *et al*., 2019) etc. and such information on recently released varieties is not available. Hence, present study was undertaken to assess the genetic variability and inter-relationships among grain physical and hydration traits in chickpea varieties.

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How to cite this article: Srivastava, A.K., Dixit, G.P., Nisar, M. and Singh, N.P. (2020). Genetic Variability and Inter-relationships among Grain Physical and Hydration Traits in Chickpea. Legume Research. 10.18805/LR-4407

Submitted: 27-04-2020 **Accepted:** 07-10-2020 **Online:** 21-12-2020

Fifty-nine chickpea (*Cicer arietinum* L.) varieties including 46 *desi* type and 13 *kabuli* type (Table 1). These varieties are popular in different parts of the country and are in breeder seed production chain based on indents from various state agencies. The material was grown at ICAR-IIPR New Research Campus during 2017-18 in randomized block design with three replications. In each replication, four rows of a variety were planted in 4m row with row to row spacing of 30 cm and plant to plant spacing of 10 cm. The harvested seeds were evaluated for their grain physical and hydration traits *viz*., 100-seed weight, seed density, hydration capacity, hydration index, swelling capacity and swelling index. Three random samples of 100 seeds from each cultivar per replication were weighed and the values were converted into grams per 100 seeds. The seed volume was determined by transferring 100 seeds into a 100 ml measuring cylinder containing 50 ml of distilled water. The gain in volume was taken as the volume occupied by the seed. Seed density was calculated as seed weight divided by seed volume. Hydration capacity was recorded as gain in weight after overnight (12h) soaking in distilled water. Hydration index was calculated as hydration capacity divided by the original seed weight. Swelling capacity was determined as gain in volume after overnight soaking in water. Swelling index was calculated as swelling capacity divided by the original seed volume. The data was subjected to analysis of variance (ANOVA) for testing the significance of variation due to varieties for six seed quality traits as described by Gomez and Gomez (1984). Mean values were calculated and compared using F-test at 5% level of significance. Correlation between these quantitative characters was estimated according to the method given by Singh and Chaudhary (1977).

The analysis of variance (ANOVA) for seed quality traits indicated significant variation for all the traits (Table 1). The seed weight ranged from 11.00 to 51.50 g/100 seeds with mean of 21.8 g/100 seeds, seed density ranged from 1.19 to 1.88 with mean of 1.37, hydration capacity ranged from 0.05 to 0.62 with mean of 0.24, hydration index ranged from 0.33 to 1.51 with mean of 1.10, swelling capacity ranged from 0.08 to 0.60 with mean of 0.25 and swelling index

Table 1: ANOVA for seed quality traits in chickpea varieties.

Source of Variations	Type	df	Mean square due to: 100 Seed weight	Seed Density	Hydration Capacity	Hydration Index	Swelling Capacity	Swelling Index
Replication	Desi	2	1.361	0.002	0.001	0.006	0.001	0.001
	Kabuli	2	2.960	0.009	0.001	0.007	0.001	0.004
	Overall	2	2.782	0.001	0.001	0.005	0.002	0.001
Varieties	Desi	46	60.31**	0.048**	0.012**	0.190**	0.013**	0.349**
	Kabuli	11	315.29**	0.004	0.042**	0.031**	0.040**	0.041**
	Overall	58	205.27**	0.041**	0.035**	0.164**	0.032**	0.285**
Error	Desi	92	0.93	0.005	0.001	0.003	0.001	0.007
	Kabuli	22	2.964	0.004	0.001	0.003	0.001	0.006
	Overall	116	1.332	0.005	0.001	0.003	0.001	0.007

** Significant at P=0.01.

Table 2: Genetic components for seed quality traits in chickpea varieties.

