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Impact of Chickpea Research in Gujarat

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Abstract

This study assesses the impact of improved chickpea cultivars in the state of Gujarat in India. It is based on a household survey of chickpea growers spread over 24 villages spanning four districts — Panchmahals, Jamnagar, Ahmedabad, and Junagadh. Growth and instability in chickpea yield, extent of adoption, on-farm benefits, factors influencing adoption of improved cultivars, and farmers' perception of varietal traits and constraints are critically evaluated. The survey revealed that improved chickpea varieties showed distinctly superior performance over local cultivars in terms of yield, net income, and per unit cost of reduction, proving their cost- and profit-maximizing characteristics. Results from the estimated Tobit model suggest that holding size, chickpea duration, and yield risk significantly determined the probability and degree of adoption. Also, yellow color, bold size, *desi* type, and round shape were the most preferred quality traits of chickpea in Gujarat.

Résumé

Impact de la recherche sur le pois chiche dans le Gujarat. La présente étude évalue l'impact des cultivars améliorés de pois chiche dans l'Etat de Gujarat en Inde. Elle se base sur une enquête menée auprès des producteurs de pois chiche dans 24 villages répartis dans quatre districts - Panchmahals, Jamnagar, Ahmedabad, et Junagadh. L'accroissement et l'instabilité du rendement du pois chiche, le niveau d'adoption, les avantages en milieu paysan, les facteurs déterminant l'adoption des cultivars améliorés et la perception des paysans par rapport aux caractéristiques et contraintes variétales ont fait l'objet d'une évaluation critique. L'enquête a révélé que les variétés améliorées de pois chiche ont donné des résultats nettement supérieurs à ceux des cultivars locaux, en termes de rendements, de revenus nets et de réduction du coût unitaire, prouvant ainsi leurs propriétés de maximisation des coûts et des profits. Les résultats obtenus en utilisant le modèle Tobit indiquent que la taille de l'exploitation agricole, le cycle du pois chiche et les risques liés au rendement ont permis de déterminer la probabilité et le degré d'adoption. De même, la couleur jaune, la grosseur et le type desi et la forme ronde du pois chiche étaient les traits qualitatifs les plus appréciés de cette culture dans l'état de Gujarat.

Impact of Chickpea Research in Gujarat

R L Shiyani, P K Joshi, and M C S Bantilan

Gujarat Agricultural University
Junagadh 362 001, Gujarat, India

and

ICRISAT
International Crops Research Institute for the Semi-Arid Tropics
Patancheru 502 324, Andhra Pradesh, India

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About the Authors

R L Shiyani Associate Professor, Department of Agricultural Economics, Gujarat Agricultural University, Junagadh 362 001, Gujarat, India.

P K Joshi Principal Scientist, National Centre for Agricultural Economics and Policy Research, Library Avenue, Pusa, P.O. Box 11305, New Delhi 110 012, India.

M C S Bantilan Director, Socioeconomics and Policy Program, ICRISAT, Bulawayo, Zimbabwe.

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Introduction

Ensuring nutritional security to a growing population and sustainable crop production are priorities for scientists in India, where pulses play a key role. Among pulses, chickpea is the most important crop with high acceptability and wider use. It accounts for about 35% of area and 45% of total production of pulses in India, according to the All India Coordinated Research Project (AICRP 2000). Besides being rich in protein, its ability to use atmospheric nitrogen through biological nitrogen fixation (BNF) is economically more sound and environmentally acceptable. Chickpea is cultivated mainly on marginal lands under rainfed conditions. Failure of rains at the tail end of the rainy season often results in a drastic decline in acreage and production. Vagaries of weather and changing biotypes/races of pathogens have made it impossible to make a dent in yield. Therefore, biotic and abiotic factors which pose a major challenge to chickpea production need to be addressed.

History of chickpea research

Chickpea, along with other legumes, has undergone expansion in both area and production in India. Sustained research efforts have resulted in the release of a large number of chickpea varieties in India (Table 1). While only three varieties of chickpea were released between 1948 and 1970, the number of releases increased between 1973 and 1985. The establishment of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in 1972, the activities of the Indian Council of Agricultural Research (ICAR) under the All India Co-ordinated Research Project on Chickpea, and the efforts of state agricultural universities (SAUs) in the 1970s and 1980s strengthened chickpea breeding research in the country. The total number of chickpea varieties released in India from 1948 to 1999 was in fact as high as 108.

Chickpea in Gujarat

Chickpea is one of the most important postrainy-season pulse crops grown in Gujarat state of India. The area sown to it which fluctuated around 69 000 ha during the 1980s, reached 144 000 ha in 1999 (Figure 1). Chickpea production in the state grew from about 32 000 t to 125 000 t during the same period. Chickpea occupies an important niche in the rainfed farming system of resource-poor farmers of the state. Since chickpea is grown on receding residual soil

Table 1. Chickpea varieties released in India since 1948.

Year	Number of varieties released	Cumulative number of varieties released
1948	1	1
1958	1	2
1970	1	3
1973	6	9
1974	1	10
1976	2	12
1978	6	18
1980	1	19
1981	3	22
1982	13	35
1983	6	41
1984	10	51
1985	13	64
1986	1	65
1987	1	66
1988	2	68
1989	5	73
1990	5	78
1991	1	79
1992	2	81
1993	2	83
1994	2	85
1995	3	88
1996	5	93
1997	4	97
1998	0	97
1999	11	108

moisture during the postrainy season, soil moisture is a critical factor from the beginning of plant establishment to grain development and maturity. This limiting factor is much more important in a state like Gujarat, where the winters are short and comparatively warm, and potential evaporation is far in excess of the annual rainfall. The problem of moisture stress in the postrainy season on soils with poor water-holding capacity has been tackled to some extent by selecting early-maturing varieties to fit the length of the growing season.

Many biotic and abiotic constraints inflict serious yield losses and destabilize chickpea production. Scientists and government agencies face the challenge of finding ways of raising the yield per hectare in a situation where area expansion is

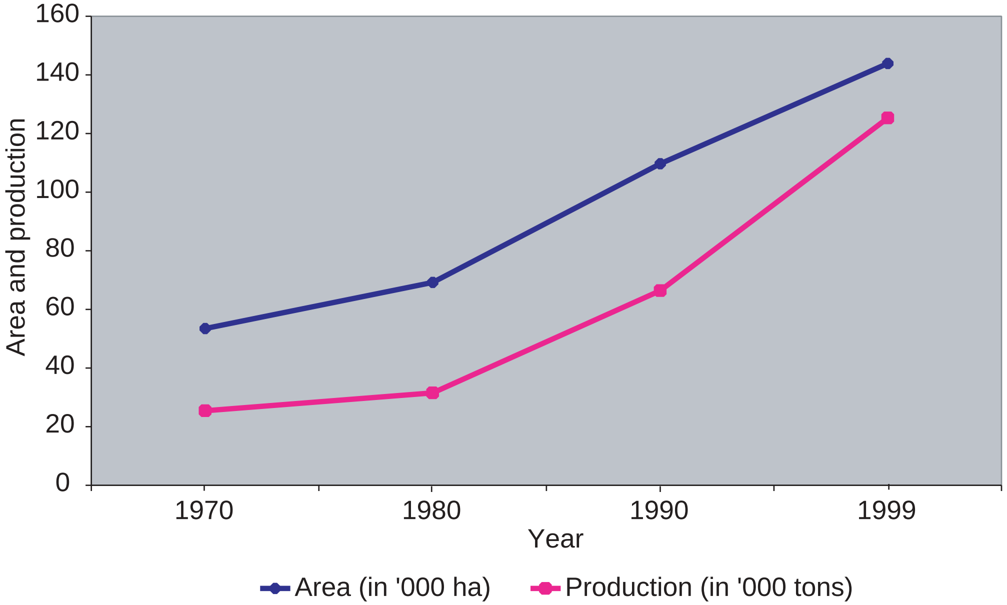

Figure 1. Area and production of chickpea in Gujarat.

increasingly constrained. ICRISAT and the national agricultural research system (NARS) adopted a major approach to alleviate these constraints through the use of genetic resistance to individual stress factors. During the past two decades, a limited number of improved chickpea cultivars have been released by the State Varietal Release Committee and/or the National Varietal Release Committee. This unambiguously suggests that a scientific study comparing the benefits of improved chickpea cultivars over local varieties would be useful in formulating policies appropriate for promoting chickpea production in Gujarat. In addition, despite a wide consensus on the adoption and impact of improved cultivars (ICs), no scientifically-based results are available indicating the precise extent of their adoption. The present study aims to assess the impact of improved chickpea cultivars in Gujarat. The results of the study would provide important feedback to researchers as well as the seed sector and also provide inputs for measuring the impact of investment in chickpea research.

