Chickpea mini core germplasm collection as rich sources of diversity for crop improvement

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Citation: Meena HP, Kumar J, Upadhyaya HD, Bharadwaj C, Chauhan SK, Verma AK and Rizvi AH. 2010. Chickpea mini core germplasm collection as rich sources of diversity for crop improvement. Journal of SAT Agricultural Research 8.

Abstract

A mini core collection consists of a limited set of accessions derived from an existing collection, chosen to represent the genetic spectrum in the collection, and provides the user a set of genetically and ecologically distinct accessions. The evaluation of germplasm accessions at New Delhi, India revealed considerable variation among accessions for all the traits studied. On the basis of data on mean performance for yield and other traits, six diverse and superior genotypes, namely, ICC 14778, ICC 6279, ICC 4567, ICC 4533, ICC 1397 and ICC 12328 were found promising for more than one trait and were selected for use in chickpea improvement. Correlation coefficient suggested that selection of plants with high or more plant height, total number of branches per plant, number of pods per plant, biological yield and harvest index would be effective in identifying genotypes with high seed yield potential in chickpea.

Introduction

Chickpea (*Cicer arietinum*) is an important legume crop of the semi-arid tropics (SAT) and the West Asia North Africa (WANA) region. It is cultivated on 11.6 million ha in the world with 8.7 million tons of production (FAOSTAT 2009). About 97% of the chickpea area is in developing countries, where it is largely grown under marginal conditions and under moisture stress. In Asia, India accounts for 65.3% of the area and 67.2% of the production. Other important Asian countries such as Iran, Myanmar, Pakistan and Turkey account for about 23% of the area and 20% of the production. The productivity in these countries ranges from 0.41 t ha^{-1} in Iran to 1.10 t ha^{-1} in Myanmar.

Access to genetic variability is a prerequisite for any crop improvement program. Because of the increased recognition of its importance, evaluation and characterization of chickpea germplasm has received the attention of plant breeders. Utilization of exotic and genetically diverse germplasm is needed to develop stable and high-yielding cultivars with a broad genetic base. Genetically diverse lines provide ample opportunity to create favorable gene combinations, and the probability of producing a unique genotype increases in proportion to the number of genes by which the parents differ. However, it is a difficult task to select a few probable parental lines from a huge germplasm collection. Representative core collections (10% of the entire collection) have been suggested (Frankel 1984, Frankel and Brown 1984) as a means to identify useful accessions for crop improvement through replicated multilocational evaluation. Upadhyaya et al. (2001) developed a core collection of chickpea consisting of 1956 accessions. However, it became evident that the size of core collection was still large for a critical evaluation. To overcome this, Upadhyaya and Ortiz (2001) postulated the mini core concept and developed a chickpea mini core consisting of 211 accessions (1.1% of entire collection).

Geographically the mini core composition reflected the predominance of Asian entries (172 out of 211) in the subset. The number of entries in the mini core is listed: 86 (40.8%) from India; 53 (25.1%) from Iran; 14 (6.6%) from Ethiopia; 7 (3.3%) from Afghanistan; 6 (2.8%) from Turkey and Russia and CIS; 5 (2.3%) from Pakistan and Morocco; 4 (1.9%) from Mexico; 3 (1.4%) from Malawi; 2 (0.9%) from Syria, Algeria, Cyprus, Israel, Italy, Nepal and Myanmar; 1 (0.4%) from Portugal, Nigeria, Tanzania, Peru, USA, Chile and Bangladesh; and 1 (0.4%) from unknown source.

Materials and methods

The major objectives of the present investigation were to evaluate the chickpea mini core collection for genetic variability in various quantitative traits, and to establish relationship between different traits. Two hundred and eleven mini core collections of chickpea from the

