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Research Article

Diversity Analysis of Chickpea Germplasm for the Yield Related Traits

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ABSTRACT

Chickpea is one of the major food legumes cultivated on a large area in the world and is famous for highly proteinaceous seeds. Germplasm diversity plays a key role in chickpea improvement programs. In this regard, the experiment was conducted for the assessment of phenotypic diversity present in chickpea germplasm for yield related traits. The 74 genotypes and 14 modern cultivars of chickpea were sown following the randomized complete block design at the farm area of MNS University of Agriculture, Multan, in November 2018. The evaluation was based on the morphological parameters including plant height (cm), number of pods per 5 plants, number of seeds per pod and 100 seed weight (g). The analysis of variance represented that significant differences were present for these traits among germplasm lines. Based on recorded results, the plant height ranged from 52.58 cm to 82.60 cm in genotypes and from 46.73 cm to 72.86 cm in cultivars. In the case of 100 seeds weight, the range was 13.99 g to 26.51 g in genotypes while 16.67 g to 22.58 g in cultivars. The number of pods in five plants ranged from 23.33 to 211.33 in genotypes and that of 98.33 to 210 in cultivars. Finally, the minimum and the maximum number of seeds per pod in genotypes were 1.53 and 2.93, respectively, while those in the case of the cultivars were 1.6 and 2.5, respectively. Further, based on yield-related traits viz. No. of pods per plant, No. of seeds per pod and 100 seed weight, the TGK1508 was the highest yielding genotype and the D072-11 remained the lowest yielding genotype while Fakhar-e-Thal performed best and was the highest yielding cultivar.

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1. INTRODUCTION

Chickpea (*Cicer arietinum* L.) is a chief proteinaceous pulse cultivated in 59 countries worldwide (FAOSTAT, 2014; Varshney *et al.*, 2017). It is counted as the top 3rd legume for production (contributing 15.42 % of total) and 2nd for cultivation area (covering 15.3 of total). Its annual production is 11.67 million tons occupying the third rank after beans and peas (Merga and Haji, 2019). Further, Asia is the top chickpea producer contributing 83% in total production while India is the top producer country with a contribution of 65% to total chickpea production . Moreover, chickpea is the only cultivated specie from the *Cicer* genus and might be originated from bordering areas of Syria and south-eastern Turkey (Singh and Ocampo, 1997; Singh, 2020). It has diploid chromosomes (2n = 14) with a 738.09 Mbp genome size (Varshney *et al.*, 2013). It is a self-pollinated crop having two major types based on seed color *viz.* Desi and Kabuli. The Kabuli type have white colored seeds while Desi type have black or brown seed color with pink, blue and purple or sometimes white flowers (Sajja *et al.*, 2017).

Moreover, chickpea is grown as a multiuse crop and used in various ways e.g. directly in diet or indirectly in the form of different processed dishes (e.g. daal and basin) or as cattle feed in various cases (Kumara and Deb, 2014). The seed of chickpea is the edible plant part, rich in carbohydrates (almost 61.5%), protein (almost 23.3-28.9%), fats (almost 4.5%) and a lot of minerals *viz* calcium, zinc, phosphorus, iron and magnesium, etc (Patil *et al.*, 2018). Its consumption in daily diet maintains cholesterol level and digestion in humans. It is also utilized for the treatment of blood disorder, bronchitis, snake bite, biliousness, leprosy, sunstroke and skin diseases, etc. Whereas, 3.4-gram of chickpea available per day for each person worldwide while its value is 16.23 grams in case of Pakistan (Khan *et al.*, 2017). Further, chickpea incorporates residual nitrogen in cultivated land and augments the fertility of soil for the cropping system (Siddique *et al.*, 2005). It is also cultivated in rotation with cereals due to its activity of fixing the nitrogen. Though, the yield and production of chickpea are not moving over the last few decades in developing countries.