Objectives of the study

- To estimate the growth and level of instability in the area, production, and yield of chickpea in selected districts of Gujarat

- To assess the role of Krishak Bharti Co-operative Limited (KRIBHCO), a Non-Government Organization (NGO), in disseminating improved cultivars of chickpea
- To assess the on-farm benefits of improved chickpea cultivars
- To identify the factors influencing the adoption of improved cultivars of chickpea and to quantify their influence
- To determine farmers' preferences for varietal traits and management practices

Methodology

Sampling

This study, confined to the state of Gujarat in western India, is based on a household survey of chickpea growers spread over 24 villages spanning four districts — Ahmedabad, Jamnagar, Junagadh, and Panchmahals (Appendix A). The districts were selected on the basis of their higher share in the acreage and production of chickpea in the state (Figs. 2 and 3). Together, the four districts contributed nearly two-thirds of the area and production of chickpea in 1999. Two blocks from each district and three villages from each selected block were randomly selected for the study. A list of chickpea growers in each selected village was prepared and ten cultivator households from each village chosen randomly. Thus the survey sample consisted of 240 chickpea growers. Since KRIBHCO has taken the lead in disseminating improved cultivars of chickpea, particularly in the tribal area of Panchmahals district, another survey in four villages in Limkheda block of this district was conducted to assess the NGO's role in dissemination. Twelve farmers who had adopted improved chickpea cultivars were selected randomly from each village, constituting a total of 48 adopters. An equal number of nonadopters was selected on a similar pattern. Information was gathered from all the sample households in each village through personal visits and a structured questionnaire. Details regarding their characteristics, cropping pattern, adoption pattern, seed source, varietal preferences of farmers, biotic and abiotic constraints, and cost of cultivation were elicited. This was supplemented with detailed discussions with progressive farmers, extension personnel, seed producers, and researchers in the state and secondary data on area, production, and yield of chickpea from the Directorate of Agriculture of the state.

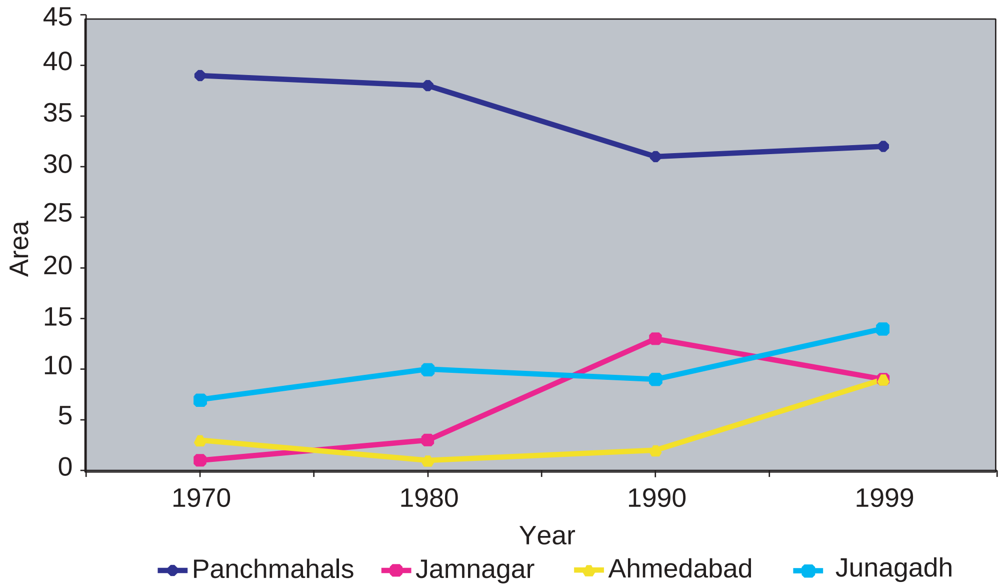

Figure 2. Districtwise area (%) of chickpea in Gujarat.

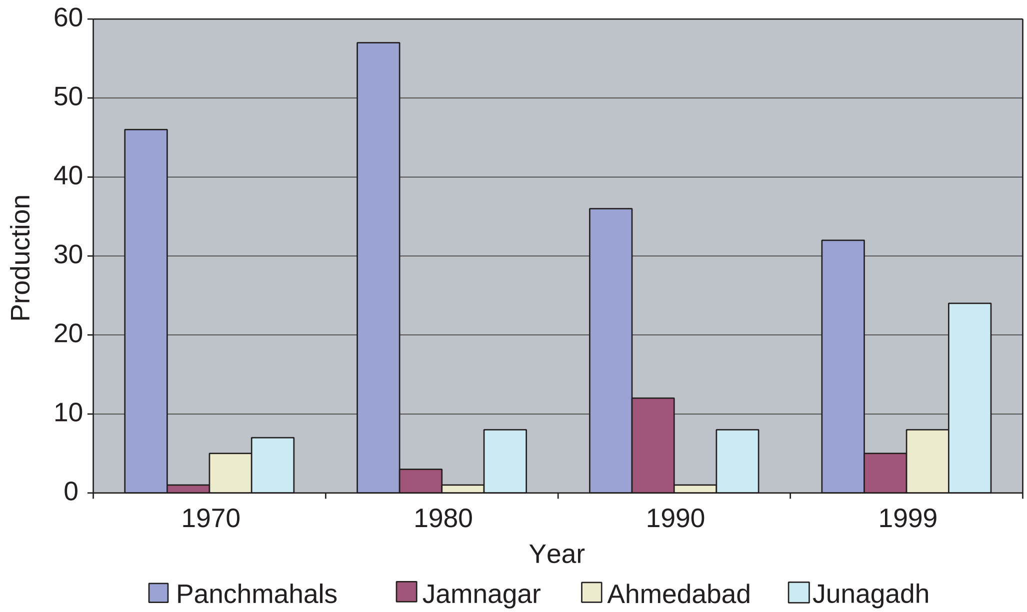

Figure 3. Districtwise production (%) of chickpea in Gujarat.

Analytical framework

High growth and low instability in production are prerequisites for sustainable agricultural performance. There is a growing concern that technological change in pulse production has increased variability, which is considered to be one of the threats to food security. Sen (1967) addressed a causal link between growth in agricultural production and instability with the hypothesis that variability in production increased due to the expansion of cultivation to marginal lands and increased use of purchased inputs.

Since the magnitude of growth and instability in chickpea production has serious implications for policymakers, the growth and level of instability in the area, production, and yield of chickpea in Gujarat were estimated. The simple coefficient of variation (CV) often contains the trend component and thus overestimates the level of instability in time series data characterized by long-term trends. To overcome this problem, this study used the Cuddy Della Valle index which corrects the coefficient of variation by:

$$\text{Instability Index (I.I.)} = C\,V\,\sqrt{1-R^2}$$

Where

CV is the simple estimate of coefficient of variation in %, and

R^2 is the coefficient of determination from a time trend regression adjusted by the number of degrees of freedom.

The annual compound rate of growth in area, production, and yield of chickpea was estimated using the following equation:

$$\text{Log } Y = \log a + t \log b$$

Where

Y is the area/production/yield of chickpea, and

t is the time trend, denoting years.

The annual compound growth rate in % ={Antilog of (log b)-1}*100.

A disaggregated analysis was attempted to assess the adoption of different chickpea varieties. Adoption of a cultivar is a dynamic process since the farmer has to decide when to replace the seed used; the sources of the seed; and when to replace the variety once it is adopted. Farmers being the basic economic decision-makers, this analytical framework attempts to understand their perception of the factors that convinced them to adopt new cultivars. An econometric model (Tobit) was estimated to understand the adoption decision.

Tobit model. A limited dependent variable model provides a good framework to study adoption behavior. In general, the Probit, Logit, and Tobit models are appropriate for such a study. This study uses the Tobit model (Tobin 1958) since it measures not only the probability of a chickpea grower adopting a new variety but also the intensity of technology use once adopted (Adesina and Zinnah 1993). The functional form of the Tobit model is given below:

$$Y_i = X_i b, \text{ if } i^* = X_i b + \mu_i > T$$

or

$$Y_i = 0, \text{ if } i^* = X_i b + \mu_i \leq T \quad ....(1)$$

Where

Y_i is the probability of adoption and the intensity of use of improved chickpea cultivars;

i^* is a nonobservable latent variable;

T is the nonobserved threshold level;

X is the $n \times k$ matrix of the explanatory variables;

b is a $K \times 1$ vector of parameters to be estimated; and

μ_i is an independently normally distributed error term with zero mean and constant variance $ó^2$.

This equation is a simultaneous and stochastic decision model. If the nonobserved latent variable i^* is greater than T, the observed variable Y_i which indexes adoption becomes a continuous function of the explanatory variables, and zero otherwise (i.e., nonadoption). The Tobit model uses the maximum likelihood method to estimate coefficients of equation. The regression coefficients are asymptotically efficient, nonbiased, and normally distributed. Where a substantially large number of farmers have completely adopted improved chickpea cultivars, a variant of the one-limit Tobit model shown in equation (1), i.e., a two-limit Tobit proposed by Rosett and Nelson (1975) could be used (e.g., Gould et al. 1989). However, a two-limit Tobit model is not appropriate for this study as none of the farmers completely adopted the improved chickpea cultivars on their total cropped area. The use of the one-limit Tobit model here is consistent with earlier studies

(Akinola and Young 1985; Shakya and Flinn 1985; Norris and Batie 1987; Adesina and Zinnah 1993).

