Table 1. Analysis of variance for the rooting percentage of chickpea shoots from seeds germinated in BAP media.

Source	Experiment 1 df	Experiment 1 MS	Experiment 2 df	Experiment 2 MS
Genotype	1	0.142	1	0.101
BAP	2	0.060	2	0.008
Rooting medium[1]	2	0.008	1	1.942*
Genotype × BAP	2	0.005	2	0.001
Genotype × medium	2	0.025	1	0.064
BAP × medium	4	0.017	2	0.038
Genotype × BAP × medium	4	0.028	2	0.022

1. In Experiment 1 different NAA concentrations (1, 2, or 4 mg L^{-1}) were studied and in Experiment 2 solid vs liquid media were studied.
* Significant at $P < 0.05$

In both experiments the percentage of rooted shoots per genotype, BAP, and rooting medium were recorded after 8 weeks. The data on percentage of rooted shoots was transformed using arcsine transformation, and a variance analysis was applied to the resulting data.

No significant differences for genotype, NAA, and BAP were detected in the first experiment (Table 1). The average percentage of rooted shoots was 45.3. Although no significant differences were detected in the shoots from different BAP concentrations (6, 11, and 17 mg L^{-1}), rooting decreased by about 35% when the BAP concentration was higher. Malik et al. (1993) observed that a longer exposure of developing shoots on BAP inhibited rooting in *Lathyrus* spp. Accordingly, we performed the second experiment with a lower BAP concentration in the germination media (0, 4, and 11 mg L^{-1}).

In the second experiment, significant differences between solid and liquid rooting media were noted (Table 1). The average rooting was 16.5% in solid medium and 84.7% in liquid medium. Our results show that the rooting method of using a bridge of filter paper between the liquid medium and the shoot is quite efficient, and that oxygen availability may be a factor that should be considered to obtain high rooting frequency in chickpea.

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Agronomy/Physiology

On-farm Benefits of ICRISAT's Chickpea Cultivars in Gujarat

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Chickpea is an important pulse crop with high economic returns to the farmers of Gujarat, India. It is a relatively a low-risk crop in the rainfed farming environment. In recent years, chickpea scientists were challenged to increase yield by alleviating several major abiotic and biotic constraints. Accordingly, ICRISAT developed and released a number of improved cultivars for India, three of which are for Gujarat, ICCC 4, ICCV 2, and ICCV 10.

ICCC 4 was released in Gujarat in 1983. It is of medium duration (110–140 days), has medium to large seed size, is yellow to light brown in color, and is moderately resistant to *Helicoverpa* (pod borer). ICCV 2 (Swetha), released in 1989, is an extra-short duration (85 days) kabuli type, and is resistant to fusarium wilt. It is adapted to normal and late sowing, and has the important drought escape trait. Its green pods are also consumed as a vegetable. ICCV 10 was released as Bharti in 1991 for cultivation in the Central and Peninsular Zones of India. It is a medium-duration, high-yielding, wilt- and root rot-resistant cultivar with wide adaptability and drought tolerance.

ICCC 4, ICCV 2, and ICCV 10 were identified as suitable for Jamnagar and Panchmahals districts of Gujarat, which have witnessed a significant increase in the cultivated area under chickpea during the past decade. These districts were selected for on-farm trials and demonstrations by the state department and nongovernment organizations; and in 1995 a study was undertaken with 158 farmers from 10 villages in these two districts to evaluate the economics of these three cultivars and to compare their performance with local cultivars. Five indicators—yield, price premium, profit, unit cost of production, and marketable surplus—were used to assess the on-farm benefits derived by adopting ICRISAT cultivars. The results are given in Table 1.

Grain yield. The results revealed that ICCC 4, ICCV 2, and ICCV 10 provided considerable yield gains over the local cultivar, Dahod Yellow. The yield of ICCC 4 was about 67% higher than the local cultivar grown in Jamnagar district. Similarly, the yield gain over Dahod Yellow was 34% for ICCV 2 and for ICCV 10 in Panchmahals district. ICCC 4 had the highest yield with supplemental irrigation in Jamnagar district. ICCV 2 and ICCV 10 were grown under rainfed condition in Panchmahals district.

