Identification of Large-Seeded High-Yielding Diverse Kabuli Accessions in Newly Assembled Chickpea Germplasm

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Chickpea (*Cicer arietinum* L.) is an important grain legume grown for easily digestible quality protein and its nitrogen fixing capability that improves soil fertility. It is cultivated on 10.38 million ha in 45 countries across the globe producing 8.57 million tons with productivity of 0.83 t ha^{-1} (FAO 2004), which is rather low. India, Pakistan, Myanmar, Turkey, and Iran in Asia; Mexico in North Central America; and Ethiopia in Africa are the largest chickpea producing countries. Of late chickpea is being cultivated on considerable area in Canada, Australia, and USA. Two types of chickpeas – kabuli and desi – are recognized. The kabuli types have owl-shaped, large beige colored seeds with thin seed coat and white colored flowers; while the desi types have angular-shaped seeds with thick seed coat, generally colored flowers and seeds. Kabuli types account for about 15% of the world chickpea production. However, about two-thirds of chickpea-growing countries cultivate only the kabuli types (Singh 1987). Kabuli types fetch higher prices in markets. In India the price of kabuli chickpeas is up to 100% more than that of the desi chickpeas. In Canada, where chickpea is grown as a cash crop mainly for export to other countries, kabuli chickpeas with seed weight of 50 g 100 seed^{-1} fetch 60% higher price than the small seeded (25 g 100 seed^{-1}) desi chickpeas (Liu et al. 2003). A similar premium on kabuli types prevails in Australia. Over 67000 accessions of chickpea germplasm have been conserved globally. ICRISAT holds in trust 17258 chickpea accessions and USDA has over 4900. However, there has been very limited use of these accessions in genetic enhancement of chickpea (Upadhyaya et al. 2001), leading to cultivars with narrow genetic base and low genetic gain. The aim of our study is to identify large-seeded high-yielding kabuli germplasm accessions in the 335 newly introduced kabuli chickpea germplasm accessions from USDA, Pullman, USA.

ICRISAT assembled 996 desi accessions (originating from 28 countries), 335 kabuli accessions (originating from 27 countries) and 11 pea shaped accessions (originating from seven countries), from USDA, Pullman, USA in August 2004. These newly assembled germplasm accessions were evaluated in an augment design with five control cultivars (Annigeri, G 130, ICCV 10, KAK 2, and L 550). Annigeri, ICCV 10, and G 130 are early, medium, and late maturing desi type cultivars, respectively. KAK 2 is an early-maturing and L 550 is a medium-duration kabuli cultivar. A control cultivar was repeated after every 19 test entries on a rotational basis. The experiment was conducted under high input (100 kg ha^{-1} diammonium phosphate as basal dose, and protection against insect pest and diseases, and two irrigations) on a Vertisol (Kasireddypally series- Isohyperthermic Type Pellustert) field at ICRISAT center, Patancheru, India (18°N, 78°E, 545 m.a.sl., and 600 km inland) during the 2004-2005 postrainy season. Each plot consisted of a 3 m row on a ridge, with 60 cm distance between rows and 10 cm between plants within a row. Data was recorded following IBPGR, ICRISAT, and ICARDA (1993) descriptors. Data were analyzed using random model of Residual Maximum Likelihood (REML) in Genstat 8.1. Variance components due to genotype (δ^2g), error (δ^2e) and their standard errors (SE), and broad sense heritability (h^2) were estimated. Best Linear Unbiased Predictors (BLUPs) were calculated for all quantitative traits. Fourteen kabuli accessions with more than 40 g 100-seed^{-1} weight and having greater or similar seed yield to the kabuli control cultivars (KAK 2, L 550) were identified. Principal component analysis (PCA) on standardized data of 18 agronomic (days to 50% flowering, flowering duration, plant height, plant width, days to maturity, number of basal primary and secondary branches, number of apical primary and secondary branches, tertiary and total number of branches, number of pods per plant, number of seeds per pod, 100-seed weight, plot and plant yields, productivity per day, and SPAD (Soil Plant Analyses Development) chlorophyll meter reading) traits was performed. Cluster analysis of selected 14 accessions and two control cultivars, using scores of first 5 Principal Components (PC) was performed following the Ward (1963) method.

REML analysis of data of all the 1342 accessions revealed significant genotypic variance for days to 50% flowering, flowering duration, plant height, plant width, apical primary, basal secondary, and tertiary branches, seed per pod, 100-seed weight, plot yield and SPAD chlorophyll meter reading. Genotypic variances were significant for all the traits except apical secondary branches and SPAD reading in the kabuli accessions (335). It indicated that even within this set of kabuli accessions, there is scope for selecting large-seeded accessions with different maturity duration and seed yields.

