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Research Article

Association analysis in *Kabuli* chickpea (*Cicer arietinum* L.)

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Abstract
In the millennium of an ever-growing population, feeding the millions ample amount of food with necessarily required nutrition has become a tough challenge. To cater protein requirement, plant-based protein, especially pulses, have always been a better option. Among the pulses, chickpea is one of the choicest crops being extensively cultivated throughout the world. However, the production and productivity of crops are not sufficient to meet consumer demand throughout the world. To aid in the selection process of chickpea breeding, the present study was performed to evaluate fifty-one *kabuli* chickpea (*Cicer arietinum* L.) germplasm lines along with four checks for the degree and direction of association of twelve quantitative characters on yield in fifty five *kabuli* chickpea genotypes. Considerable positive correlation was found between the weight of 100 seeds and the height of the chickpea plant, but the number of pods per plant and seed volume per weight were observed to be in negative association with the former trait. The primary branch depicted a substantial amount of positive correlation with harvest index, seed yield per individual plant, pods produced per plant. Secondly, the current study on association analysis also unveiled positive and highly significant correlations of the number of primary branches, height at the first pod set, pods/plant, and weight of 100 seeds on seed yield, suggesting their further use as selection criteria in the process of crop improvement.

Keywords: Association analysis, Correlation, Germplasm, *Kabuli* chickpea

INTRODUCTION

Pulses, as an integral part of food grains, account for a major constituent of diet around the globe of starting rich to very poor, not for one but all. Due to its richness in protein, several amino acids, and other nutrients with great taste, these compounds have been cultivated for immemorial time. Being quickly growing crops with the ability to fix atmospheric nitrogen through biological nitrogen fixation on rich to marginal soil, they suit very well in any cropping system in any season with an average to good remuneration. The king of pulses, Chickpea (*Cicer arietinum* L.) is adored by approximately all parts of the world as a cool-season *rabi* food legume (Jukanti *et al.,* 2012).
The genus *Cicer* comprises forty-three species that share forty-two wild (thirty-four perennials and eight annuals) and one cultivated species (*Cicer arietinum* L.). Out of the two groups of cultivars *viz. "Desi"* and *"Kabuli"* types, *Kabuli* or macrosperma types have larger seeds with a paper thin seed coat and higher test weight with colors ranging from white to a pale cream colored tan. It is one of the highest consumed legumes in the world. According to the statistical data released by the Directorate of Economics and Statistics, DAC & FW, Govt. of India, a total chickpea production of 11.35 MT was obtained in 2019-20 from an area of 10.17 Mha, and the average productivity was 1116 kg/ha (Anonymous, 2021). The standard per capita per day availability of the pulses ought to be 80 g (World Health Organization - WHO recommendation) and 70 g (Indian Council of Medical Research-ICMR recommendation), while the national-level recommendation is only 54.9 g (Anonymous, 2017). To make pulses available per the

WHO standard, there is a great need to have high-yielding chickpea varieties resistant to various biotic and abiotic stresses along with wider adaptability and stability to overcome malnutrition problems.

Considering that yield of *kabuli* chickpea is a dynamic trait regulated by many genes and affected by several climatic factors, straightforward production-based direct selection may indeed be ineffective. In this regard, comprehensive insight into the pattern and extent of association between different attributes and yield is critical. This experiment was conducted to analyze the correlation among various yield contributing traits and yield to choose parameters to be focused and used as selection criteria for high yielding variety development and the germplasms that can be used most effectively in chickpea breeding.

MATERIALS AND METHODS

Fifty-one *kabuli* chickpea (*Cicer arietinum* L.)germplasm accessions along with four check varieties were collected from the Pulses and Castor Research Station, Navsari Agricultural University (NAU), Navsari, in the western coastal belt of India. The germplasm lines were derived from advanced generation breeding material and the maintained germplasm stock at NAU, Navsari. The checks used in evaluating the lines are Kripa, Virat, Himali, and PKV-2. The present trial was performed in a randomized block design (RBD) with three replications in heavy black soil with a pH of approximately 7.3 to 7.5. Accessions were sown in a double row on a bed of 1 m length with rows at a distance of 45 cm; plant spacing was kept 10 cm in rows. The crop is well maintained with standard crop requirements and pest management practices. To mitigate the attack and border effects, the entire region was encompassed with guard rows. A total of twelve quantitative traits were measured per plant. Two traits involved the day count (days to crop maturity and 50% flowering); two were concerned with branch count (primary and secondary type), five were concerned with production data directly {counting pod numbers, the value of harvest index (%), seed volume per weight (ml/g), yield in the form of seed (g), the weight of 100 seeds (g)}; two involved measurements of height {height at first pod set (cm), plant height (cm)); and one quality parameter (protein content (%)} (Anonymous, 1985).

Five plants were randomly chosen and tagged in each plot of each replication, eliminating border plants to reduce border effects. For the trait involving flowering and maturity, the observations from the entire plot were recorded. Except these, the rest of the variables were evaluated with five random plants from each plot. Various statistical parameters, such as the mean, range, standard deviation, and coefficient of variation, were derived using MS Excel. The mean data were analysed statistically using WINDOSTAT software. Covariances are calculated according to Panse and Sukhatme (1978) for every line. Correlation coefficients were calculated from the covariance values; the positive and negative associations of the various characteristics with yield were deduced.