Variables in the conceptual model. The theoretical model discussed suggests many important hypotheses relating adoption of improved chickpea cultivars to key economic and physical parameters. It assumes that the dependent variable – the proportion of the area under improved chickpea cultivars in the total area of chickpea — depends on many variables. However, on the basis of data availability and its quantifiable nature, the following explanatory variables are considered: education, size of holding, chickpea duration, farmer's experience in growing chickpea, distance to market, number of parcels, village representation, and yield risk.

The independent variables used in the Tobit model as well as the hypothesized signs are given in Appendix B. The chickpea growers' education was measured on a 0-5 scale, where 0 = illiterate, 1 = primary education, 2 = high school, 3 = secondary school, 4 = graduation, and 5 = postgraduation. Education was found to influence the adoption of improved cultivars. The level of education was hypothesized to be positively related to adoption as it helps an individual acquire knowledge about improved cultivars. Adesina and Seidi (1995) assumed a positive relationship between education and adoption of modern mangrove rice varieties in Guinea Bissau. Similarly, Kebede et al. (1990) found a positive effect of education on adoption of new technologies in Ethiopian agriculture.

It is generally assumed that the size of holding exerts a positive influence on adoption of improved cultivars as a large farm is a surrogate for a number of factors such as access to credit, inputs, and information. This translates into preferential treatment for large farmers in terms of obtaining such inputs (Mitra 1971; Sarap 1990). A positive association between farm size and adoption of new high-yielding varieties has been highlighted in many studies (Dasgupta 1977; Asaduzzaman 1979; Sarap and Vashist 1994). Seemingly contradictory evidences have been cited by Hayami (1981) from Barker and Herdt's (1978) study of 30 villages in five Asian countries, and also by Ahmed (1981) and Allauddin and Tisdell (1988). Muthia (1971), Schluter (1971), and Sharma (1973) found that small and medium farmers in India adopted high-yielding varieties over a higher proportion of their holdings than large farmers. Adesina and Seidi (1995) reported that the effect of farm size on adoption is unclear in adoption literature. Therefore, the hypothesized sign of size of holdings remains undecided in this study.

Early-maturing cultivars of chickpea (ICCV 2 and ICCV 10) were preferred most by farmers because grain price is relatively higher early in the season. Moreover, they also felt that earlier-maturing cultivars would escape the stress caused by receding soil moisture and pod borer infestation. Hence, it is hypothesized that chickpea duration is negatively related to adoption.

Years of experience in chickpea farming is expected to be related to the farmer's ability to obtain, process, and use information relevant to chickpea cultivation. Experienced farmers are assumed to be more knowledgeable about new practices and more willing to bear risk due to their longer planning horizons. They may also be the elders in the village and have preferential access to new information or technologies through extension services or development projects. Older farmers may have more skills in accessing improved cultivars in relation to the local varieties that exist in the village. It is, therefore, hypothesized that experience in chickpea farming is positively related to the probability of adoption of improved cultivars. Adesina and Seidi (1995) and Adesina and Forson (1995) also hypothesized that experience was positively related to adoption.

Distance to factor and product markets is one of the important variables, particularly in this study area where tribal farmers do not have easy access to markets. Our hypothesis for this variable is that market distance is negatively related to adoption.

Fragmentation of land holdings hampers the rate of adoption as it consumes more time and resources per unit production. Therefore, it is assumed that the number of parcels is negatively related to the adoption of improved chickpea cultivars.

Since the villages selected for this study differed in terms of soil type, cropping pattern, rainfall, forest area, etc., village dummies were included in the model to ascertain whether spatial changes in adoption could be attributed to region-specific agroclimatic characteristics like soil, rainfall, temperature, etc. The village dummies are measured as binary variables, i.e., 1 for representing village and zero otherwise.

Yield is more uncertain with an unfamiliar technology. Quite often objective risks are uncertain due to weather fluctuations, susceptibility to pests, uncertainty regarding the timely availability of crucial inputs, etc. (Feder et al. 1985). However, empirical studies have rarely treated this factor because of the difficulty in measuring it. O'Mara (1980) and Binswanger et al. (1980) obtained a measure of farmers' risk aversion through direct interviews. This study measures yield risk as a coefficient of variation of chickpea yield in bad, normal, and good years. A farmer's higher risk-bearing ability is an indication of a quicker rate of adoption. Hence, a positive relationship between yield risk and the probability of adoption of improved chickpea cultivars is hypothesized.

Growth and instability in chickpea production

Information on the contribution of modern chickpea cultivars to growth and instability in chickpea production would aid policymakers in countering instability. Compound growth rates and instability indices in area, production, and yield of chickpea in select districts of Gujarat were estimated. Table 2 shows the periodwise annual compound rate of growth in area, production, and yield of chickpea. Based on these rates, the districts can be classified into four: category A (high growth) – growth rate of 5% and above; category B (moderate growth) – growth rate of > 1 and 5%; category C (slow growth) – positive growth rate of up to 1%; and category D – negative rate of growth. This classification was used with the extent of instability (Table 3). A similar classification was followed by Deb et al. (1999) in their study on sorghum. During period I, in all the selected districts except Panchmahals, chickpea production exhibited high growth due to relatively higher growth in area. During 1970-80 and 1980-90, chickpea yield registered negative growth in all the districts; so did the state as a whole except for Panchmahals district. However, during period III, positive growth rates in area, production, and yield were found in all the districts except Ahmedabad and Junagadh which experienced negative growth in area alone.

It is generally hypothesized that production instability has increased due to expansion of modern cultivars. In order to confirm this, instability indices were computed (Table 3). Again, the districts were classified on the basis of instability indices:

	For area and production	For yield
High instability	>40	>20
Low instability	up to 40	up to 20

This classification was combined with the classification of growth rates (Table 4). It is interesting to note that relatively low instability in area, production, and yield of chickpea was noticed only in Panchmahals district during almost all the periods. This is obvious because farmers of Panchmahals district have been

Table 2. Compound rates (%) of growth in area, production, and yield of chickpea in selected districts of Gujarat.

	Period I (1970-80)			Period II (1980-90)			Period III (1990-95)			Overall period (1970-95)		
District	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
Ahmedabad	17.7	9.7	-7.8	4.2	0.4	-3.6	-1.3	3.1	4.5	9.6	7.2	-2.1
Jamnagar	19.4	16.1	-2.8	5.6	3.2	-2.3	0.8	3.2	2.4	20.1	19.0	-0.9
Junagadh	11.1	7.3	-3.5	-4.9	-10.9	-6.3	-11.0	48.2	60.5	5.2	4.8	-0.4
Panchmahals	-0.8	2.3	3.2	-5.0	-11.1	-6.5	6.9	7.4	0.5	-0.2	-0.1	0.1
Gujarat	4.2	2.3	-1.6	-3.5	-6.2	-2.8	2.5	8.1	5.5	2.4	2.1	-0.3

Table 3. Instability indices in area, production, and yield of chickpea in selected districts of Gujarat.

	Period I (1970-80)			Period II (1980-90)			Period III (1990-95)			Overall period (1970-95)		
District	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
Ahmedabad	68.9	66.8	18.8	64.0	60.9	18.2	33.2	44.1	18.9	67.0	70.4	24.4
Jamnagar	102.3	129.8	22.0	91.8	116.6	26.9	75.8	149.8	40.9	125.1	205.1	31.3
Junagadh	66.2	73.0	39.7	70.9	99.3	38.7	60.3	55.0	10.9	76.1	134.4	52.4
Panchmahals	13.8	18.1	31.5	32.9	35.0	17.9	13.4	23.0	13.1	42.7	40.9	27.6
Gujarat	26.8	38.0	26.3	40.2	45.8	14.6	34.2	44.1	13.0	41.2	50.7	25.4

Table 4. Association[1] between growth and instability in area, production, and yield of chickpea.

	Period I (1970-80)			Period II (1980-90)			Period III (1990-95)			Overall period (1970-95)		
District	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
Ahmedabad	AB	AB	NA	MB	BB	NA	NA	MB	MA	AB	AB	NB
Jamnagar	AB	AB	NB	AB	MB	NB	BB	MB	MB	AB	AB	NB
Junagadh	AB	AB	NB	NB	NB	NB	NB	AB	AA	AB	MB	NB
Panchmahals	NA	MA	MB	NA	NA	NA	AA	AA	BA	NB	NB	BB
Gujarat	MA	MA	NB	NB	NB	NA	MA	AB	AA	MB	MB	NB

1. AA = High growth with low instability; AB = High growth with high instability; BA = Low growth with low instability; BB = Low growth with high instability; MA = Moderate growth with low instability; MB = Moderate growth with high instability; NA = Negative growth with low instability; and NB = Negative growth with high instability.

growing chickpea since decades and the district leads in chickpea area and production throughout the state since the last four decades. On the other hand, farmers of Ahmedabad and Jamnagar began growing chickpea only since the last two decades. However, this constitutes only a small fraction of the area. It is in this light that the issue of high variability in yield needs to be addressed.