Fourteen selected large-seeded kabuli accessions produced an average of 8.2% more seed yield and 44.3% larger seeds than the average of the two kabuli control cultivars, and had 9.8% higher 100-seed weight and produced 18.8% higher seed yield than the best control cultivar KAK 2 (Table 1). EC 543533 (originating from USA) and EC 543599 (Mexico) were early flowering and took 36 and 37 days to flower, had large seeds (45.5 and 53.1 g 100 seed^{-1}), and produced high seed yield (1700 and 1906 kg ha^{-1}) compared to control KAK 2 (39 days; 40.9 g; and 1406 kg ha^{-1}) and L 550 (58 days; 20.2 g; 1695 kg ha^{-1}) (Table 1). Furthermore, scatter plot of plot yield and 100-seed weight revealed that ECs 543594, 543598, 543599, 543583, 543586, 543533, 543584, 543593, and 543597 had large seeds (40.0 g–54.9 g) and produced higher yields (1645 to 1906 kg ha^{-1}) (Fig. 1).

Cluster analysis performed on the scores of first five PCs (total variation 90.77) resulted in four clusters (Fig. 2). Two control cultivars formed separate clusters. KAK 2 occurred in first and L 550 in the third cluster. ECs 543598, 543594, 543584, 543597, 543586, 543583, 543599, 543593, 543582 from Mexico, and 543533 from USA formed a second cluster. ECs 543451, 543562, 543587, and 543588 formed the fourth cluster. The delineation of the first cluster from the other three was mainly on maturity related traits indicated by significantly lower mean values than the other clusters for flowering duration and maturity. Large-seeded accessions with high seed yield with early and medium duration, high per-day productivity and SPAD reading were included in cluster 2. Cluster 4 included medium to long duration accessions with low yield per plant and plot.

The identification of the large-seeded, early-maturing and agronomically superior diverse parents will prompt breeders to use them in crop improvement programs (Upadhyaya et al. 2006). Early maturity is advantageous in chickpea to avoid terminal drought and make adequate use of available soil moisture during growth, as chickpea is usually grown on conserved soil moisture, where soil moisture reduces towards maturity. In the present study, a few more very early-flowering genotypes such as ECs 543533, 543582, and 543599 were identified. As mentioned earlier, large seed size has a price premium in trade. In this study we have identified ECs 543533, 543584, 543593, 543598, and 543599 as additional sources of large seed size for improvement in chickpea. While selecting the exotic germplasm lines for inclusion in the breeding programs, it is important to consider the genetic background and agronomic performance of the lines, as it will be useful in predicting its behavior in hybrid combinations with the adapted genotypes.

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Table 1. Geographic origin and agronomic characters of selected kabuli chickpea accessions evaluated at ICRISAT Patancheru, India, 2004–2005 season.

EC_No	Identity	Origin	Days to 50% flowering	100-seed weight (g)	Plot yield (kg ha^{-1})	Plant yield $^{-1}$ (g)	Productivity (kg ha^{-1} day^{-1})
EC543451	W6 30	Morocco	50	44.1	1522	6.5	13.7
EC543533	W6 10543	USA	37	45.5	1700	9.0	14.9
EC543562	W6 12855	Morocco	62	40.3	1463	6.4	12.9
EC543582	W6 17590	Mexico	38	40.4	1531	11.6	13.9
EC543583	W6 17591	Mexico	42	40.0	1846	16.0	15.4
EC543584	W6 17592	Mexico	46	47.3	1690	13.0	14.5
EC543586	W6 17594	Mexico	43	41.9	1698	9.6	14.9
EC543587	W6 17595	Mexico	45	40.8	1568	13.0	13.8
EC543588	W6 17596	Mexico	57	40.3	1430	9.4	13.3
EC543593	W6 17601	Mexico	45	54.9	1645	18.0	14.5
EC543594	W6 17602	Mexico	54	40.2	1881	15.6	15.5
EC543597	W6 17605	Mexico	44	42.3	1746	7.6	14.9
EC543598	W6 17606	Mexico	51	45.7	1856	13.6	15.4
EC543599	W6 17607	Mexico	36	53.1	1906	16.6	15.8
L550		India	58	20.2	1695	16.0	14.8
KAK2		India	39	40.9	1406	9.8	13.6
Trial Mean			59.4	18.7	1557	9.57	13.92
SE ±			3.17	3.33	308.02	0.05	2.28
CV (%)			5.9	20.6	36.6	52.3	41.3

