Identification of high-yielding large-seeded kabuli chickpeas with drought avoidance root traits

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In recent years, the interest in large-seeded kabuli chickpea (*Cicer arietinum*) is increasing among the farmers as the market prices of these kabuli types are higher by 150 to 200% compared to desi varieties. Breeding and selection for new large-seeded kabuli chickpea varieties, therefore, is an urgent requirement to meet the growing farmers' interest. Also this situation offers to raise the status of chickpea from a poor farmer's subsistence crop to a cash crop. In response to the need, the large-seeded kabuli chickpea germplasm accessions that originated from eight countries were selected from the genebank at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). For a well focused utilization of these accessions in breeding programs, these entries need to be characterized primarily for the key desirable traits that would enhance yield stability. In this context, first, the expression of the desired seed size among these new accessions need to be investigated with reference to already released benchmark kabuli cultivars, KAK 2 and JGK 1. In addition, the characterization for the yield potential as well as the drought escape traits (early maturity) and drought avoidance traits (root traits) is also important as drought is one of the most serious constraints for chickpea production (Subbarao et al. 1995). Earlier efforts at ICRISAT to cater the needs of kabuli requirement in short-duration environment led to the release of an early kabuli chickpea genotype, ICCV 2. This variety has been phenomenally successful in peninsular India and some short-duration environments across the world due to drought escape mechanism. A germplasm accession, ICC 4958 (desi), had also been identified as one of the best genotypes with highly desirable root systems (Saxena et al. 1993, Kashiwagi et al. 2005). This genotype is currently being used to develop drought tolerant varieties by incorporating the deep and large root system characteristics into a well-adapted genetic background. The objectives of this study were to assess the extent of expression of the large seed size and grain yield under the short-duration environment of Patancheru, India and to identify the superior ones for drought avoidance root traits in the newly identified large-seeded kabuli chickpea germplasm accessions.

Fifty large-seeded kabuli germplasm accessions and four control cultivars of *C. arietinum* (KAK 2, JGK 1, ICCV 2 and ICC 4958) were evaluated for 100-seed weight and yield in a field trial with two replications at ICRISAT, Patancheru. These entries were grown in plots of 6 m^2 area in a Vertisol field with two more irrigations besides the pre-sowing irrigation. These accessions were also grown in a separate trial for the root length density (RLD) assessment in PVC cylinders (18 cm diameter, 120 cm long) in a randomized complete block design with five replications. The cylinders were filled with an equi-mixture (w/w) of Vertisol and sand, with an initial soil water content equivalent to 70% field capacity. The plants were allowed to grow under receding soil moisture conditions thereafter, to mimic field terminal drought. The cylinders were placed in pits to avoid differential heating of the cylinders due to direct solar radiation. The sampling for RLD was done at 35 days after sowing, a time when early duration genotypes (well adapted to the lower latitudes) are known to exhibit maximum differences in root growth.

The 100-seed weight of JGK 1 was 31.3 g and that of KAK 2 was 35.4 g. Among the 50 new kabuli accessions tested in this study, the genotype that showed the smallest 100-seed weight was ICC 8151 (30.9 g) and the mean 100-seed weight was 44.3 g. This showed that larger proportion of the kabuli lines tested are promising in terms of larger seed size and are potential candidate lines for inclusion in breeding programs aimed to develop large-seeded kabuli varieties. Table 1 presents the top 15 accessions out of 50 kabuli accessions that had more than 50 g of 100-seed weight. However, the grain yields of those 15 accessions varied widely. The yield of several entries such as ICC 18591 (EC 543599), ICC 17452 (EC 543586), ICC 17456 (EC 543591), ICC 19189 (EC 543533), ICC 11883, ICC 19195 (EC 543597), ICC 17457 (EC 543594), ICC 17450 (EC 543583) and ICC 7345 was comparable to that of KAK 2.

Table 1. The 100-seed weight, seed yield and root length density (RLD) of the 15 top large-seeded kabuli accessions evaluated in 2006/07 postrainy season at ICRISAT, Patancheru, India.

Accession	Identity	Origin	100-seed weight (g)	Time to maturity (days)	Yield (kg ha^{-1})	RLD (cm cm^{-3})
ICC 7345	Bremizado	Mexico	50.0	126	1182.1 (16)[1]	0.218 (17)[1]
ICC 8156	NEC 2303	USA	52.5	126	652.2 (41)	0.237 (5)
ICC 11883	Spanish cultivar	Spain	54.3	126	1154.4 (19)	0.213 (21)
ICC 12034	Surutato 77	Mexico	50.0	126	617.8 (43)	0.230 (9)
ICC 14203	120-TBB	Mexico	51.6	117	885.8 (31)	0.249 (3)
ICC 14195	TA RBB-1 II GAB-S1-M-11-M-M	Mexico	52.8	126	646.6 (42)	0.219 (15)
ICC 17450	W6 17591; EC 543583; CuGa-290	Mexico	50.5	114	1163.3 (17)	0.274 (1)
ICC 17452	W6 17594; EC 543586; CuGa-288	Mexico	60.6	114	1577.8 (5)	0.198 (35)
ICC 17456	W6 17599; EC 543591; CuGa-208	Mexico	55.3	115	1422.1 (7)	0.194 (42)
ICC 17457	W6 17602; EC 543594; CuGa-137	Mexico	51.2	114	1708.3 (3)	0.232 (8)
ICC 18591	W6 17607; EC 543599; Blanco Sinaloa 92	Mexico	61.6	114	1234.8 (12)	0.197 (38)
ICC 19189	W6 10543; EC 543533	USA	55.0	108	1552.4 (6)	0.232 (7)
ICC 19192	W6 17592; EC 543584	Mexico	56.9	112	937.0 (28)	0.243 (4)
ICC 19194	W6 17601; EC 543593	Mexico	50.6	113	825.1 (33)	0.202 (32)
ICC 19195	W6 17605; EC 543597	Mexico	53.0	113	1021.9 (25)	0.221 (13)
JGK 1	Released large-seeded kabuli variety (2002)	India	31.3	104	1109.1	–
KAK 2	Released large-seeded kabuli variety (2000)	India	35.4	108	1359.5	–
ICCV 2	Released super-early kabuli variety (1989)	India	19.1	103	1090.8	–
ICC 4958	Released drought tolerant desi variety (1993)	India	30.4	108	1717.3	0.252
Mean			44.3	118.4	1042.0	0.211
SE±			2.8	2.0	307.6	0.007
LSD (5%)			5.7	4.1	615.1	0.045

1. Figures in parentheses indicate ranking of each trait.

Among the top 15 accessions, none of them matured earlier than ICCV 2 (103 days to maturity). Most of the accessions showed medium to late maturity except ICC 19189 (EC 543533) (108 days). On the other hand, these 15 accessions had as large a RLD as that of ICC 4958 (0.252 cm cm^{-3}) except for four accessions, ICC 18591 (EC 543599) (0.197 cm cm^{-3}), ICC 17452 (EC 543586) (0.198 cm cm^{-3}), ICC 17456 (EC 543591) (0.194 cm cm^{-3}) and ICC 19194 (EC 543593) (0.202 cm cm^{-3}). One accession ICC 17450 (EC 543583) (0.274 cm cm^{-3}) showed significantly larger RLD than ICC 4958. The new kabuli genotypes identified in this work could be utilized as valuable breeding sources for large-seeded kabuli chickpea improvement with drought tolerance.

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