Lower diversity present in cultivated chickpea is among the topmost constraints causing a major decline in chickpea production (Bharadwaj *et al.*, 2013). The repeated use of cultivated varieties resulted in low chickpea production. A lot of diversity has been varnished from chickpea due to the destruction of landraces and conventional chickpea types after the release of the modern cultivars. Further, four evolutionary bottleneck stages have been reported in chickpea. Those are (I) deficiency and restricted dispersal of wild progenitor (II) domestication leading to the founder effect, (III) shift from winter crop sowing to spring crop sowing and (IV) destruction of local landraces by introducing modern elite cultivars developed through modern breeding techniques (Abbo *et al.*, 2003). The susceptibility of genetically identical modern cultivars to diseases, harsh climates and insect pests is extensively accepted. Moreover, the chickpea germplasm and exotics progenitors resources have a huge variability for agronomic traits along with the diversity for tolerance against biotic stresses as well as a biotic stresses (Chen *et al.*, 2017; Agrawal *et al.*, 2018; Balasaheb *et al.*, 2018; Jha *et al.*, 2018; Jida and Alemu, 2019; Varshney *et al.*, 2019). The exploitation of these resources in chickpea breeding programs is necessary to improve the diversity and production of crops.

Based on the above considerations, the present study was aimed to find out the phenotypic diversity and characterize various chickpea genotypes and cultivars for yield-related traits.

2. MATERIALS AND METHODS

2.1 Experimental location

This research was conducted in the MNS University of Agriculture, Multan.

2.2 Plant material and sowing conditions

Chickpea germplasm was collected from the Arid Zone Research Institute (AZRI). Seventy-four chickpea genotypes and fourteen modern cultivars were used in this experiment for the screening of germplasm based on yield contributing parameters.

The recommended cultural practices for chickpea cultivation were used for conducting the field experiment. All of the experimental units were maintained equally and the same management practices were applied to each unit. The land selected for the cultivation of the experiment contained loamy soil which is best for crop production. The previous cultivated crop was kept in view while preparing the soil and the land was well prepared by two times tillage.

2.3 Experimental Design and Data Collection

The chickpea seeds were collected and primed by soaking in water for 8 hours. Chickpea seed priming in water enhances germination rate (Patil *et al.*, 2018). The experiment was sown in November 2018 following the randomized complete block design with three replications. Each genotype was sown in two lines and each line had a 150 cm length. The plant-plant distance was seven cm and the row-row was 30 cm. Hence, 20 seeds were manually sown in each line. The experiment was maintained till crop maturity. The data for morphological parameters including plant height (cm), number of pods per plant, number of seeds per pod and 100 seed weight (g) were recorded for assessment of variation among germplasm lines under consideration.

3- RESULTS

The results of the experiment are presented as follows.

3.1- Plant height

Plant height is one of the most important plant attributes for crop improvement. Highly significant ($P \leq 0.05$) results among the germplasm lines were observed for plant height indicating the presence of adequate variations for this attribute (Table 1). In the case of genotypes, the highest plant height was noted in genotype NCS0803 scoring 82.60 cm while the lowest plant height was observed in genotype TG1415 scoring 53 cm (Fig. 1). Hence, the average plant height in genotypes was 63.01 cm.

While in the case of modern cultivars, the highest plant height was noted in cultivar Dasht scoring 72.87 cm while the lowest plant height was observed in cultivar DG-92 scoring 46.73 cm and an average plant height of cultivars was 61.26 cm (Fig. 2).

3.2- 100 seed weight

Seed weight is a chief yield-related trait considered during chickpea breeding for high yield. Highly significant ($P \leq 0.05$) results were seen for 100 seed weight in germplasm (Table 1). The data collected for germplasm evaluation revealed that the genotypes had an average 100 seed of 21.68 g. Out of 74 genotypes, the TGK1508 had the highest 100 seed weight with a value of 26.51 g while the lowest 100 seed weight of 12.99 g was observed in genotype TGK1504 (Fig.3).

While, in the case of modern cultivars, the average 100 seed weight was 19.09 g while the Thal-2006 had the highest and KK-1 had the lowest 100 seed weight scoring 22.59 and 16.67 g, respectively (Fig. 4).

3.3- No of pods per 5 plants

The data collected revealed that the average number of pods in 5 randomly selected plants of genotypes were 110.16, highest No. of pods were observed in genotype TGK1503 scoring 211.33 pods while the lowest value was observed in genotype D072-11 that was 23.33 pods (Fig. 5). Whereas the average value in case of modern cultivars was 151 pods in five plants, the maximum value was observed in Chattan scoring 210 pods and the minimum value recorded in KK-3 was 98 pods (Fig. 6). Significant variations ($P \leq 0.05$) were present among germplasm for the number of pods (Table 1).