Table 4 shows eight kinds of association between growth and instability in area, production, and yield of chickpea: AA – high growth with low instability; AB – high growth with high instability; BA – low growth with low instability; BB – low growth with high instability; MA – moderate growth with low instability; MB – moderate growth with high instability; NA – negative growth with low instability; and NB – negative growth with high instability. From the development point of view, high growth with low instability (AA) is the best situation, whereas NB indicates the worst scenario. AB would be preferable to BA. Similarly, MA would score over MB whereas BB and NA are not the desired situations. Interestingly, high growth and low instability in yield were noticed only in the case of Junagadh district and Gujarat state during 1990-95. In Panchmahals district, a similar situation prevailed for area and production. Compared to Periods I, II and the overall period, the situation has been relatively better in recent years (1990-95). This means that a moderate to high growth with relatively less instability in chickpea yield was observed during Period III. Therefore, it may be concluded that the expansion of improved chickpea cultivars helped increase yield. This suggests that future chickpea research in Gujarat should focus on yield enhancement rather than yield stabilization.

Characteristics of sample farmers

The average land area owned per farm was the highest (53.8 ha) in Ahmedabad district because it includes the popular 'Bhal' area where the size of holdings is very high. This was followed by Junagadh (8.2 ha), Jamnagar (5.6 ha), and Panchmahals (2.9 ha), with an overall average of 17.6 ha (Table 5). The irrigated area varied between 10.7% of the total area in Ahmedabad district and 63.4% in respect of Panchmahals district while it was only 16.9% for all the sample households. Chickpea was grown over 15.7% of the total area in the study area, ranging from about 10.5% (Ahmedabad) to 45.9% (Panchmahals). The number of parcels varied from 1 to 3, while experience in growing chickpea ranged between 6 years (Jamnagar) and 30 years (Panchmahals). About 53% of the total sample of farmers did not grow chickpea continuously in the same plot. There is a general tendency of rotating chickpea in different plots to enhance soil fertility

Table 5. Characteristics of sample households.

Characteristic	Ahmedabad	Jamnagar	Junagadh	Panchmahals	All
Average size of holding (ha)	53.8	5.6	8.2	2.9	17.6
Average operated area (ha)	50.7	5.6	8.1	2.5	16.7
Irrigated area to total area (%)	10.7	48.5	20.0	63.4	16.9
Number of parcels	2	1	3	1	2
Chickpea area grown to total area (%)	10.5	22.3	34.4	45.9	15.7
Experience in growing chickpea (years)	9	6	19	30	16
Chickpea in same plot (% of sample farmers)	35	20	48.3	83.3	46.7
Use of insecticides (% of sample farmers)	51.7	75.0	85.0	80.0	72.9

and increase the productivity of the subsequent rainy-season crop. However, more than 83% of the sample farmers in Panchmahals district have grown chickpea continuously in the same plot. More extension efforts are needed to educate the tribal farmers of Panchmahals district about rotating chickpea cultivation in different plots. Nearly 73% of the sample farmers used insecticides to prevent yield damage by insects/pests. Improved cultivars resistant to insects/ pests and diseases would help chickpea growers in preventing yield losses.

Crop rotation and chickpea

Table 6 presents the crop rotation practices followed by the sample farmers. The farmers of Jamnagar and Junagadh districts generally grew chickpea after groundnut, which is the ruling rainy-season crop in these districts. In Panchmahals district, chickpea was grown after paddy and maize, which are major rainy-season cereal crops. Maize grain is widely consumed and the fodder used as animal feed. Sorghum-chickpea rotation was generally followed by the farmers of Ahmedabad district. Many farmers in Ahmedabad district were unable to grow any crop during the rainy season due to waterlogging. In general, the

Table 6. Crop rotation and chickpea in Gujarat.

	Crop	Number of farmers	Percentage of farmers
Ahmedabad	Fallow-chickpea	29	12.1
	Sorghum-chickpea	31	12.9
Jamnagar	Groundnut-chickpea	58	24.2
	Indecisive	2	0.8
Junagadh	Groundnut	30	12.5
	Fallow-chickpea	21	8.8
	Indecisive	9	3.8
Panchmahals	Paddy-chickpea	36	15.0
	Maize-chickpea	24	10.0
All	Fallow-chickpea	50	20.8
	Sorghum-chickpea	31	12.9
	Groundnut-chickpea	88	36.7
	Paddy-chickpea	36	15.0
	Maize-chickpea	24	10.0
	Indecisive	11	4.6
Total		240	100.0

overall results indicated that groundnut-chickpea rotation was adopted by about 36.7% of the sample followed by fallow-chickpea (20.8%), paddy-chickpea (15%), sorghum-chickpea (12.9%), and maize-chickpea (10%), whereas 4.6% of the sample farmers were indecisive.

Sources of chickpea seed

Sources of seed and information are very important in the spread of improved cultivars. Easy availability of seeds may help new cultivars reach more farmers. The sources of chickpea seed in the selected districts of Gujarat are shown in Table 7. It is interesting to note that a majority of the farmers (77.1%) retained their own farm seeds for use in the next season. Again, the proportion of farmers using their own farm seeds was highest in Panchmahals district (91.7%). This suggests the need for an annual awareness campaign on the use of improved cultivars of chickpea and fresh seed. That seed shops too play an important role as sources of chickpea seed was evident from the fact that about 16.3% of the sample farmers purchased their seeds from shops. Seed corporations/the Department of

Table 7. Sources of chickpea seed.

Sources	Ahmedabad	Jamnagar	Junagadh	Panchmahals	Total number of farmers
Farmers' own seed	40 (66.7[1])	46 (76.7)	44 (73.3)	55 (91.7)	185 (77.1)
Seed shops	20 (33.3)	8 (13.3)	6 (10)	5 (8.3)	39 (16.3)
Other farmers	-	-	8 (13.3)	-	8 (3.3)
Seed Corporations/ Department of Agriculture/research institutes	-	-	2 (3.3)	-	2 (0.8)
Others	-	6 (10)	-	-	6 (2.5)
Total	60 (100)	60 (100)	60 (100)	60 (100)	240 (100)

1. Figures in parentheses are percentage of the total number of farmers.

Agriculture/research institutes, and other farmers are also involved in the distribution of seeds, though their share is meager. It can be inferred that all these agents have to play a complementary role in order to efficiently disseminate improved chickpea cultivars to farmers. Government agencies and NGOs could take the lead in distributing assured quantities of quality seeds at reasonable prices to farmers.

Date of sowing

The sowing date is one of the most crucial factors influencing yield of chickpea as well as disease and insect pest incidence. In general, farmers start sowing chickpea between the last week or second week of October to the end of November (Table 8). However, in Bhal area of Ahmedabad district, chickpea is

Table 8. Frequency distribution of chickpea sowing period in selected districts of Gujarat (percentage of farmers).

Period	Ahmedabad	Jamnagar	Junagadh	Panchmahals	Overall
2nd week October	13.33	-	-	-	3.33
3rd week October	41.67	-	-	-	10.42
4th week October	30.00	20.00	6.66	26.67	20.84
1st week November	15.00	13.33	11.67	46.67	21.67
2nd week November	-	6.67	35.00	16.66	14.58
3rd week November	-	40.00	41.67	10.00	22.91
4th week November	-	20.00	5.00	-	6.25
Total	100.00	100.00	100.00	100.00	100.00

sown from the second week of October to the first week of November. This could be because many farmers keep land fallow during the rainy season due to waterlogging. In Panchmahals district, about 73% of the farmers started sowing chickpea by the first week of November; on the other hand, a majority of the farmers of Jamnagar and Junagadh districts sowed chickpea during the third week of November. Paikaray and Misra (1992) found that the highest seed yields were obtained when chickpea was sown on 18 November (i.e., third week of November). This was mainly due to the favorable temperature at flowering and pod filling. This supports the findings of Arvadia and Patel (1988) in Gujarat. Tripathi and Singh (1985) observed yield reduction when chickpea is sown earlier or later than the optimal date of sowing. This suggests that the extension system should address this issue for the chickpea growers of Ahmedabad and Panchmahals districts.

