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RESEARCH NOTES

Adoption of Improved Chickpea Varieties: Evidences from Tribal Region of Gujarat

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INTRODUCTION

A comprehensive understanding of the farmers' behaviour on adoption of improved varieties in diverse agro-ecological and socio-economic environments, though complex, is necessary to design appropriate strategies to harness their potential benefits in target domains. Lack of adequate information on farmers' perception about new varieties often placed them in wrong target regions where they either failed or met with partial success. This paper examines the factors influencing adoption of recently developed improved chickpea varieties in few remote and backward tribal villages of Gujarat State in India.

India is a leading producer of chickpea in the world accounting for about 68 per cent of the total production. Gujarat, one of the states in the western part of India, harvested nearly 99 thousand tonnes of chickpea from about 123 thousand hectares (ha) in 1998 (Government of Gujarat, 1998). Nearly one-third of chickpea production in Gujarat State is contributed by Panchmahals district alone. Although chickpea area in the state has increased from 70 thousand ha in 1980 to 123 thousand ha in 1998, the yield levels remained stagnant around 800 kg/ha. Similar trends were noted in Panchmahals district, where chickpea area expanded from 20 thousand ha in 1980 to 39 thousand ha in 1998, yields vacillated around 800 kg/ha. The stagnating yields of chickpea called for alleviating production constraints by introducing improved chickpea varieties and management techniques in the chickpea growing regions. Although a large number of improved varieties are developed and released for cultivation (Sethi and van Rheenen, 1994), no sincere efforts were initiated to

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disseminate them on the farmers' fields. Private and public seed sectors do not have much incentive to multiply seeds of chickpea, which is considered to be a 'high-volume and low-profit' seed production activity. This is more true particularly in remote tribal areas due to larger market distance and general perception of the tribal farmers for the non-adoption of improved varieties.

The Krishak Bharati Co-operative Limited (KRIBHCO)[1] took the initiative to disseminate improved chickpea varieties in a few tribal areas including Panchmahals district of Gujarat. Using the Farmers' Participatory Varietal Selection,[2] KRIBHCO discovered that identification of improved varieties having farmers' preferred traits and their procurement will be the most effective approach to improve the livelihood of tribal farmers. To identify suitable improved varieties for the region, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)[3] was associated.

Five phenotypically diverse chickpea varieties were identified and introduced in 1992 in six tribal villages adopted by the KRIBHCO. These varieties were ICCV 1, ICCV 2, ICCV 10, ICCC 37 and ICCV 88202. These varieties were developed at the ICRISAT and released in different regions for cultivation. The performance and traits of these varieties were compared with the local varieties by the tribal farmers in their fields. In the process, ICCV 2 and ICCV 10 were rated high by the majority of the farmers, ICCV 88202 was moderately rated by limited number of farmers, while other varieties were rated low for their larger adoption in the study area. The results of an earlier survey in different target domain confirmed that majority of the sample farmers had resown ICCV 2 and ICCV 10 varieties who first adopted them in 1993-94 season (Joshi and Witcombe, 1996). The present study aims to confirm whether adoption trends of ICCV 2 and ICCV 10, which were rated higher, continued in the six tribal villages, where these varieties were introduced for wider adoption, or the farmers reverted to their traditional varieties.

More specifically, the present study has three objectives: (i) to assess adoption pattern of improved chickpea varieties in the target area, (ii) to evaluate on-farm benefits of improved chickpea varieties, and (iii) to identify factors influencing adoption of improved chickpea varieties.

METHODOLOGY

Sampling Framework

The data for this study came from 96 farmers selected from Limkhera block of Panchmahals district in Gujarat. This block was purposively selected because improved chickpea varieties were introduced in this tribal dominated block by KRIBHCO. Four villages were randomly selected from the selected block. To select farmers in each village, a list of chickpea growers was prepared with information about their adoption of improved varieties. In each village, the list was divided into two strata: (i) adopters of improved varieties, and (ii) non-adopters of improved varieties. From each stratum, 12 farmers were randomly selected. The data were collected from the selected farmers on farmers' characteristics, size of land holding,

soil types, cropping pattern, irrigation facilities, adoption of improved chickpea varieties, input use and output attained, marketable surplus and home consumption of chickpea, etc. The data were collected in a pre-tested questionnaire by survey method for the year 1995-96 crop season.