RESULTS AND DISCUSSION

Association analysis by the correlation coefficient provides a way to assess the parameters that influence the dependent variable, such as crop yield. It also aids in the design of a selection process and concurrent improvement criteria of economic yield and other important characteristics (Akansha *et al.,*2017; Dawane *et al.,* 2020).

In present study, days to 50% flowering showed a highly significant and negative correlation with pods per plant (-0.344), and a nonsignificant correlation (-0.085) was recorded with seed yield per plant in chickpea. As demonstrated in Table 1, a positive and highly significant correlation was observed for the weight of 100 seeds along with days taken for maturity. A similar pattern was also seen with the height of the plant and amount of protein in relation to the above trait. The result of the current study was similar to the findings of Ali and Ahsan (2012) in chickpea for plant height, Thakur and Sirohi (2009), and Dahal *et al*. (2016) in chickpea for 100-seed weight, days taken for maturity, and Johnson *et al*. (2015) in chickpea for days taken for maturity and height of the plant.

A highly significant positive correlation of height at first pod set (0.22), 100 seed weight (0.20), seed volume per weight (0.236), and protein content (0.239) was observed with days to maturity. The rest of the traits had a nonsignificant association. A negative and highly significant relationship was seen with pods per plant and significant with secondary branches per plant. Similar observations were reported by Ali and Ahsan (2012) in chickpea for total pods produced in one plant.

Primary branch count depicted a highly positive substantial correlation with harvest index, seed yield in individual plants, pods produced in one plant and secondary branch count. It was significantly and negatively associated with the weight of 100 seeds and the height of the plant and significantly correlated with seed volume/weight. Parallel results were observed by Ali and Ahsan (2012) in chickpea for harvest index and seed yield in individual plants, pods/plants, and secondary branches and Naveed *et al*. (2012) in chickpea for seed yield in individual plants and pods/plants.

The present study showed that genotypic correlation of height at first pod of *kabuli* chickea was highly significant and positive with the amount of individual plant seed yield, weight of 100-seeds, plant height, furthermore negative association observed in context with harvest index. Correlation coefficients of plant height

Table 1. Genotypic (r_g) and phenotypic (r_p) correlation coefficients showing correlations among twelve characteristics in *kabuli* chickpea

Character		Days to 50% flowering	Days to maturity	Primary branches/ Plant	Secondary branches/ Plant	Height at first pod set (cm)	Plant height (cm)	Pods/ plants	100 -Seed weight	Seed volume/ weight	Harvest index %	Protein content
Days to 50% flowering	r_g	1.000										
	r_p	1.000										
Days to maturity	r_g	0.970**	1.000									
	r_p	0.881**	1.000									
Primary branches/ plant	r_g	0.085	-0.067	1.000								
	r_p	0.076	0.041	1.000								
Secondary branches/plant	r_g	-0.007	-0.162*	1.784**	1.000							
	r_p	-0.078	-0.139	0.283**	1.000							
Height at first pod set (cm)	r_g	0.179*	0.220**	-0.003	-0.046	1.000						
	r_p	0.146	0.140	0.070	0.064	1.000						
Plant height(cm)	r_g	0.213**	0.196*	-0.225**	0.037	0.523**	1.000					
	r_p	0.150	0.085	0.007	0.079	0.404**	1.000					
Pods per plants	r_g	-0.344**	-0.463**	0.972**	0.656**	-0.180*	-0.024	1.000				
	r_p	-0.292**	-0.367**	0.268**	0.461**	-0.074	0.004	1.000				
100 Seed weight(g)	r_g	0.218**	0.253**	-0.265**	-0.277**	0.342**	0.432**	-0.332**	1.000			
	r_p	0.206**	0.201**	-0.016	-0.163*	0.296**	0.400**	-0.304**	1.000			
Seed volume/ Weight (ml/g)	r_g	0.148	0.236**	-0.163*	-0.046	0.024	-0.207**	-0.081	-0.355**	1.000		
	r_p	0.120	0.174*	-0.001	0.023	0.035	-0.133	-0.082	-0.320**	1.000		
Harvest index (%)	r_g	0.059	0.001	0.523**	0.264**	-0.261**	0.146	0.141	0.014	0.055	1.000	
	r_p	0.055	-0.001	0.095	0.187*	-0.163*	0.139	0.131	0.023	0.032	1.000	
Protein content (%)	r_g	0.229**	0.239**	-0.121	-0.179*	-0.037	0.262**	-0.296**	0.109	0.022	0.074	1.000
	r_p	0.192*	0.179*	-0.006	-0.118	-0.025	0.240**	-0.272**	0.105	0.027	0.062	1.000
Seed yield/plant (g)	r_g	-0.085	-0.044	0.585**	0.142	0.253**	0.172*	0.250**	0.247**	-0.355**	0.039	-0.259**
	r_p	-0.067	-0.042	0.071	0.018	0.186*	0.083	0.223**	0.213**	-0.337**	0.022	-0.249

*, ** at 5% and 1% significance level respectively

with protein percentage in seed and weight of 100-seeds concluded a considerable amount of positive association among them. A significant relationship with seed yield/plant and plant height was also noted. It also exhibited a significant and negative correlation with seed volume per weight (-0.207). The rest of the traits had a nonsignificant association. Observations reported by Zardari (2016) in chickpea for the primary branch count and yield of the seed at the single-plant level are similar to the outcome of the present study.