Price premium. The price of chickpea grain was relatively higher for the ICRISAT cultivars. The price is largely governed by color, grain size, kabuli or desi type, and texture. ICCV 2 brought a very high price in the market due to its kabuli characteristics. However, the tribal farmers of Panchmahals district were exploited by village traders through the practice of advance lending. The Krishak Bharati Cooperative Limited (KRIBHCO) has been working to safeguard the interests of tribal farmers by developing a mechanism to purchase chickpea from the farmers and provide higher prices, in addition to its various developmental activities.

Profit. The gross returns and net returns ha^{-1} of chickpea cultivation were maximized in case of ICCV 10, followed by ICCV 2, ICCV 4, and the local cultivar. The gross returns for ICCC 4 was 68% higher than for Dahod yellow in Jamnagar district. The gross returns for ICCV 2 were 58% higher than the local cultivar and 68% higher for ICCV 10. The cost of cultivation was invariably high in Jamnagar district due to high wage rates and irrigation charges. The per hectare net profit of ICCV 10 was the highest among all the improved cultivars of chickpea. It was observed that a net profit of about 155% could be realized by adopting ICCC 4 over the local cultivar in Jamnagar district. Similarly, in comparison to Dahod Yellow, the profit was 84% higher for ICCV 10 and 68% higher for ICCV 2 in Panchmahals district.

Unit cost of production. Cost analysis showed that the adoption of ICCC 4 brought down the unit cost of production by as much as 31% or Rs 1501 t^{-1}. Similarly, for adoption of ICCV 10 the unit cost reduction was about 23% (Rs 556 t^{-1}) and 5% (Rs 108 t^{-1}) for ICCV 2 compared to the local cultivar. The adopters of improved chickpea cultivars also enjoyed higher labor productivity (defined as grain yield produced by one unit of labor, usually one man day). The average labor productivity was highest for ICCV 10, followed by ICCV 2, ICCC 4, and Dahod Yellow. This shows that human labor is more efficiently utilized in the cultivation of improved chickpea cultivars compared to local cultivars.

Table 1. Benefits of chickpea cultivars developed at ICRISAT in Jamnagar and Panchmahals districts of Gujarat, India, during the postrainy season, 1995/96[1].

District/ Chickpea cultivar	Yield ($kg\ ha^{-1}$)	Price ($Rs\ kg^{-1}$)	Gross returns ($Rs\ ha^{-1}$)	Total cost ($Rs\ ha^{-1}$)	Net profit ($Rs\ ha^{-1}$)	Unit cost ($Rs\ t^{-1}$)	Labor productivity ($kg\ day^{-1}$)
Jamnagar							
ICCC 4	2138	7.91	16912	7315	9598	3421	47.4
Local	1279	7.86	10057	6298	3758	4922	31.2
Panchmahals							
ICCV 2	1470	12.16	17880	3362	14517	2287	75.8
ICCV 10	1696	11.18	18965	3120	15845	1839	88.4
Local	1096	10.26	11247	2626	8622	2395	43.5

1. The results are the mean values of farm-level data. A total of 60 farmers were surveyed in Jamnagar district and 98 in Panchmahals district.

Marketable surplus. Farmers adopting the ICRISAT chickpea cultivars attained a higher marketable surplus (produce left after retaining for own consumption) in both districts compared to those farmers growing the local cultivar. In Jamnagar district, the marketable surplus of ICCC 4 was as high as 80% of the total production, while it was 65% for the local cultivar. Similarly, in Panchmahals district, the highest marketable surplus of chickpea was observed for ICCV 2 (60%), followed by ICCV 10 (20%), and the local cultivar (3%). Higher marketable surplus among the tribal farmers growing ICCV 2 was related to the higher market price for the kabuli type, and lower consumer preference for the kabuli type by the tribal farmers. The household consumption needs of tribal farmers growing ICCV 2 were satisfied through the purchase of a desi-type cultivar at a cheaper rate. The reason for the higher marketable surplus of chickpea in Jamnagar district could be attributed to higher yields and the relatively large proportion of area under improved chickpea cultivars.