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) were evaluated at the Division of Genetics, Indian Agricultural Research Institute (IARI), New Delhi, India under field conditions during 2007–08 in augmented block design (Federer 1956). Accessions were sown in five blocks, four blocks with 42 accessions and one block with 43 accessions and two checks (desi type Pusa 256; and kabuli type Pusa 1053). The farm is situated at 28°40' N latitude and 77°12' E longitude and 228.6 m altitude. The zone has a subtropical semi-arid climate with dry summer and cold winter. Seeds were sown on sandy loam soils, each accession occupying a single row on flat bed with a row length of 4 m and row-to-row spacing of 50 cm. The plant spacing was 15 cm. Fertilizer [diammonium phosphate (DAP)] was applied at 100 kg ha^{-1}. One irrigation was given at the podding stage. Observations on different morphological and agronomical traits like plant height (cm), total number of branches per plant, number of pods per plant, number of seeds per pod, biological yield per plant (g), time to 50% flower (days), time to maturity (days), duration of flowering (days), 100-seed weight (g), seed yield per plant (g) and harvest index (%) were recorded as per the descriptors for chickpea (IBPGR, ICRISAT and ICARDA 1993).

Results and discussion

The evaluation of 211 mini core accessions for various yield and related traits in the present study revealed that genotypic variances were highly significant for all the traits.

Mean performance and range for different traits. The mean performance of the chickpea germplasm for various characters is presented in Table 1. Plant height of the 211 accessions ranged from 41 cm (ICC 16915) to 95 cm (ICC 6279) and the mean was 57 cm. In total, 91 accessions exceeded the mean significantly. The number of pods per plant ranged from 15 (ICC 506) to 184 (ICC 14778). The mean number of pods per plant was 65.1 and 82 germplasm lines surpassed the mean significantly. The number of seeds per pod varied from 1 (ICC 1356, ICC 708, ICC 3218, ICC 3512, ICC 5337, ICC 6877, ICC 7272, ICC 8151, ICC 8612, ICC 9137, ICC 10755, ICC 10885, ICC 11879, ICC 12328, ICC 13187, ICC 14199, ICC 15612, ICC 15868 and ICC 11764) to 3 (ICC 3362) and the mean was 1.6 seeds per pod. In total, 92 germplasm accessions exceeded the experimental mean significantly. The lowest and highest 100-seed weight were recorded in ICC 7184 (7.5 g) and ICC 16796 (36.5 g) respectively. In total, 72 accessions exceeded the experimental mean of 16.5 g significantly. Highest biological yield per plant of 190.0 g was noticed in ICC 14778 and the least was 22.5 g in ICC 506; 90 germplasm accessions excelled the mean of 69.8 g significantly. Highest seed yield per plant of 77.0 g was obtained in ICC 14778 and the least was 4.1 g in ICC 506. Seventy-eight accessions gave significantly higher yield than the mean of 21.8 g. Harvest index of ICC 1392 was highest (64.6%) and the lowest was in ICC 1398 (3.7%). The mean for harvest index was 32.1% and 94 accessions exceeded the mean value significantly. Among the 211 germplasm accessions, the earliest to flower was ICC 4533 in 69 days and the last to flower was ICC 791, which took 111 days. The mean time to flower was 91.4 days and flowering was significantly early (<91.4 days) in 92 accessions. Among the mini core accessions, the earliest to mature were ICC 4814 and ICC 8195 in 151 days and the last to mature was ICC 4567, which took 169 days. Time to maturity was significantly earlier in 102 accessions than the mean (159.2 days).

Table 1. Mean and range for different traits in mini core collection of chickpea.

Characters	Mean ± SE	Range	
		Minimum	Maximum
Time to 50% flower (days)	91.4 ± 0.14	69.0	111.0
Duration of flowering (days)	49.7 ± 0.11	28.0	70.0
Time to maturity (days)	159.2 ± 0.56	151.0	169.0
Plant height (cm)	57.0 ± 0.41	41.0	95.0
Total number of branches	40.6 ± 0.12	17.0	103.6
Pods per plant	65.1 ± 0.41	15.0	184.0
Seeds per pod	1.6 ± 0.11	1.0	3.0
100-seed weight (g)	16.5 ± 0.13	7.5	36.5
Biological yield per plant (g)	69.8 ± 0.27	22.5	190.0
Seed yield per plant (g)	21.8 ± 0.16	4.1	77.0
Harvest index (%)	32.1 ± 0.24	3.7	64.6

Check entries had higher total branches, 100-seed weight and seed yield per plant than mean values of the mini core lines, whereas the other traits of checks were similar compared to the mean values of the mini core lines. The chickpea accessions that were promising for various traits (Table 2) are better than checks for all the traits.