Traits	Type	Mean ± S.E.	Range	Coefficient of variation Genotypic (GCV)	Phenotypic (PCV)	Heritability (Broad Sense)	Expected genetic advance as % of mean
100 seed weight	Desi	18.95 ±0.56	11.00 to 30.00	23.48	24.03	0.96	47.26
	Kabuli	33.00 ± 0.99	19.00 to 51.50	30.92	31.36	0.97	62.81
	Overall	21.81 ± 0.67	11.00 to 51.50	37.81	38.18	0.98	77.14
Seed Density	Desi	1.38 ±0.04	1.19 to1.88	8.71	10.05	0.75	15.53
	Kabuli	1.31 ± 0.04	1.27 to 1.39	0.64	4.84	0.02	0.18
	Overall	1.37 ± 0.04	1.19 to 1.88	8.08	9.53	0.72	14.11
Hydration Capacity	Desi	0.21 ± 0.01	0.05 to 0.34	31.04	31.55	0.97	62.92
	Kabuli	0.39 ± 0.01	0.27 to 0.62	29.71	30.11	0.97	60.38
	Overall	0.24 ± 0.01	0.05 to 0.62	44.41	44.77	0.98	90.75
Hydration Index	Desi	1.08 ± 0.03	0.33 to 1.51	23.13	23.69	0.95	46.53
	Kabuli	1.20 ± 0.03	1.07 to 1.42	7.96	9.30	0.73	14.03
	Overall	1.10 ± 0.03	0.33 to 1.51	20.96	21.57	0.94	41.96
Swelling capacity	Desi	0.22 ± 0.01	0.08 to 0.38	29.63	30.06	0.97	60.18
	Kabuli	0.39 ± 0.01	0.25 to 0.60	29.39	29.88	0.97	59.54
	Overall	0.25 ± 0.01	0.08 to 0.60	40.63	40.99	0.98	82.98
Swelling Index	Desi	1.59 ± 0.05	0.62 to 2.33	21.19	21.81	0.94	42.42
	Kabuli	1.56 ± 0.05	1.35 to 1.79	6.94	8.64	0.65	11.48
	Overall	1.59 ± 0.05	0.62 to 2.33	19.22	19.9	0.93	38.25

Table 3: Estimates of correlation coefficient for seed quality traits in chickpea varieties.

Traits	Type	r	Seed Density	Hydration Capacity	Hydration Index	Swelling capacity	Swelling Index
100 seed weight	Desi	r_G	-0.063	0.761**	0.000	0.828**	0.008
		r_P	-0.054	0.739**	-0.004	0.803**	0.012
	Kabuli	r_G	-0.063	0.761**	0.001	0.828**	0.008
		r_P	-0.054	0.739**	-0.004	0.803**	0.012
	Overall	r_G	-0.188*	0.920**	0.108	0.934**	-0.054
		r_P	-0.222*	0.931**	0.117	0.946**	-0.062
Seed Density	Desi	r_G		-0.218**	-0.261**	-0.001	0.529**
		r_P		-0.2020*	-0.223**	0.000	0.422**
	Kabuli	r_G		-0.218**	-0.261**	-0.001	0.529**
		r_P		-0.2020*	-0.2239**	0.000	0.422**
	Overall	r_G		-0.265**	-0.264**	-0.156*	0.414**
		r_P		-0.314**	-0.302**	-0.186*	0.528**
Hydration Capacity	Desi	r_G			0.655**	0.954**	0.441**
		r_P			0.629**	0.929**	0.426**
	Kabuli	r_G			0.655**	0.954**	0.441**
		r_P			0.629**	0.929**	0.426**
	Overall	r_G			0.455**	0.972**	0.174*
		r_P			0.473**	0.984**	0.175*
Hydration Index	Desi	r_G				0.499**	0.685**
		r_P				0.478**	0.648**
	Kabuli	r_G				0.499**	0.685**
		r_P				0.478**	0.648**
	Overall	r_G				0.378**	0.615**
		r_P				0.397**	0.658**
Swelling capacity	Desi	r_G					0.522**
		r_P					0.512**
	Kabuli	r_G					0.522**
		r_P					0.512**
	Overall	r_G					0.238**
		r_P					0.241**

$r_{G:}$ Genotypic correlation coefficient; $r_{P:}$ Phenotypic correlation coefficient; HSW: 100 seed weight; SD: Seed Density; HC: Hydration capacity; HI: Hydration Index; SC: Swelling capacity; SI: Swelling Index

