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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Extra-Large Kabuli Chickpea with High Resistance to Fusarium Wilt

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There is an increasing international market for extra-large (>50g 100-seed^{-1}) kabuli chickpea. Such chickpeas are being sold at about three times the price of desi chickpea and about two times the price of medium-seeded (~25 g 100 seed^{-1}) kabuli chickpea in India, the largest chickpea importing country. None of the kabuli chickpea varieties released to date in India has seed size larger than 40 g 100 seed^{-1}. Thus, the Government of India has launched a 3-year project from 1 April 2006 on breeding extra-large kabuli chickpea with resistance to fusarium wilt under the Integrated Scheme of Oilseeds, Pulses, Oil Palm and Maize (ISOPOM).

Fusarium wilt (FW), caused by *Fusarium oxysporum* f. sp *ciceri*, is the most important root disease of chickpea in the semi-arid tropics (SAT), where the chickpea growing season is dry and warm. Resistance to FW is required in all chickpea cultivars targeted for SAT and other FW-prone areas of the world. There are many sources with high resistance to FW available in desi type, while resistance sources in kabuli type are limited. A world collection of over 13,500 germplasm accessions from 40 countries was evaluated for race 1 of *Fusarium oxysporum* at ICRISAT-Patancheru. Of the 160 resistant accessions identified, only 10 accessions were of kabuli type (Haware et al. 1992). Desi × kabuli crosses have been widely used at ICRISAT for enhancing FW resistance of kabuli chickpea. However, most kabuli varieties that involved one or more desi parents in the pedigree have a brown tinge in seed color, e.g. Swetha (ICCV 2), KAK 2 (ICCV 92311), JGK 1 (ICCV 92337), and Vihar (ICCV 95311), while the market prefers cream to white (zero tannin) seed color in kabuli chickpea. Thus, it is important to identify additional sources of FW resistance in kabuli chickpea, particularly in the large-seeded category, so that large-seeded kabuli varieties with high resistance to FW and typical kabuli type seed (ram's head shape and white seed color) can be developed from kabuli × kabuli crosses.

We selected 50 large-seeded kabuli chickpea germplasm from ICRISAT's genebank and evaluated these for agronomic traits at ICRISAT-Patancheru during the 2004/05 postrainy season. From these, 12 accessions having seed size larger than 50 g 100 seed^{-1} were selected for further

evaluation. During the 2005/06 postrainy season, one set of these 12 genotypes was grown in wilt-sick plot for screening against FW and another set in wilt-free area for evaluation of agronomic traits.

Two accessions, ICC 14194 and ICC 17109, originating from Mexico, showed complete resistance (0% plant mortality) to FW, whereas other lines showed 11–100 % plant mortality (Table 1). The resistant control (WR 315) had 0% plant mortality, whereas the early-wilt susceptible check (JG 62) had 100%, and the late-wilt (K 850) susceptible check had 87% mortality. Both the resistant accessions had pinnate (fern) leaves, which is the common

Table 1. Morphological and agronomic characteristics of twelve extra-large kabuli chickpea germplasm evaluated during postrainy season 2005/06 at ICRISAT-Patancheru.

Accession	Origin	Leaf type	Days to flower[1]	Days to mature[1]	100-seed mass (g)[1]	Wilt reaction (%)[2]
ICC 7344	Mexico	Pinnate	38	100	50.2	95.2
ICC 8155	USA	Simple	45	112	62.2	100.0
ICC 11742	Chile	Pinnate	64	130	51.9	86.4
ICC 11883	Spain	Pinnate	56	130	58.7	90.9
ICC 13821	Ethiopia	Simple	50	118	51.0	92.0
ICC 14194	Mexico	Pinnate	38	97	52.9	0.0
ICC 14195	Mexico	Simple	50	109	60.2	52.2
ICC 14198	Mexico	Pinnate	42	94	50.2	70.8
ICC 14202	Mexico	Pinnate	46	118	58.1	75.0
ICC 15576	Mexico	Pinnate	52	120	55.6	81.0
ICC 16670	USA	Simple	45	110	50.1	11.1
ICC 17109	Mexico	Pinnate	46	115	63.2	0.0
WR 315 (Resist. check)	India	Pinnate	44	102	13.5	0.0
K 850 (Late wilting sus. check)	India	Pinnate	56	109	28.9	87.0
JG 62 (Early wilting sus. check)	India	Pinnate	42	103	15.8	100.0

1. Data from crop grown in wilt-free field.
2. Data on resistance to race 1 of *Fusarium oxysporum* f. sp *ciceri* from screening in wilt nursery.