3.4- Number of seeds per pod

The number of seeds per pod is a key yield contributing trait. The data for this trait was highly significant ($P \leq 0.05$) showing the presence of diversity in germplasm for No. of seeds per pod (Table 1). In the case of genotypes, the highest No. of seeds/pod was noted in genotype TGK1508 scoring 2.93 seeds while the lowest value was observed in genotype GGP1506 that was 1.53 seeds per pod whereas the average was 2.18 seeds per pod (Fig. 7). While the modern cultivars revealed an average of 2.15 seeds per pod with a highest value of 2.53 seeds pod^{-1} recorded in Chattan while the lowermost number was recorded in DG-92 that was 1.6 seeds with an average of 2.15 seeds per pod (Fig. 8).

Table 1- Mean square for quantitative morphological traits of chickpea germplasm analysis of variance (ANOVA)

Source of Variation	DF	Mean Squares			
		PH	SW	NPP	NSP
Replications	2	246.202	5.2909	805.62	2.60830
Genotypes	87	99.013**	19.4359**	5856.93**	0.28731**
Error	174	2.905	1.0396	291.06	0.00561

DF: Degree of freedom, PH: Plant height, SW: Seed weight, NPP: Number of pods 5 $plants^{-1}$, NSP: Number of seeds pod^{-1}, **: Highly Significant