Adoption pattern of chickpea

The role of KRIBHCO

With support from the British Overseas Development Administration (ODA), KRIBHCO has been promoting participatory natural resource development in the predominantly poor tribal districts of western India, including Panchmahals district in Gujarat, under the KRIBHCO Indo-British Rainfed Farming Project, which started in 1993. High on KRIBHCO's priorities is the improvement of the quality of life in these areas through the use of improved varieties and other activities. The NGO concentrates on issues related to seed technology, as seed is one of the vital components of the basic inputs needed for enhancing crop yield. After rigorous efforts with various agricultural research stations, KRIBHCO identified a few varieties of chickpea —ICCV 1, ICCV 2, ICCV 4, ICCV 10, and ICCV 88202 —which were tested by farmers in their fields along with the local varieties. Through this process of farmer-managed participatory research, ICCV 2 and ICCV 10 were identified as the more promising lines. The search for chickpea cultivars was made through chickpea breeders at ICRISAT. It must be mentioned here that none of the varieties identified had been popular earlier in the project area nor multiplied by any agency. Therefore, KRIBHCO's role in disseminating improved chickpea cultivars (ICCV 2 and ICCV 10) was assessed in this study.

It was found that the extent of adoption of ICCV 2 and ICCV 10 was almost similar (20%) during 1994 (Figure 4). In subsequent years, their adoption increased

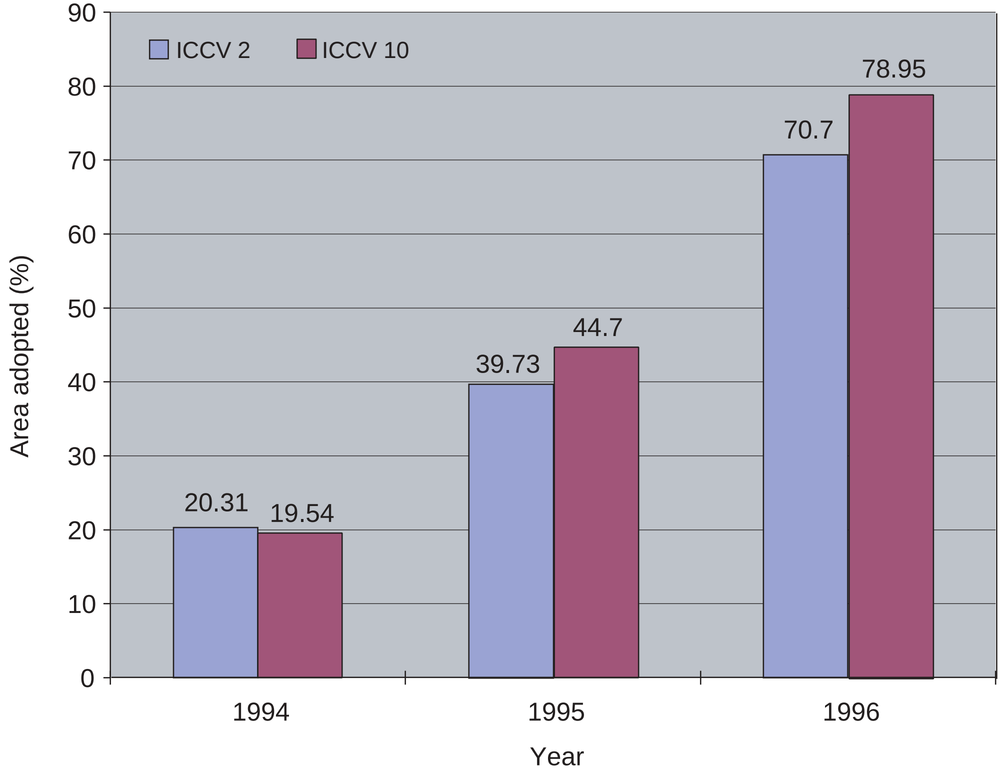

Figure 4. Extent of adoption of chickpea cultivars by sample farmers of KRIBHCO villages.

significantly by substituting the most popular local variety (Dahod Yellow). The adoption rate was faster in the case of ICCV 10.

KRIBHCO's participatory approach of understanding farmers' needs relating to different varietal traits and identifying specific varieties played a significant role in the wider acceptance and spread of improved chickpea cultivars. It has been reported that KRIBHCO is now taking up commercial seed production to develop a mechanism which may ensure adequate and timely availability of good quality seeds of improved varieties. With such a mechanism institutionalized, the adoption rate of improved varieties is expected to be quicker, which in turn would yield several direct and indirect on-farm benefits to farmers.

Table 9 presents the frequency distribution of the extent of adoption of improved chickpea varieties. It is interesting to note that over the three-year period (1994-1996), farmers increased their adoption levels. During 1994, about 60% of them

Table 9. Extent of adoption of improved chickpea varieties (percentage of farmers).

Adoption range (Percentage of total chickpea area)	Number of farmers (%)					
	ICCV 2			ICCV 10		
	1994	1995	1996	1994	1995	1996
< 20	58.62	17.24	-	63.16	5.26	-
20 - 40	34.48	34.48	6.90	31.58	31.58	5.26
40 - 60	6.90	37.93	31.03	52.63	52.63	5.26
60 - 80	-	10.35	51.72	10.53	10.53	42.11
> 80	-	-	10.35	-	-	47.37

adopted ICCV 2 and ICCV 10 to the extent of about 20% of their total chickpea area. During the next two years, these varieties covered more than 80% of their chickpea area. Of course, this proportion of adopters was relatively more in the case of ICCV 10. About 50% of the farmers sowed ICCV 2 and ICCV 10 in the range of 60-80% of their chickpea area. Such an impressive adoption rate could mainly be attributed to KRIBHCO's involvement.

The rate of change in the adoption of improved chickpea varieties during the three years was also assessed for ICCV 2 and ICCV 10 (Table 10). The proportion of chickpea growers whose adoption increased up to 50% in 1995 over 1994 was relatively faster in the case of ICCV 2 than in ICCV 10. Examining the increase in adoption in the 50-100% range in 1996 over 1995, it was observed

Table 10. Increase in rate of adoption of improved chickpea varieties (percentage of sample farmers).

Increase in rate of adoption (%)	Number of farmers (%)					
	ICCV 2			ICCV 10		
	1995 over 1994	1996 over 1995	1996 over 1994	1995 over 1994	1996 over 1995	1996 over 1994
<50	34.48	24.14	3.45	26.32	21.05	–
50 - 100	31.03	44.82	27.59	47.37	47.37	10.53
100 - 150	24.14	24.14	13.79	5.26	15.79	5.26
150 - 200	6.90	9.90	3.45	–	5.26	10.53
> 200	3.45	–	51.72	21.05	10.53	73.68

that the proportion of chickpea growers was maximum for both the varieties (44.82% for ICCV 2 and 47.37% for ICCV 10). A higher proportion of chickpea growers was found in the upper range in the rate of adoption in 1996 over 1994 for both the improved varieties. However, this proportion was significantly higher in ICCV 10 as compared to ICCV 2. This could be attributed mainly to the relatively higher yield of ICCV 10 and its suitability in rainfed conditions as irrigation facilities are limited in the study area. Farmers reported that ICCV 10 is a better replacement for the predominant local variety Dahod Yellow.

Complementary information on adoption

Seed production and distribution data provided clues to the spread of the cultivars and helped define target areas. The major problem in the case of chickpea seed production is the limited demand for particular variety as the varieties are adapted to specific agroclimatic regions. Such a potentially low seed demand structure is not economically attractive for the seed industry. Table 11 presents the distribution of breeder seed of chickpea in Gujarat. It was observed that except during 1994-95, the quantum of breeder seed of ICCC 4 was higher than that of Dahod Yellow and Chaffa in all the years. The total breeder seed of all varieties of chickpea amounted to 1800.50 kg in 1987-88, which increased to 5400.73 kg in 1995-96. Large-scale production of breeder seeds of ICCV 2, ICCV 10, and other improved cultivars of chickpea is essential for the speedy flow of new improved varieties from research stations to farmers' fields.

Table 11. Distribution of chickpea breeder seed in Gujarat state (in kgs).

Year	ICCC 4	Dahod Yellow	Chaffa	Total
1987-88	1200.50	600.00	-	1800.50
1988-89	600.00	600.00	-	1200.00
1989-90	1400.25	800.00	-	2200.25
1990-91	4500.55	3700.28	900.55	9200.38
1991.92	3500.50	1500.00	1200.00	6200.50
1992-93	4000.00	1400.50	500.00	5900.50
1993-94	2600.75	900.50	1200.90	4900.15
1994-95	2200.25	3000.50	700.16	5900.91
1995-96	2500.23	2000.50	900.00	5400.73

Source: Directorate of Agriculture, Government of Gujarat (1996).