The number of pods in plants showed an extremely large positive association with the per plant seed yield level. It was found to be negatively correlated with the weight of 100 seeds and the protein content. Analogous outcomes were reported in chickpea by Saleem *et al.* (2002), Sail *et al*. (2003), Brar *et al.* (2004), and Ali *et al*. (2009) for seed yield per plant and Ali and Ahsan (2012), (Akansha *et al.,*2017), (Dawane *et al.,* 2020) for 100 seed weight.

In the case of this characteristic, the weight of 100 seeds exhibited a highly significant association with seed yield/plant and was negatively correlated with seed volume/weight. No significant association was seen for the rest of the traits. Parallel observations were depicted in the experimental outcomes of Gular *et al*. (2001), Saleem *et al.* (2002), and Atta *et al*. (2008), (Dawane *et al.,* 2020) for seed yield level of the individual plant in chickpea, whereas Sail et *al*. (2003) showed a negative correlation with the same. Patil *et al.* (2008) also reported a high positive association of the above characteristics in relation to individual plant seed yield in same species mentioned earlier.Seed volume/weight displayed a considerable negative association in relation to seed yield. It has a nonsignificant and positive correlation with protein content and harvest index.

A nonsignificant and positive correlation was found between the harvest index and seed yield per plant and protein content. The correlation status shown by the harvest index in the current study is found to be in line with the results depicted in Arun Kumar *et al.* (2000), Guler *et al.* (2001), Kumar *et al*. (2001b), Narayan and Reddy (2002), Akansha *et al.* (2017), Dawane *et al.* (2020) for seed yield/plant using chickpea as the experimental material, all of these reports showed a positive correlation of harvest index and yield. A contrasting result was obtained by Sail *et al.* (2003), who showed a negative association with seed yield per plant in chickpea. Protein content had a negative and significant association with the number of pods and level of seed yield in individual plants. A considerable association was seen with plant height, days taken to 50% flowering, and maturity. Analogous observations were observed by Kumar *et al.* (2016) in the case of chickpea seed yield/plant.

The most important attribute and major focus area of study, seed yield per plant, showed a considerable level of a positive association in connection with primary branch count, height at first pod set, number of pods in a single plant, and weight of 100-seeds. A significantly positive association was observed in the case of the height of the plant, and a negative and highly significant correlation was observed with protein percentage and seed volume/weight. A positive correlation was seen for the trait with harvest index and secondary branches/plant. The opposite condition of correlation was observed with days to maturity and days to 50% flowering; however, these associations were statistically nonsignificant. Outcome was found to be in accordance with the observations taken in various entries of chickpea by Arun Kumar *et al.* (2000), Guler *et al.* (2001), Atta *et al.* (2008), Patil *et al.* (2008), Dehal *et al.* (2016) and Kumar *et al*. (2016) for 100 seed weight; Vijaya Lakshmi *et al.* (2000), Narayan n and Reddy (2002), Brar *et al.* (2004), Atta *et al*. (2008), Patil *et al.* (2008), Kumar *et al*. (2016) and Bhanu *et al*. (2017) in the case of the number of pods produced in individual plants; Vijaya Lakshmi *et al.* (2000), Brar *et al.* (2004), Atta *et al*. (2008), Dehal *et al.* (2016), Zardari (2016) and Bhanu *et al*. (2017) for primary branches/plants; Yadav *et al.* (2001) for days to 50% flowering. In contrast, 100 seed weight was found to be significantly negatively correlated with seed yield per plant, as per Hussain *et al.* (2016).

In the present study, the degree of genotypic correlations was greater than that of phenotypic correlations, demonstrating an intrinsic link between the traits at the genotypic level. Based on the current study of interrelations, it may be inferred that an optimum plant type for enhancing seed yield in chickpea should have qualities such as early maturity, high 100-seed weight, more pods/plant, and primary branches. Thus, selection could be made for the improvement of one or combinations of such traits, which would also lead to the enhancement of other desired variables by direct selection.

Conclusion

The present scenario of poor availability of the pulses is a clear cut indication of the need to improve its product quality along with quantity together. Intending to establish the correlation of the component characteristics to that of yield in chickpea (*Cicer arietinum* L.), the present study has paved a much clearer way in the selection process to aid this larger goal. Extremely positive noteworthy association of seed yield in relation to height at first pod set, 100-seed weight, primary branches/plant and pods/plant, and high and positive direct effect with days to maturity, pods/plant, height at first pod set, harvest index, secondary branches/plant reflect their prospective use as criteria of selection and tremendous scope for enhancing the total yield of *kabuli* chickpea.

Conflict of interest

The authors declare that they have no conflict of interest.

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