Promising chickpea accessions identified from germplasm. The mini core collection accessions evaluated at Delhi indicated some promising accessions which would be useful to the breeders (Table 2). ICC 4463, ICC 3421, ICC 7315, ICC 4495 and ICC 4533 were promising for earliness. ICC 14831, ICC 11764, ICC 15333, ICC 2277 and ICC 6279 were identified as very tall. ICC 1923, ICC 4567, ICC 867, ICC 4533 and ICC 3421 were promising for long flowering duration and ICC 9002, ICC 8621, ICC 8195, ICC 13892 and ICC 4814 for early maturity. ICC 6279, ICC 1161, ICC 6571, ICC 4567 and ICC 14778 were identified for high total number of branches and ICC 2629, ICC 1397, ICC 1710 and ICC 14778 for very high number of pods per plant. The number of seeds per pod is also an important trait that contributes to high yield. ICC 1431, ICC 1397, ICC 4567, ICC 456 and ICC 3362 had high number of seeds per pod. The seed size of accessions varied considerably and ICC 11764, ICC 8058, ICC 13124, ICC 12328 and ICC 16796 were found promising for 100-seed weight. Accessions ICC 12028, ICC 12328, ICC 6279, ICC 13357 and ICC 14778 had high biomass per plant. ICC 9586, ICC 14402, ICC 1392, ICC 6279 and ICC 14778 had high seed yield per plant while ICC 1882, ICC 1392, ICC 12307, ICC 3230 and ICC 3362 had high harvest index.

Some accessions were found promising for more than one trait: ICC 4533 for time to 50% flower and duration of flowering; ICC 4567 for duration of flowering, number of seeds per pod and total number of branches; ICC 6279 for plant height, total number of branches, number of pods per plant, biological yield and seed yield per plant; ICC 1397 for number of pods per plant and number of seeds per pod; ICC 14778 for number of pods per plant, total number of branches, biological yield and seed yield per plant; and ICC 12328 for biological yield per plant and 100-seed weight.

Correlation studies. The correlation coefficient at phenotypic level between all the eleven traits in mini core germplasm of chickpea is presented in Table 3. The seed yield per plant showed significant and positive phenotypic correlation with plant height (0.153*), number of pods per plant (0.557**), biological yield (0.725**), total number of branches (0.347**) and harvest index (0.497**). Similar results were reported by Arshad et al. (2003), Kumar et al. (2003), Meena et al. (2006), Talebi et al. (2007) and Vekariya et al. (2008). The correlation coefficient of seed yield per plant at the phenotypic level with time to maturity (–0.135*) was negative and significant but not significant with duration of flowering. Similar results were reported by Islam (1997) and Dhameliya et al. (2008). Harvest index showed positive correlation with number of seeds per pod (0.208**), number of pods per plant (0.198*) and seed yield per plant (0.497**). Therefore, any selection for these characters is likely to simultaneously improve other traits. Similar results were reported by several earlier workers (Kumar et al. 2002, 2003, Babbar and Patel 2005, Jeena et al. 2005, Singh and Sandhu 2008). Positive correlations were observed between 100-seed weight and time to maturity (0.166**), plant height (0.317**) and biological yield per plant (0.284**). Similar results have been reported by Brar et al. (2004), Obaidullah et al. (2006), Renukadevi and Subbalakshmi (2006) and Sidramappa et al. (2008).

The correlations indicate that among the yield components number of pods per plant, biological yield per plant and total number of branches per plant are significantly associated with seed yield. Thus these yield components are important traits for selection in breeding for yield improvement.

Table 2. Promising chickpea accessions for various traits identified in the mini core collection of chickpea.