Though a large number of chickpea varieties have been identified and released, their impact on yield levels in farmers' fields was difficult to assess because till recently there was no organized seed production and distribution system backed by strong research efforts. In recent years, this problem has attracted attention and attempts are being made to produce sufficient quantities of certified chickpea seed varieties in Gujarat (Table 12). The Gujarat State Seed Corporation (GSSC) reports that between 1980-81 and 1994-95, sales of chickpea seed increased. It is worth mentioning that GSSC started playing a major role in this effort since 1990-91. The state seed farms, Gujarat Cooperative Marketing Society Limited (GUJCOMASOL), National Seed Corporation (NSC), and others are also involved in the distribution of certified seeds of chickpea, though their share is meager. Since the inadequacy of seeds of improved cultivars is a major constraint, seed production and distribution need to be well-organized and involve the public and private sectors.

On-farm benefits

The on-farm benefits of improved chickpea varieties accruing to the sample farmers of KRIBHCO villages were also assessed (Table 13). It was observed that ICCV 2 and ICCV 10 provided considerable yield gains over the local chickpea variety. This was much higher in the case of ICCV 10 (55%) than ICCV 2 (34%).

Table 12. Distribution of certified chickpea seed in Gujarat state (in kgs).

Year	GSSC	GUJCOMASOL	State seed farms	NSC	Others	Total
1980-81	9700	-	10500	-	-	20200
1981-82	32900	-	21000	-	-	53900
1982-83	11800	-	21000	-	-	32800
1983-84	76200	-	-	1300	53200	130700
1984-85	29600	-	15300	-	2000	46900
1985-86	37100	-	-	-	30900	68000
1986-87	27300	-	-	-	25900	53200
1987-88	47600	-	-	-	2900	50500
1988-89	14900	-	-	-	-	14900
1989-90	47100	2600	-	-	-	49700
1990-91	164600	-	-	-	-	164600
1991-92	152100	5400	30000	-	85000	272500
1992-93	224100	1300	-	-	9600	235000
1993-94	140500	35600	31000	-	35100	242200
1994-95	140000	18500	-	-	-	158500

Table 13. On-farm benefits of improved chickpea varieties to sample farmers in KRIBHCO villages.

Varieties	Yield (kg ha^{-1})	Price (Rs kg^{-1})	Gross returns (Rs ha^{-1})	Cost (Rs ha^{-1})	Net income (Rs ha^{-1})	Unit cost (Rs t^{-1})	Labor productivity (kg day^{-1})
ICCV 2	1470	12.16	17 880	3362	14 518	2287	97.50
ICCV 10	1696	11.18	18 965	3120	15 845	1840	93.14
Local	1096	10.26	11 247	2626	8 621	2396	50.12

The higher yields of improved varieties resulted in a decline in the per unit cost of production and an increase in profitability levels.

Every enterprise is judged by the test of profitability. The net income over variable cost of improved chickpea varieties was Rs 14 518 ha^{-1} for ICCV 2 and Rs 15 845 ha^{-1} for ICCV 10. The corresponding value for the local variety was only Rs 8621 ha^{-1}. This shows that the net returns for ICCV 10 were 84% higher than for the local variety. The corresponding figure for ICCV 2 was 68%. The price of chickpea grain was relatively higher for ICCV 2 (Rs 12.16 kg^{-1}), followed by ICCV 10 (Rs 11.18 kg^{-1}), and the local variety (Rs 10.26 kg^{-1}). Though ICCV 2 is a k*abuli* type, farmers did not get a very good price for it in the market. To protect farmers from disadvantageous local lending practices, it is expected that KRIBHCO may play a role in purchasing chickpea grain from farmers. This would enable chickpea growers to realize higher prices. Moreover, popularizing small *dhal* (pulses) mills on a cooperative basis for processing and storing produce over long periods would help farmers get remunerative prices.

Another benefit of adopting improved varieties was higher labor productivity. Average labor productivity was highest for ICCV 2 (97.50 kg day^{-1}), followed by ICCV 10 (93.14 kg day^{-1}), and the local variety (50.12 kg day^{-1}), showing that adopters of improved chickpea varieties utilized labor more effectively than nonadopters.

Generation of additional marketable surplus was another benefit derived from the cultivation of improved varieties. Figure 5 presents the proportion of the marketable surplus of adopters and nonadopters of improved chickpea varieties among the sample households. The marketable surplus of those who adopted ICCV 2 was highest (60.55%), followed by those who adopted ICCV 10 (21.23%). For those who cultivated local varieties, the marketable surplus was as low as 2.66%. Relatively more marketable surplus of ICCV 2 was expected as the

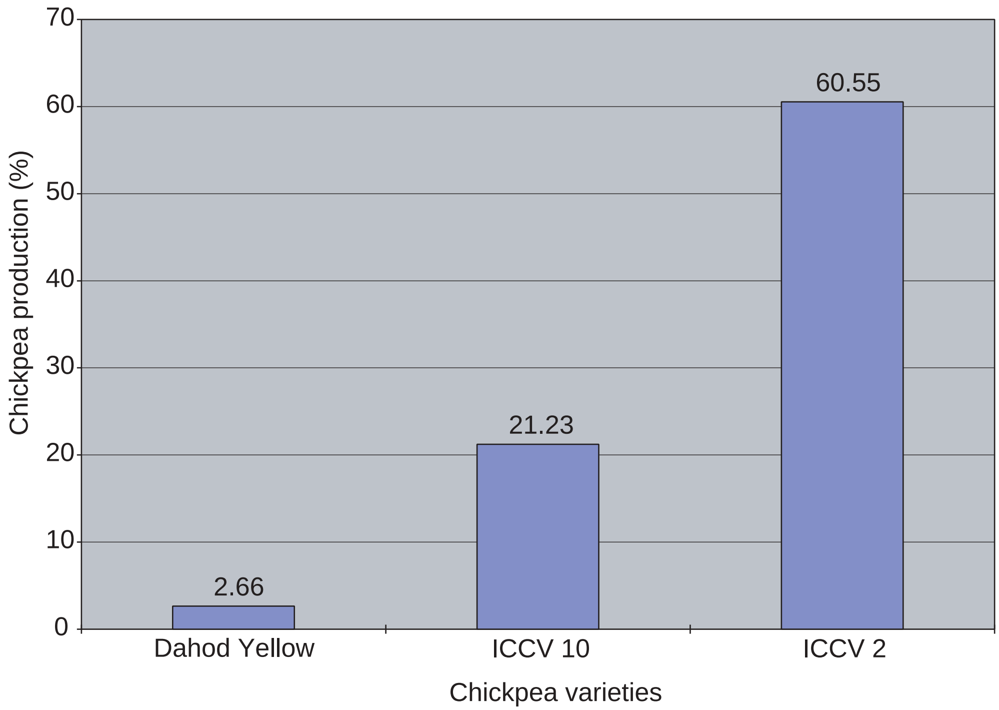

Figure 5. Marketable surplus of chickpea by sample farmers of KRIBHCO villages.

variety has a *kabuli* trait with a higher market price and lower preference for consumption by the rural poor. Therefore, farmers sell greater quantities of this variety in the market in order to earn more profit. The locally preferred variety is purchased at lower prices to meet consumption requirements. It may be inferred from this analysis that the improved chickpea cultivars have a positive impact on the economy of the farmers in the study areas.

The frequency distribution of the proportion of farmers in different ranges of cost of production is given in Table 14. A large proportion of farmers (68.42%) who adopted ICCV 10 was in the cost range of up to Rs 3000 t^{-1}. The corresponding figures for ICCV 2 and local cultivars were 48.28% and 37.50%. A cost of production of more than Rs 9000 t^{-1} was noticed in 31.25% of the farmers growing local varieties, while the corresponding figures for ICCV 10 and ICCV 2 were only 10.53% and 13.79%. This implies that a majority of the farmers growing improved cultivars enjoyed the benefit of cost reduction compared to local cultivars.

Table 14. Frequency distribution of cost of production of chickpea (percentage of farmers).

Cost range (Rs t^{-1})	ICCV 2	ICCV 10	Local
Up to Rs. 3000	48.28	68.42	37.50
3001 to 6000	31.03	5.26	20.83
6001 to 9000	6.90	15.79	10.42
> 9000	13.79	10.53	31.25
Total	100	100	100

Table 15. Distribution of chickpea yield risk (percentage of sample farmers).

	Adopters		Nonadopters	
CV of yield (%)	%	Cumulative	%	Cumulative
Up to 10	4.17	4.17	0.00	0.00
10-20	12.50	16.67	0.00	0.00
20-30	14.58	31.25	4.17	4.17
30-40	12.50	43.75	6.25	10.42
40-50	18.75	62.50	41.67	52.09
50-60	29.17	91.67	39.58	91.67
60-70	8.33	100.00	8.33	100.00

Table 15 presents the frequency distribution of adopters of improved varieties and chickpea yield risk. Yield risk was measured by computing the CV in chickpea yield during bad, normal, and good years. About 44% of the adopters of improved chickpea varieties had a CV of less than 40%, whereas only 10% of the nonadopters had this CV in yield.