Conclusion. The results of the survey data showed that all three improved cultivars, ICCC 4, ICCV 2, and ICCV 10, provided higher yield, higher profit, and lower unit cost of production over the local cultivars. Price premium was a particular added advantage for ICCV 2 because of its kabuli characteristic. The other benefits derived by adopting the ICRISAT cultivars were a higher marketable surplus resulting in higher disposable income for the farmer, and increased food security.

Influence of Seed Rates on Seed Yield in Desi Chickpea Cultivar PDG 3

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Ninety percent of the chickpea crop grown in Punjab, India, is produced in the southwestern region of the state, on marginal lands under rainfed conditions. The brackish underground water of this region causes severe damage to the crop, as well as various soilborne diseases, particularly in years of low rainfall. Continuous screening of a large number of germplasm lines under rainfed conditions and in multiple disease-sick plots resulted in the development and release of desi chickpea cultivar PDG 3 in 1996 for cultivation under limited moisture conditions (requiring only one pre-sown irrigation) in southwestern Punjab, comprising Firozpur, Faridkot, Bathinda, Mansa, Sangrur, and Muktsar districts.

The cultivar PDG 3 was developed from the cross GL 769 × GNG 146 through pedigree selection. The female parent of this cultivar is an approved cultivar for Punjab and the male is approved for Rajasthan. PDG 3 has a semierect growth habit, dark green leaves, long fruiting branches, and comparatively bolder and yellowish-brown seeds. Its plant height is about 80 cm. It takes 90 days to flower and 160 days to mature. Nutritional quality parameters are in the normal range with 21.8% protein, and 14.6 g (100-seed mass)$^{-1}$. The average incidence (1990–1995) of such diseases as ascochyta blight, gray mold, fusarium wilt, root rot, and foot rot in PDG 3 was at par with the check GL 769. Pod borer incidence in PDG 3 was relatively low (52.5%) compared to GL 769 (71%).

An agronomy experiment was conducted to study the influence of different seeding rates (45, 50, 55, and 60 kg ha^{-1}) in PDG 3 and check GL 769 under limited moisture conditions in the 1995 postrainy season at Faridkot, Punjab. An increase in seed yield was observed when the seed rate was increased from 45 kg ha^{-1} to 50 kg ha^{-1} and from 50 kg ha^{-1} 55 kg ha^{-1} in both PDG 3 and GL 769 (Table 1). In PDG 3, seed yield declined from 2716 kg ha^{-1} at the seed rate of 55 kg ha^{-1} to 2685 kg ha^{-1} at the seed rate of 60 kg ha^{-1}. For all four seed rates, the new cultivar PDG 3 gave higher seed yield than did GL 769. PDG 3 averaged a seed yield of 2508 kg ha^{-1} against 2168 kg ha^{-1} of GL 769, an increase of 13.6%. The maximum seed yield was obtained with a seed rate of 55 kg ha^{-1} in both PDG 3 and GL 769.

Table 1. Seed yield (kg ha^{-1}) of chickpea cultivar PDG 3 as influenced by seed rate under limited moisture conditions at the Regional Research Station, Punjab Agricultural University, Faridkot, India, 1995 postrainy season.

Seed rate (kg ha^{-1})	PDG 3	GL 769	Mean
45	2068	1759	1914
50	2562	2222	2392
55	2716	2346	2531
60	2685	2346	2526
Mean	2508	2168	
CD at 5%	Variety (V)	171	
	Seed rate (SR)	157	
	V × SR	NS[1]	

1. NS = not significant.