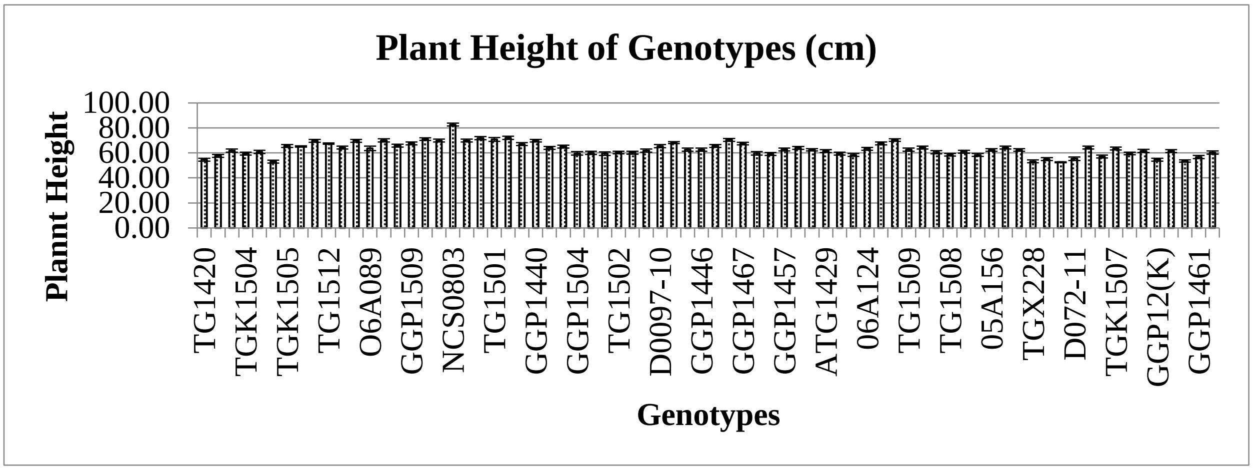

Fig. 1 - Plant height of 74 genotypes

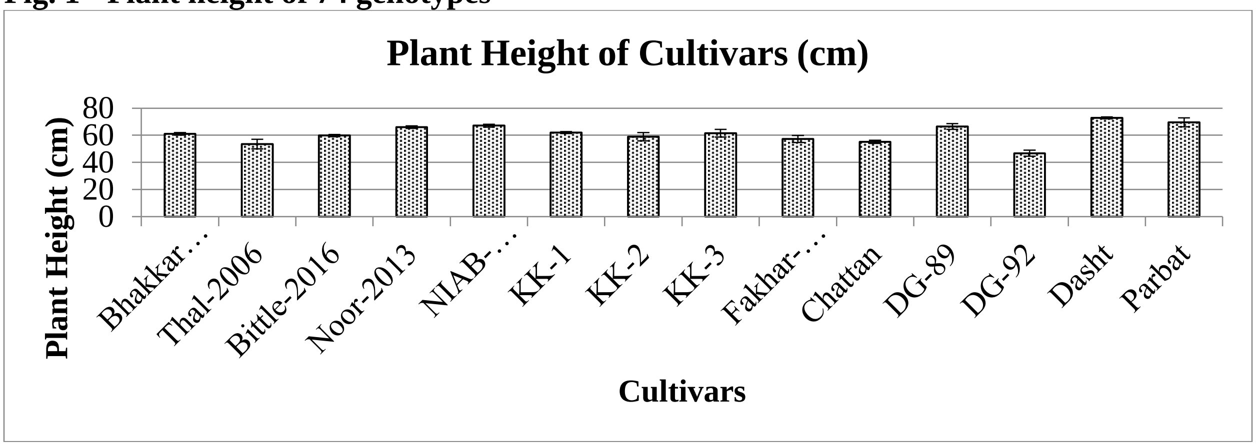

Fig. 2 - Plant height of 14 cultivars

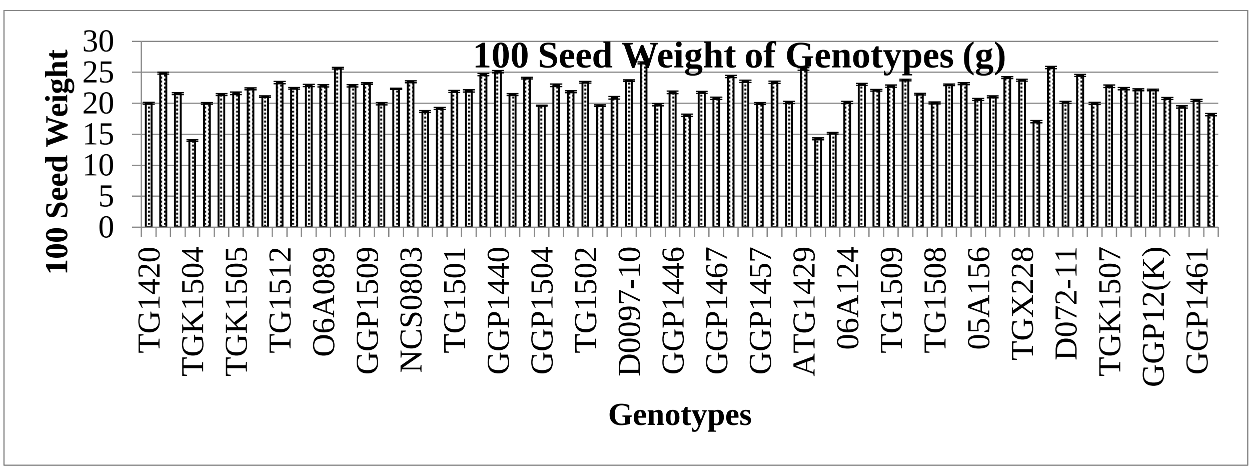

Fig. 3 - 100 seed weight of 74 genotypes

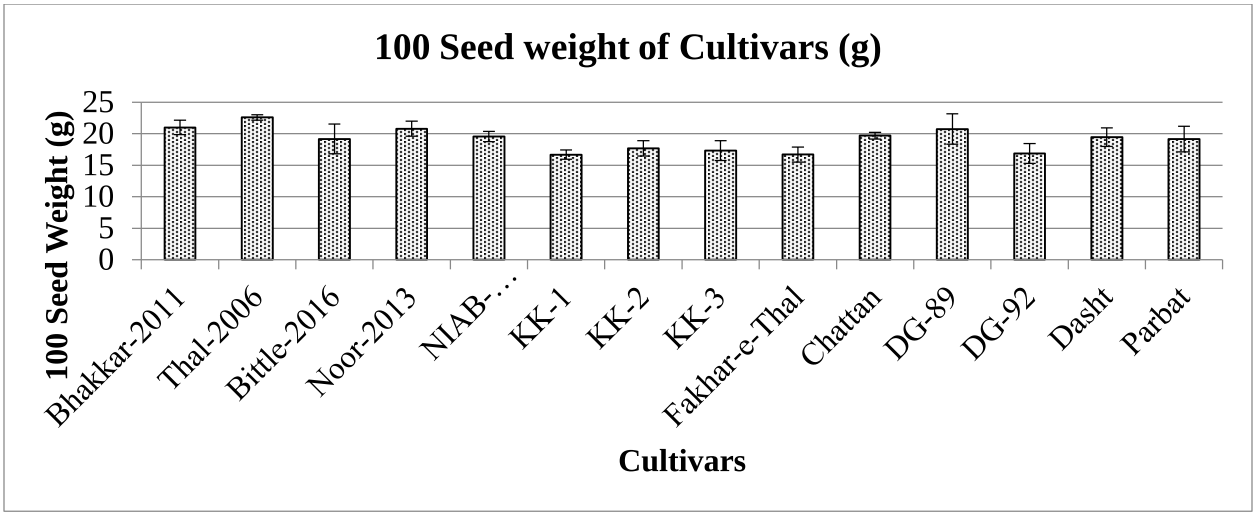

Fig. 4 - 100 seed weight of 14 cultivars

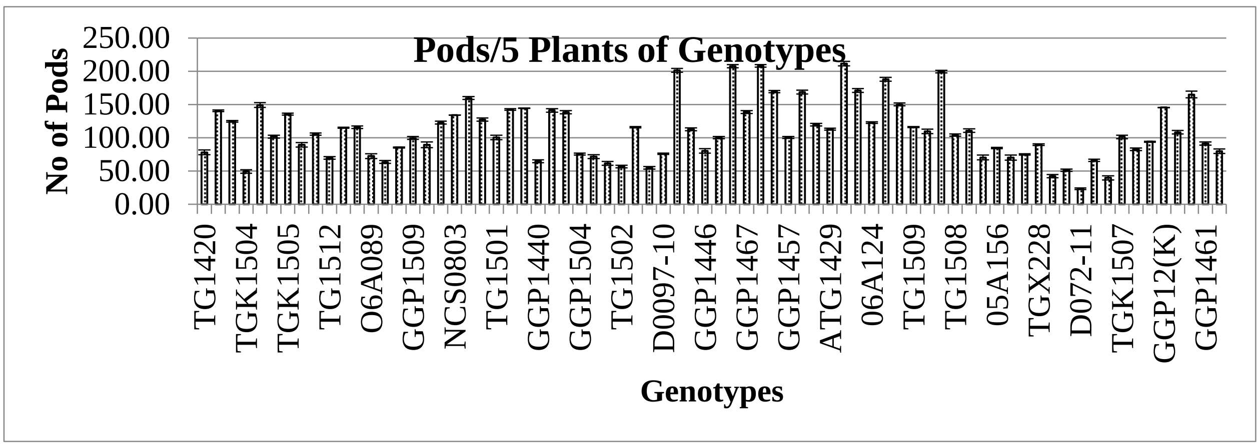

Fig. 5 - Pods per 5 plants of 74 genotypes

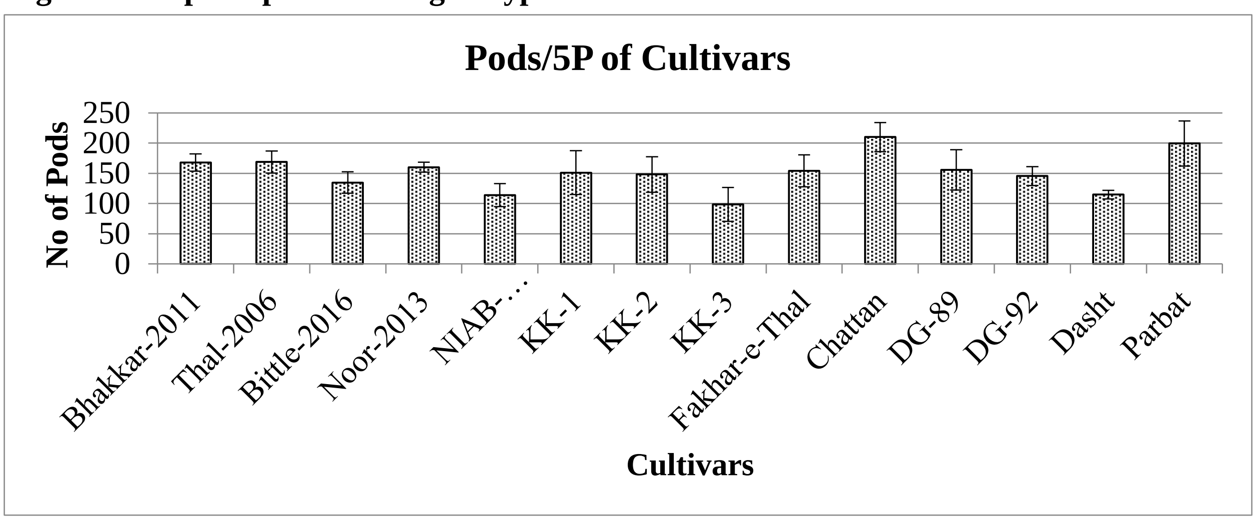

Fig. 6 - Pods per 5 plants of 14 cultivars

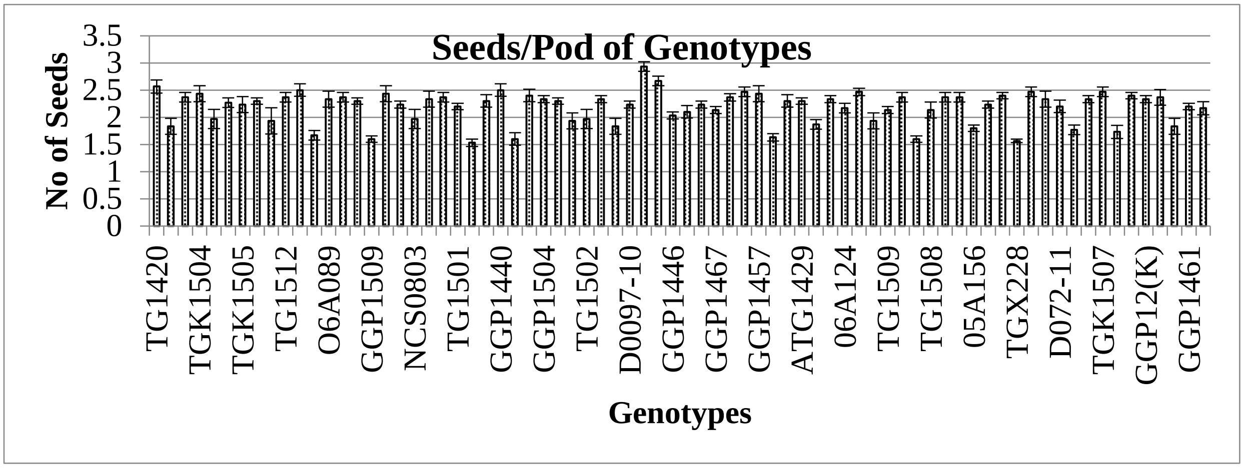

Fig. 7 - No. of seeds per pod of 74 genotypes

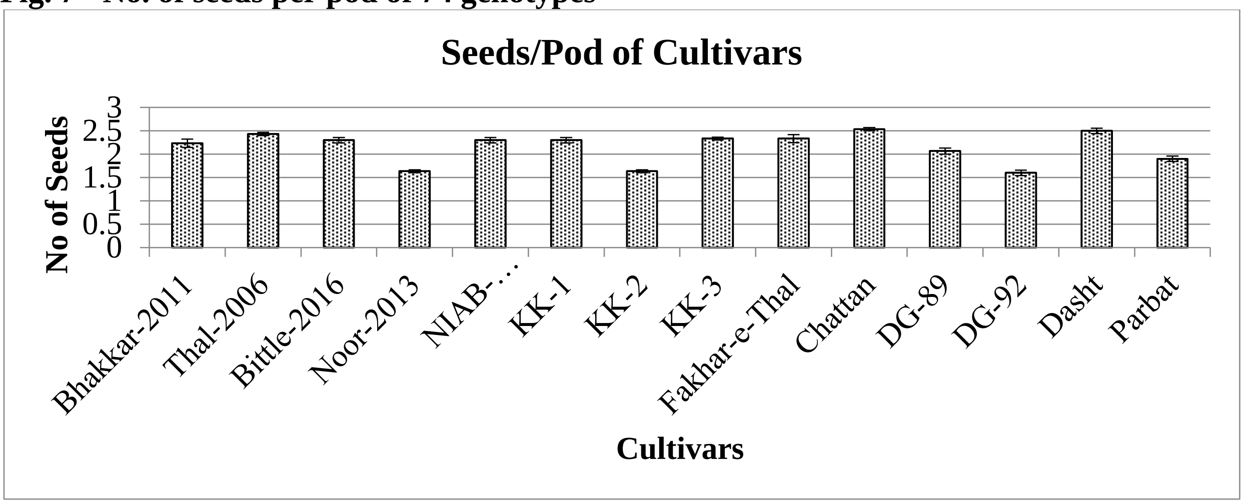

Fig. 8 - Average No. of seeds per pod of 14 cultivars

DISCUSSION

The *Cicer arietinum* is thought to be 1st domesticated in Syria and southeastern Turkey 10,000 years ago (Van der Maesen, 1987; Zohary and Hopf, 2000). It suffered through narrowing of genomic background that affected cultivated germplasm (Abbo *et al.*, 2003). This narrow genomic background increased crop susceptibility, declined in chickpea yield and prolonged breeding programs (Abbo *et al.*, 2003; Millan *et al.*, 2006; Bharadwaj *et al.*, 2013; Varshney *et al.*, 2018). Lately, Varshney *et al.* (2013) also reported the problematic narrow genetic base using genetic markers. This narrow genomic background might also be a major constraint in the advancement of chickpea crop (Konsam *et al.