Factors influencing adoption

Farmers critically assess the characteristics of new technologies against those of existing local ones. They will adopt new varieties only if they are judged superior to local varieties in respect of yield, fewer days to maturity, etc. This fortifies the need for adoption studies to diversify the portfolio of variables used in modelling adoption decision. The descriptive statistics of the variables used in the empirical model and the results obtained from the Tobit model are shown in Tables 16 and 17, respectively.

Table16. Descriptive statistics of the variables used in the empirical model.

Variable	Mean values	Standard deviation
Proportion of adoption (%)	36.85	36.27
Education (score)	0.71	0.65
Size of holding (ha)	1.26	0.59
Chickpea duration (days)	103.96	14.80
Experience in growing chickpea (years)	29.32	10.14
Market distance (km)	12.75	3.72
Number of parcels	1.32	0.62
Yield risk (%)	45.32	14.0

Two Tobit model equations were tried in this study. It was found that the number of parcels had no influence on the probability of adoption. This may have been the case since most of the sample farmers have small holdings with just one or two parcels. The number of parcels was therefore dropped in the finally adopted model, and it showed marginal improvement in the adjusted coefficient of determination (R^2). This model has a good explanatory power judging by the percentage of adjusted R^2 (88%).

Except for a single explanatory variable, all others had expected signs, with five being significant at 5% and 1% levels, and one each at 10% and 15% levels. Chickpea duration, holding size, and village representatives had a greater influence on the probability of adoption of improved chickpea cultivars in the study area. Though market distance was positively related to adoption, its influence was insignificant. Hence, it can be inferred that the adoption of improved chickpea cultivars is neutral to market distance.

Holding size showed a negative and highly significant influence on the adoption of improved chickpea cultivars. The negative effect of farm size on adoption may be because of the limited scope for expansion in the study area. Allauddin and Tisdell (1988) in their study of Bangladesh observed that while large farms were early adopters of modern varieties, small farmers adjusted quickly and adopted as fast as the large farmers. Van der Veen (1975) suggested a possible explanation for such a phenomenon in his study on Philippine rice: small farms may farm land more intensively to meet subsistence needs, and they use relatively more low-cost family labor.

The empirical results of the model revealed that chickpea duration negatively influenced farmers' adoption of improved chickpea cultivars at 1% level of

Table 17. Maximum likelihood of Tobit model estimates on factors affecting adoption of improved chickpea varieties.

	Model 1			Model 2		
		Asymptotic			Asymptotic	
Variable	Coefficients	Standard error	t-ratio	Coefficients	Standard error	t-ratio
Constant	416.9300	33.7200	12.36**	412.9000	33.0300	12.50**
Education	3.1905	3.2350	0.99	2.6649	3.1870	0.84
Size of holding	-5.6914	2.0500	-2.78**	-4.7290	1.6360	-2.89**
Chickpea duration	-3.8332	0.3064	-12.51**	-3.8212	0.3047	-12.54**
Experience in growing chickpea	0.4450	0.2765	1.61+	0.4207	0.2760	1.52+
Market distance	0.2887	1.1190	0.26	0.5436	1.0730	0.51
Parcels	3.4208	4.3800	0.78	-	-	-
Village 1	-47.8970	10.8300	-4.24**	-45.8210	10.4700	-4.38**
Village 2	-28.8410	8.1480	-3.54**	-26.4150	7.4880	-3.53**
Village 3	-14.7510	5.6820	-2.60**	-14.5640	5.6870	-2.50*
Yield risk	0.2783	0.1856	1.50+	0.3130	0.1810	1.73++
F ratio	14.7170	1.548	9.51**	14.8020	1.5570	
Adjusted R^2	87.74	-	-	87.76	-	-

** Significant at 1% level
* Significant at 5% level
++ Significant at 10% level
+ Significant at 15% level

significance. This could be attributed mainly to the farmers' perceptions that early-maturing varieties would escape drought caused by receding soil moisture; that chickpea grain price is relatively higher early in the season; and that earliness helps the chickpea crop escape pod borer infestation. While ICCV 2 matures in about 80 to 85 days, ICCV 10 matures in about 95 days, and the local variety grown by nonadopters takes about 110 days to mature. KRIBHCO, with ODA support, plays an active extension role in disseminating improved chickpea cultivars to farmers in the tribal area. The search for chickpea cultivars has been made through chickpea breeders at ICRISAT. It must be noted that none of the varieties identified earlier was either popular in the study area or multiplied by any agency. Taking into account breeders' efforts and KRIBHCO's active role, it is highly essential to guide crop improvement strategies in the future.

Years of experience in chickpea farming — assumed to be monotonic with age – had a positive influence on probability of adoption. Thus, more experienced farmers were increasingly likely to adopt improved chickpea cultivars since they know their benefits. The coefficient of farmers' experience of growing chickpea is significant at 15% level. Higher negative dummy coefficients for villages could be attributed to the different soil types. It can therefore be said that adoption decision is influenced by many other factors, some of which are not quantifiable. The inclusion of village dummies takes care of such nonquantifiable variables.

The results further indicated that the coefficient of yield risk was positive and significant at 10% level. This implies that the adopters have a risk-taking attitude while growing improved chickpea cultivars. It is essential to reduce the level of risk aversion through better education, external contact, and other appropriate measures.

Farmers' perceptions of varietal traits and constraints

Farmers' perceptions of quality traits of chickpea are highly significant for breeders to focus their research efforts towards most preferred traits. Table 18 ranks the quality traits of chickpea for domestic consumption in selected districts of Gujarat. A four-point continuum method was used to compute the composite score for various quality traits. The most preferred trait was assigned 1, moderately preferred →2, less preferred →3 and not preferred →4. Finally, the composite score was constructed using a frequency distribution of the number of farmers in each trait. The minimum value score was assigned the first rank and so

Table 18. Ranking of chickpea quality traits in Gujarat.

	Ahmedabad		Jamnagar		Junagadh		Panchmahals		All	
Particulars	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
Size	3.65	IV	2.20	II	1.97	II	1.58	I	2.35	II
Color	2.08	II	1.65	I	1.22	I	3.37	III	2.08	I
Texture	3.45	III	3.28	III	3.02	III	4.92	V	3.67	IV
Type	1.03	I	3.63	IV	4.57	V	2.12	II	2.94	III
Seed coat	4.78	V	4.42	V	3.57	IV	5.50	VI	4.56	V
Cooking quality	6.00	VI	5.82	VI	5.07	VI	4.05	IV	5.31	VI

on. Chickpea grain color (yellow) ranked first among all the quality traits, followed by bold grain size, *desi* type, round shape, seed coat, and cooking quality. There exist spatial differences in the preferences of quality traits. For instance, in Panchmahals district, farmers ranked size and type of grain, first and second respectively, whereas farmers of Ahmedabad district ranked type of grain and color of grain first and second respectively. Yellow color, bold size, and round shape were ranked the most preferred traits in that order by farmers in Jamnagar and Junagadh districts. This analysis suggests that chickpea breeding programs need to focus attention on the most preferred quality traits with a view to satisfying consumer preferences. Recently, the Gujarat Agricultural University (GAU) released Gujarat Gram-2 variety using ICRISAT materials. It is a high-yielding, extra bold grain variety with wilt tolerance. It has a bright yellow color and is popular among the farmers of Bhal and Ghed areas.

Among the biotic and abiotic constraints identified by the sample chickpea growers (Table 19), wilt disease ranked first. It may be mentioned here that given the low resource base of the farmers, built-in wilt-resistant chickpea varieties would be ideal rather than controlling wilt through fungicidal treatment. Attempts are being made to develop wilt-resistant chickpea varieties to stabilize yield in farmers' fields. Since Gujarat Gram-2 is wilt-tolerant, it needs to be popularized. The second most important biotic constraint in chickpea is insect/pests. Though several insect species attack the crop at various stages of growth, pest attacks during the reproductive stage are of major economic importance.

In order to ensure reasonably good chickpea yield, it is essential to apply insecticide spray or dust to save the crop from insect/pest damage. Emphasis needs to be placed on the use of Integrated Pest Management (IPM), which is

Table 19. Chickpea growers' rating of biotic and abiotic constraints.

	Ahmedabad		Jamnagar		Junagadh		Panchmahals		All	
Particulars	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
Frost	3.97	IV	3.10	III	2.87	III	2.41	III	3.09	III
Drought	2.85	III	3.42	IV	3.25	IV	3.18	IV	3.18	IV
Wilt	1.15	I	1.25	I	1.65	I	2.35	II	1.60	I
Insect/pest	2.03	II	2.23	II	1.77	II	2.05	I	2.14	II

based on judicious insecticide use and biological pest control through appropriate cropping systems and the use of chickpea varieties which are either less susceptible or escape damage. Use of biocontrol agents, botanical pesticides, and cultural practices should receive high priority in the IPM program. There is a long way to go before pest damage can be reduced in farmers' fields using resistant varieties.