ICCV 2 KAK 2 ICC 17109

Figure 1. The seed of fusarium wilt resistant extra-large (63 g 100-seed^{-1}) kabuli accession ICC 17109, the medium-seeded (25 g 100-seed^{-1}) kabuli variety ICCV 2, and the large-seeded (38 g 100-seed^{-1}) kabuli variety KAK 2.

leaf type in chickpea. ICC 14194 was very early (97 days), while ICC 17109 had medium maturity (115 days). A comparison of the seeds of a medium-seeded variety ICCV 2 (25 g 100 seed^{-1}), a large-seeded variety KAK 2 (38 g 100 seed^{-1}) and an extra-large-seeded kabuli line ICC 17109 (63 g 100 seed^{-1}) is shown in Figure 1.

Early maturity is important in chickpea for its adaptation to short-season environments and for escape from terminal drought, which is the number one constraint to chickpea productivity in the SAT. The development of medium- to large-seeded (25–40 g 100 seed^{-1}) early-maturing kabuli varieties, particularly ICCV 2 and KAK 2, has helped expansion of kabuli chickpea area to southern India, which has typically short-season tropical environment (Gowda and Gaur 2004). Of the 12 accessions evaluated in this study, two (ICC 14194 and ICC 14198) were very early (days to maturity <100 days) and had 50–53 g 100 seed^{-1}, suggesting that it is possible to breed early-maturing kabuli varieties with extra-large seed.

It is hoped that these new FW resistance sources will be very useful in breeding extra-large kabuli varieties with FW resistance and typical kabuli type seed. The seeds of these accessions are available for distribution at ICRISAT's genebank.

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Relationships of Pinnate (Fern) and Simple (Unifoliate) Leaf Traits with Seed Yield and Seed Size in Kabuli Chickpea

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Chickpea typically has pinnate type of compound leaves in which the leaf lamina (blade) is differentiated into a rachis and a number of leaflets. These leaflets are generally odd in number and borne directly on the rachis. Mutants have been identified that have simple (unifoliate) leaves in which the lamina is not differentiated into rachis and leaflets, though there may be deep incisions in the lamina. A single recessive gene is known to control the simple leaf trait (Pundir et al. 1990). Most chickpea cultivars released in different countries have normal pinnate leaves. The simple leaf mutants have also been exploited in chickpea breeding and some cultivars, mainly kabuli type, with simple leaves have been released, e.g. Surutato 77 and Macarena in Mexico; Dwelley, Sanford, Evans and Sierra in USA; and CDC Diva and CDC Xena in Canada (FJ Muehlbauer, personal communication; Warkentin et al. 2003).

This study was conducted to determine if the leaf type has any relationship with seed yield and major seed yield components, particularly number of pods per plant and seed weight, in kabuli chickpea. Three crosses, ICCV 2 × ICC 14195, ICCV 2 × ICC 14215 and ICC 16644 × ICC 16670, were selected from ICRISAT's chickpea breeding program. The parents of each cross differed in leaf type and seed size. ICCV 2 and ICC 16644 have pinnate leaf and medium seed size (23–25 g 100 seed^{-1}), while ICC 14195, ICC 14215 and ICC 16670 have simple leaf and large seed size (50–59 g 100 seed^{-1}). The F_2 populations from these crosses were grown at ICRISAT-Patancheru during the postrainy season 2005/06 keeping row-to-row distance of 60 cm and plant-to-plant distance of approximately 10 cm. In each cross, observations were recorded on all plants individually. There were 226 plants in ICCV 2 × ICC 14195, 247 plants in ICCV 2 × ICC 14215, and 244 plants in ICC 16644 × ICC 16670. Observations were recorded on leaf type, number of pods per plant, number of seeds per plant, 100-seed weight and seed yield per plant. In each cross, the F_2 plants were classified into two groups based on leaf type (pinnate-leaved and simple-leaved) and then mean value of each trait was calculated for each group.