Characters	Criteria	Range	Germplasm accessions[1]
Time to 50% flower (TF) (days)	Early	69.0–75.0	ICC 4463, ICC 3421(K), ICC 7315(K), ICC 4495, ICC 4533
Duration of flowering (DOF) (days)	High	67.0–70.0	ICC 1923, ICC 4567, ICC 867, ICC 4533, ICC 3421(K)
Time to maturity (DM) (days)	Early	151.0–153.0	ICC 9002, ICC 8621, ICC 8195, ICC 13892, ICC 4814
Plant height (PH) (cm)	Tall	79.0–95.0	ICC 14831, ICC 11764(K), ICC 15333(K), ICC 2277(K), ICC 6279
Total number of branches (TB)	High	77.3–103.6	ICC 6279, ICC 1161, ICC 6571, ICC 4567, ICC 14778
Pods per plant (PP)	High	147.3–184.0	ICC 2629, ICC 1397, ICC 1710, ICC 14778
Seeds per pod (SP)	High	2.4–3.0	ICC 1431, ICC 1397, ICC 4567, ICC 456, ICC 3362
100-seed weight (SW) (g)	High	32.5–36.5	ICC 11764(K), ICC 8058(K), ICC 13124, ICC 12328(K), ICC 16796(K)
Biological yield per plant (BY) (g)	High	150.0–190.0	ICC 12028, ICC 12328(K), ICC 6279, ICC 13357(K), ICC 14778
Seed yield per plant (SY) (g)	High	49.8–77.0	ICC 9586, ICC 14402, ICC 1392, ICC 6279, ICC 14778
Harvest index (HI) (%)	High	42.8–64.6	ICC 1882, ICC 1392, ICC 12307, ICC 3230, ICC 3362
TF and DOF	–	–	ICC 4533
DOF, SP and TB	–	–	ICC 4567
PH, TB, PP, BY and SY	–	–	ICC 6279
PP and SP	–	–	ICC 1397
PP, TB, BY and SY	–	–	ICC 14778
BY and SW	–	–	ICC 12328(K)

1. Accessions having (K) suffix are kabuli types and the rest are desi types.

Table 3. Phenotypic correlation for various traits in mini core collection of chickpea[1].

Characters	SY	BY	HI	TF	DOF	TM	TB	PH	PP	SP	SW
SY	–										
BY	0.725**	–									
HI	0.497**	–0.162*	–								
TF	0.015	0.048	–0.037	–							
DOF	–0.104	–0.073	–0.035	0.174**	–						
TM	–0.135*	–0.019	–0.155*	0.112	0.628**	–					
TB	0.347**	0.409**	–0.057	–0.021	0.206**	0.153*	–				
PH	0.153*	0.291**	–0.163*	0.059	0.093	0.126	0.043	–			
PP	0.557**	0.495**	0.198**	0.001	0.027	–0.155*	0.367**	0.037	–		
SP	0.074	–0.053	0.208**	–0.176**	–0.005	–0.091	0.105	–0.273**	0.216**	–	
SW	0.124	0.284**	–0.143*	–0.112	0.017	0.166**	0.068	0.317**	–0.229**	–0.345**	–

1. TF = Time to 50% flower; DOF = Duration of flowering; TM = Time to maturity; PH = Plant height; TB = Total number of branches; PP = Pods per plant; SP = Seeds per pod; SW = 100-seed weight; BY = Biological yield per plant; SY = Seed yield per plant; HI = Harvest index.
* = Significant at 5% level; ** = Significant at 1% level.

Conclusion

The main purpose of a mini core collection is to provide a small representative sample of genetic variation from a large germplasm collection to assist germplasm managers for efficient management and more importantly to the breeders a range of diversity for greater utilization. In Asia, India accounted for 83 accessions (39.3%) in the mini core collection followed by 53 accessions (25.1%) from Iran. Ethiopia, which is the secondary center of diversity for chickpea, accounted for only 14 accessions (6.6%) in the mini core collection. On the basis of mean performance for yield and other traits, six diverse and superior genotypes, namely, ICC 14778, ICC 6279, ICC 4567, ICC 4533, ICC 1397 and ICC 12328 were selected. Each of these genotypes was exceptionally good for one or more characters, with an acceptable level for other characters. Therefore, these genotypes may be involved in multiple crossing programs to recover transgressive segregates. On the basis of correlation coefficient, it is suggested that selection of tall plants with high biological yield, total number of branches per plant, pods per plant and harvest index would result in progenies with high seed yield potential in chickpea. Chickpea mini core has proved a rich mine for sources of resistance to various biotic (Pande et al. 2006) and abiotic stresses (Kashiwagi et al. 2005, Vadez et al. 2007). Our study also confirms usefulness of chickpea mini core collection for agronomic traits.

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