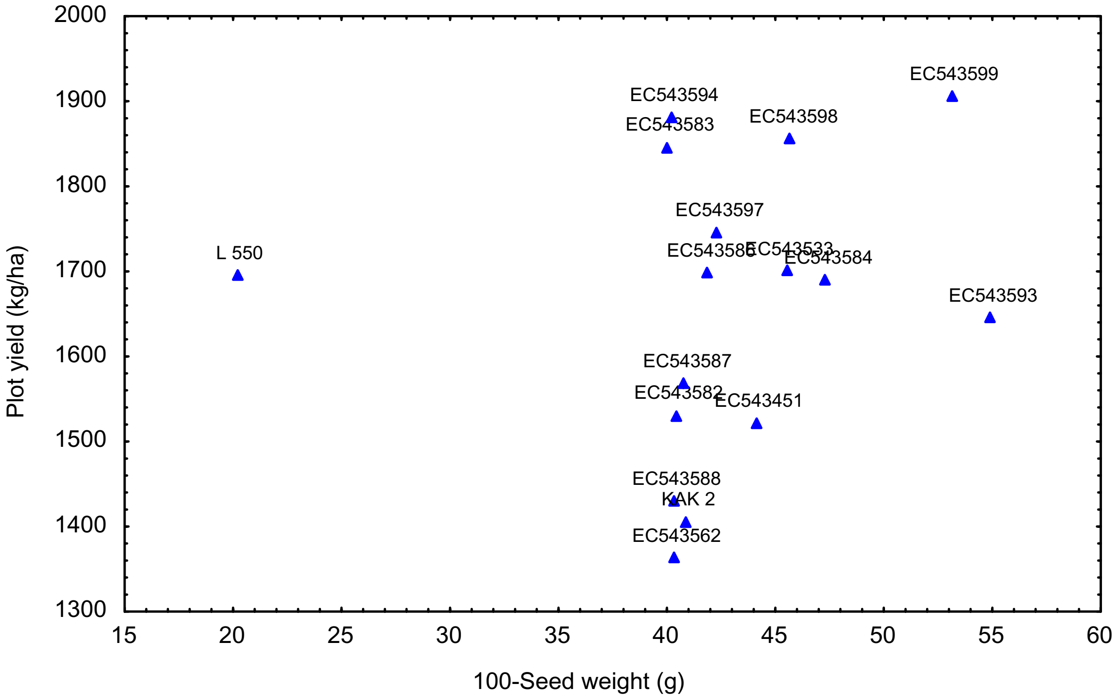

Figure 1. Scatter plots of 100-seed weight (g) and plot yield (kg ha^{-1}) in 14 selected kabuli chickpea accessions and two control cultivars.

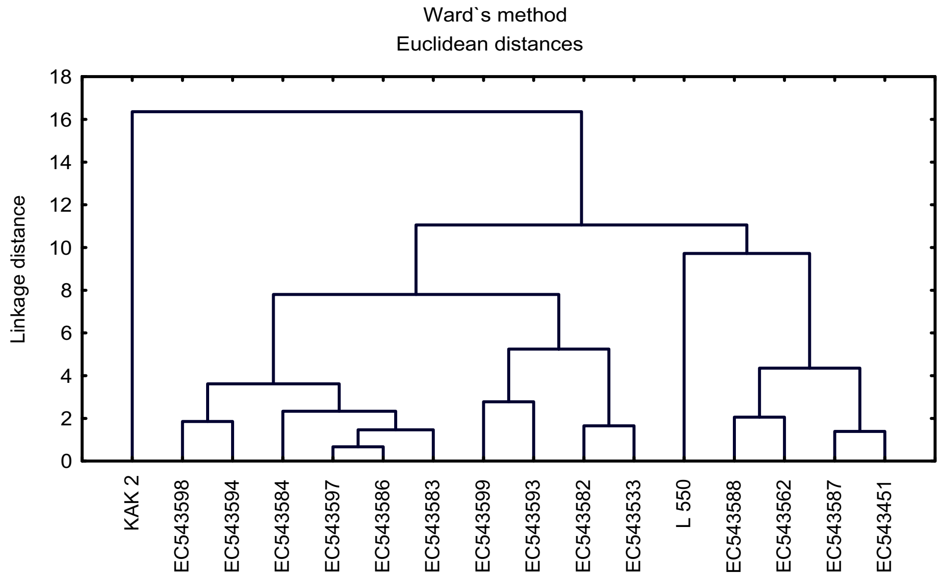

Figure 2. Dendogram based on first five principal components of 18 quantitative traits of 14 large-seeded kabuli chickpea accessions with two control cultivars.