*, 2014). Repeated utilization of a few novel lines with a narrow genomic background for cultivar development is also a major reason behind the loss of variability in major plant traits. Higher diversity may be created by the utilization of diverse chickpea germplasm lines in breeding programs (Bharadwaj *et al.*, 2010). Hence, chickpea germplasm evaluation for various traits might assist in improving the genetic background of elite cultivated varieties. A public podium for chickpea germplasm data is a basic need. The morphological data development for chickpea accessions might assist in identification of elite accessions which may best suit in breeding program. Much of work is required to characterize and asses the chickpea germplasm and to make this information in open access for breeders. In this regard, the present study was conducted using various germplasm lines along with modern cultivars for assessment based on yield related traits.

Plant height is one of the chief traits under consideration for chickpea crop improvement. Desired plant height has lower lodging issues and bearing a large number of pods. Significant variations in plant height among chickpea lines were observed in the present study. Various investigations are agreeing these findings in chickpea conducted by many authors (Rozina and Hamayoon, 2011; Malik *et al.*, 2014; Mallu *et al.*, 2014). These outcomes are further upheld by Tsehaye *et al.* (2020). Further, Kayan and Adak (2012) also found significant variations for plant height in chickpea. Hence, the genotypes with medium plant height and an acceptable range of yield-related traits might be utilized in chickpea breeding programs for genetic improvement of chickpea cultivars.