** Significant at P=0.01, * Significant at P=0.05, r_G: Genotypic correlation, r_P: Phenotypic correlation.

ranged from 0.62 to 2.33 with mean of 1.59 (Table 2). Among *desi* types, the 100 seed weight ranged from 11.0 g (Bidisha) to 30.0 g (Virat) while among *kabuli* types, it ranged from 15.0 g (GPF 2) to 51.5 g (Kripa). The seed density among *desi* types ranged from 1.19 g/ml (PBG 5) to 1.88 g/ml (Phule Vikram) and among *kabuli* types ranged from 1.27 g/ml (GNG 1969) to 1.5 g/ml (GPF 2). The hydration capacity among *desi* types ranged from 0.05 g/seed (PBG 7) to 0.34 g/seed (Virat) and among *kabuli* types ranged from 0.16 g/seed (GPF 2) to 0.62 g/seed (Kripa). The hydration index among *desi* types ranged from 0.33 (PBG 7) to 1.51 (JG 11) and among *kabuli* types ranged from 1.03 (GPF 2) to 1.42 (GNG 1969). The swelling capacity among *desi* types ranged from 0.08 ml/seed (Pant G 186) to 0.38 ml/seed (Virat) and among *kabuli* types ranged from 0.17 ml/seed (GPF 2) to 0.60 ml/seed (Kripa). The swelling index among *desi* types ranged from 0.62 (Pant G 186) to 2.33 (Phule Vikram) and among *kabuli* types ranged from 1.35 (PKC 1) to 1.79 (HK 4). Similar range for seed weight (16 to 39 g/100 seeds), seed density (0.87 and 1.33 g/ml), hydration capacity (0.14–0.37 g/seed), hydration index (0.01–0.02), swelling capacity (0.02–0.34 ml/seed) and swelling index (0.06–2.4) have been reported by Singh *et al* (2010). The magnitude of PCV was slightly high than the GCV for seed quality traits indicating moderate influence of environment on expression of these traits. Similar findings have been reported earlier (Lokare *et al*., 2007; Malik *et al*., 2011). High heritability coupled with high genetic advance was recorded for 100-seed weight, hydration capacity and swelling capacity in both *desi* and *kabuli* genotypes. These findings are in agreement with those of Pandey *et al*. (2007) and Malik *et al*. (2010). These results indicate that high heritability of these traits is predominantly due to additive gene action and hence direct selection for these traits is expected to be effective. The 100-seed weight showed significant positive correlations with hydration capacity and swelling capacity among both *desi* and *kabuli* types (Table 3). Muller (1967) reported the role of cell wall structure, seed composition and cell compactness on water absorbing capacity of seeds. Larger seed size and thinner seed coat facilitate water absorption by seeds (Sefa-Dedeh and Stanley, 1979). Many researchers have reported positive correlation between seed weight and hydration capacity (Khattak *et al*., 2006; Nizakat *et al*., 2006; Ozer *et al*., 2010 *et al*.) and seed weight and swelling capacity (Kaur *et al*., 2005). Seed density showed negative correlation with hydration capacity and hydration index in both *desi* and *kabuli* types. Cultivars with high seed density have compact endosperm which results in lower hydration (Singh *et al*, 2010) and subsequently lower swelling capacity. Hydration capacity was positively correlated with hydration index, swelling capacity and swelling index in both *desi* and *kabuli* types. Similar findings have been reported by Kaur *et al*. (2005) and Ozer *et al*. (2010).

CONCLUSION

The present study estimates the genetic variability and inter-relationship between chickpea seed quality traits *viz*., 100-seed weight, seed density, hydration capacity, hydration index, swelling capacity and swelling index among recently released and popular chickpea varieties. The results indicate high heritability of these traits, predominantly due to additive gene action with possibility of direct selection for improving these traits. Chickpea seed volume and swelling capacity are important traits for consumers, particularly when whole grains are consumed after soaking and cooking. Enough variability exists for seed quality traits among *desi* and *kabuli* chickpea types. Since most of these traits are positively correlated with seed size among both *desi* and *kabuli* types, indirect selection for seed size in breeding population may be effective for simultaneous improvement in physical and hydration traits. It is high time that concerted efforts should be made for developing chickpea varieties possessing consumer preferred quality traits.

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