Frost is the third important constraint to chickpea production. Between mid-December and late January, frost may sometimes damage chickpea crop. The damage is severe if the frost coincides with early pod development. The damage can be minimized by selecting tolerant varieties. Drought, a recurrent phenomenon in the study area, is another important constraint causing yield losses. Since chickpea is grown on residual soil moisture which is often not favorable towards the end of the season, even if good plant growth is obtained, grain yield is poor. In such a situation, yield loss may be minimized by adopting early-maturing chickpea varieties like ICCV 2. More efforts are needed to develop varieties tolerant to abiotic stress like moisture deficiency at the initial and terminal stages, apart from biotic stresses in order to increase chickpea production to the desired level.

Costs and returns

It is hypothesized that chickpea producers are rational and, would therefore like any other entrepreneur, want to maximize their profit, given technology and prices of inputs and products. This section assesses the economics of chickpea production, covering local and improved cultivars. Per hectare costs and returns have been computed using the conventional framework (Table 20). It was observed that the total variable cost per hectare was higher in the case of improved chickpea cultivars compared to the local variety. The additional cost was attributed mainly to higher seed cost. The public and private seed sectors and

Table 20. Cost and returns (Rs ha^{-1}) of chickpea production.

Item	Local	ICCV 2	ICCV 10	All improved cultivars
Costs				
Male labor	491.0	354.6	421.5	382.4
Female labor	151.3	88.9	112.4	97.5
Total human labor	642.3	443.6	533.9	479.9
Bullock labor	361.5	238.4	270.9	252.5
Tractor	0.3	0.8	0	0.3
Seed	1296.8	2526.2	2002.0	2318.7
Farmyard manure	69.0	65.8	64.3	65.2
Fertilizer	207.6	53.5	243.0	131.9
Plant protection	15.4	24.3	0	14.2
Miscellaneous	32.4	9.7	6.2	8.2
Total variable cost	2625.6	3362.2	3120.1	3270.9
Returns				
Yield (kg ha^{-1})	1096.2	1470.4	1696.4	1559.8
Price (Rs kg^{-1})	10.3	12.2	11.2	11.7
Gross income	11247.3	17879.7	18965.4	18312.4
Net income	8621.8	14517.5	15845.3	15041.6

other NGOs should jointly address the issue of distributing reasonably priced seed of improved cultivars. It is clear that improved chickpea cultivars offer large yields, higher grain price, and more income benefits compared to local cultivars.

Table 21 presents unit cost reduction in chickpea production. The total cost of cultivation per hectare was Rs 5080 in the case of improved cultivars and Rs 4269 for local cultivars. On an average, a 42% increase in yield of improved cultivars relative to the local cultivars was reported. The average total cost of production per ton was Rs 3256 for improved cultivars and Rs 3881 for local cultivars. It can be inferred that the total unit cost reduction in improved cultivars was Rs 625 t^{-1} (16.10%), which was achieved via large yield gains. Thus improved cultivars are more efficient in the use of resources than local cultivars.

Gender

Gender is considered to be an important socioeconomic variable while studying the impact of any agricultural technology. Data on labor use (by gender) in chickpea production (Table 22) reveals that female labor requirement per hectare for local cultivars was 8.26 labor days, whereas it was 5.35 days for ICCV 2, and

Table 21. Unit cost reduction in chickpea production.

Particulars	Local cultivars	Improved cultivars
Total variable cost (Rs ha^{-1})	2626	3271
Total fixed cost (rental value of land, tax, depreciation, interest on capital, etc.) (Rs ha^{-1})	1643	1809
Total cost (Rs ha^{-1})	4269	5080
Chickpea output (t ha^{-1})	1.10	1.56
Change in output (%)	-	41.82
Unit cost assessments		
Unit variable cost (Rs t^{-1})	2387	2097
Unit fixed cost (Rs t^{-1})	1494	1159
Unit total cost (Rs t^{-1})	3881	3256
Unit cost reduction		
Unit variable cost reduction (Rs t^{-1})		290
Unit fixed cost reduction (Rs t^{-1})		335
Unit total cost reduction (Rs t^{-1})		625
Percentage unit cost reduction (%)		16.10

Table 22. Labor use (in labor days ha^{-1}) by gender in chickpea production in Gujarat.

	Local		ICCV 2		ICCV 10		All improved cultivars	
Operation	Male	Female	Male	Female	Male	Female	Male	Female
Land preparation	3.10	0	2.28	0	2.19	0	2.22	0
Seedbed preparation	2.02	0	1.75	0	2.08	0	1.88	0
FYM application	1.44	0.70	0.86	0.90	1.31	1.21	1.06	1.05
Sowing	2.06	1.18	1.21	0.12	1.55	0	1.34	0.04
Fertilizer application	0.30	0	0.17	0	0.34	0	0.24	0
Plant protection	0.24	0	0.28	0	0.11	0.20	0.21	0.08
Harvesting	2.57	3.16	1.53	2.24	1.93	2.60	1.68	2.38
Threshing	1.88	3.22	1.65	2.09	1.86	2.83	1.74	2.39
Total	13.61	8.26	9.73	5.35	11.37	6.84	10.37	5.94

6.84 labor days for ICCV 10. This shows that ICCV 2 and ICCV 10 reduced the burden on women in terms of additional work in the field by about 35 and 17%, respectively. This reduction originated mainly in harvesting and threshing.

Conclusions and policy implications

Growth and instability in chickpea yield, extent of adoption, on-farm benefits, factors influencing adoption of improved chickpea cultivars, and farmers' perceptions of varietal traits and constraints in Gujarat were critically evaluated in this paper. Moderate growth with low instability in chickpea yield during recent years suggests that research efforts should concentrate on enhancing yield. However, due weightage to yield instability must be given while fixing the support price of chickpea. Since sowing date is an important factor influencing chickpea yield, farmers should be educated about the optimal date of sowing. Also, farmers are unaware of seed replacement, since a majority of the sample farmers used their own farm-produced seed.

The extent of adoption of ICCV 2 and ICCV 10 was almost similar in the initial year. Subsequently, ICCV 10 was found to be an excellent replacement for the existing dominant local variety, Dahod Yellow. Though KRIBHCO's efforts in disseminating improved chickpea cultivars have been rewarding, these cultivars could be further popularized through well-organized field level demonstrations (FLDs), distribution of minikits, mass contact with farmers involving the State Department of Agriculture, SAUs, KVKs, and other NGOs. A buy-back system for seeds from FLDs may be encouraged and seed requirements for FLDs could be worked out a year in advance.

The improved chickpea cultivars showed a distinctly superior performance over the local cultivars in terms of yield, net income, and per unit cost reduction, thus proving both their profit-maximizing and cost-minimizing characters. Higher marketable surplus and price premium are the added advantages of the ICs. However, the higher seed cost of ICs suggests that seed-producing agencies could launch promotional programs to make the seeds available to farmers at a reasonable price. The creation of seed banks involving public and private sector seed companies may help meet seed shortage.

Results from the estimated Tobit model suggest that holding size, chickpea duration, and yield risk significantly determine the probability and degree of adoption. Hence, these need to be the focus areas of the future in order to achieve greater adoption of improved cultivars. Considering breeders' efforts and

KRIBHCO's active role in disseminating improved chickpea cultivars, it is highly essential to guide future crop management strategies.

Yellow color, bold size, *desi* type, and round shape were found to be the most preferred quality traits of chickpea in Gujarat. Chickpea researchers should incorporate these features in the future to satisfy consumer demand. While wilt and insect/pests were the major biotic constraints causing yield loss in chickpea, frost and drought were the abiotic constraints limiting chickpea yield. The need to develop an efficient and cost-effective IPM program cannot be overemphasized.

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Appendices

Appendix A. List of selected villages and blocks.

District	Blocks	Villages
Ahmedabad	Dholaka	Arnej, Jawaraj, Kesargadh
	Dhandhuka	Fedra, Khadol, Khasta
Jamnagar	Jam Khambhaliya	Harsharpur, Kolra, Sutaria
	Lalpur	Gajena, Haripur, Lalpur
Junagadh	Keshod	Bava – Simarali, Kevadra, Sondarada
	Porbandar	Chikasa, Garej, Navagam
Panchmahals	Dahod	Himala, Rachharada, Timbarada
	Godhra	Bhatha, Khatva, Metral

Appendix B. The independent variables considered in the Tobit analysis.

Variables	Hypothesized sign
Education (1–5 score)	+
Size of holding (acres)	+/–
Chickpea duration (days)	–
Farmer's experience in growing chickpea (years)	+
Market distance (km)	–
Number of parcels	–
Village dummies (binary)	+/–
Yield risk (CV %)	+

List of publications in this series

Bantilan, M.C.S., and Joshi, P.K. 1996. Returns to research and diffusion investments on wilt resistance in pigeonpea. (In En. Summaries in En, Fr.) Impact Series no.1. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 36 pp. ISBN 92-9066-356-1. Order code ISE 001.

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