The No. of pods per plant directly contribute to improvement in the economical yield of chickpea. The yield may be estimated through the No. of pods per plant. The results revealed that significant variations were present among genotypes for this trait. These findings are indorsed by different investigators (Malik *et al.*, 2014; Tsehaye *et al.*, 2020). Admas and Abeje (2017) also found variations for No. of pods per plant in 84 chickpea genotypes. Moreover, the findings of Upadhyay and Lavanya (2019) also reported significant difference in chickpea germplasm for pods per plant.

The No. of seeds per pod is also one of the topmost yield attributing characters in chickpea. Sometimes exceeding No. of seeds per pod cause pod shattering. So, it must be under consideration that the genotypes selected for cultivar development programs must be shattering free with a higher number of seeds per pod. Significantly variable values for this trait were noted in various genotypes. Jakhar (2014) also suggested significant variations for No of seeds per pod in chickpea as the main yield attributing trait in chickpea. These findings also matched with those of Malik *et al.* (2014).

Seed weight is the key trait for yield improvement in all legumes grown for seed consumption. It was also recommended as the exact measure of seed size in chickpea (Joshi *et al.*, 2010). So, to attain specific seed size and fulfill the market demand through breeding, proper information about seed weight and seed size in mandatory. Diverse range of variations for these traits is present between and within chickpea types from some Kabuli types with larger size than desi and vice versa. The plants with higher seed weight and a reasonable range of remaining traits might be used in research programs. A significant amount of variations were recorded for 100 seed weight among genotypes in the present study. Similar conclusions were drawn in various investigations by different authors (Qureshi *et al.*, 2004; Rozina and Hamayoon, 2011). These results in chickpea are further defended by the findings of Ahmad *et al.* (2012). Moreover, Malik *et al.* (2010) also observed similar conclusions in support of the present study for the seed weight in chickpea.

Concludingly, the lines which are resistant to pod shattering with the highest No. of pods per plant, No. of seeds per pod and maximum seed weight with modest plant height are best suited for cultivar development in chickpea breeding programs.

CONCLUSION

Based on conducted study, adequate amount of diversity was present among germplasm material. While, based on yield-related traits *viz.* No. of pods per plant, No. of seeds per pod and 100 seed weight, the TGK1508 was the highest yielding genotype and the D072-11 remained the lowest yielding genotype while Fakhar-e-Thal performed best and was the highest yielding cultivar.

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