Analytical Technique

Many socio-economic and demographic features of farm households, and important traits of improved varieties affect the adoption decisions of improved varieties. To study the adoption behaviour, limited dependent variable model provides a good framework, and for that Probit, Tobit and Logit models are found appropriate and used. In the present study, Tobit model (Tobin,1958) is used. The advantage of this model is that it not only measures the probability of adoption of improved variety but also takes care of the intensity of its adoption (Adesina and Zinnah, 1993). The functional form of the Tobit model is given below:

$$Y_i = X_i b \quad \text{if } i^* = X_i b + u_i > T$$
$$\text{or} \quad Y_i = 0 \quad \text{if } i^* = X_i b + u_i < T \qquad \ldots (1)$$

where Y_i is the probability of adopting and extent of adoption of improved chickpea varieties; i* is a non-observable latent variable; b is a k x 1 vector of parameters to be estimated; and u_i is an independently normally distributed error term with zero mean and constant variance δ^2. The above equation is a simultaneous and stochastic decision model. If the non-observed latent variable i* is greater than T, then observed variable y_i that indexes adoption becomes a continuous function of the explanatory variables, and zero otherwise (i.e., non-adoption of improved varieties). The maximum likelihood approach is used to estimate the coefficients in equation (1).

Variables in the Model

The theoretical model discussed above suggests many important hypotheses related to the adoption of improved chickpea varieties vis-à-vis economic, physical and agro-ecological characteristics. The model is derived from the equation, which was developed using the farm and farmer-specific attributes, and the farmers' perception on technology specific characteristics. The model assumes that the dependent variable which is defined as proportion of area under improved chickpea varieties in the total chickpea area depends on the following explanatory variables: size of land holding, education level of the farmer, farmer's experience of growing chickpea, length of chickpea growing period, market distance, yield risk and village features representing agro-ecological characteristics.

A list of all independent variables used in the Tobit model along with their units and hypothesised signs is given in the Appendix. On the relationship between size of

land holding and adoption of improved technologies, there are two schools of thought. One argues that the variable has a positive influence on adoption of the technologies as large farmers generate more income which provides a better capital base and enhances risk bearing ability (Asaduzzaman,1979 and Sarap and Vashist, 1994). Another argument advocates that small farmers utilise the limited resources more efficiently and adopt new technologies at a faster rate (Barker and Herdt, 1978; Ahmed, 1981; Allauddin and Tisdell, 1988). In the present study, the latter argument is hypothesised.

The level of education of the farmer is measured as zero for illiterate, 1 for primary schooling, 2 for high school education, 3 for secondary education, 4 for the graduate, and 5 for the post-graduate. The level of farmers' education is hypothesised to be positively related with the adoption of improved varieties as it provides an opportunity to the individual to acquire knowledge about new varieties. Adesina and Seidi (1995) found positive relationship between education and the adoption of modern mangrove rice varieties in Guinea Bissau. Similarly, Kebede *et al.* (1990) found positive effect of education on the adoption of new technologies in Ethiopian agriculture. Similarly, farmer's experience of growing chickpea is expected to be related to his ability to obtain, process and use information relevant to its cultivation. Therefore, a positive relationship between this variable and the probability of adoption of improved varieties is hypothesised. Adesina and Seidi (1995) and Adesina and Forson (1995) also confirmed that experience was positively related with the adoption of new technologies.

Early maturing varieties of chickpea are given high preference by the farmers because these escape drought caused due to receding soil moisture and also escape pod-borer infection (Joshi and Witcombe, 1996). Therefore, it is hypothesised that longer the duration of chickpea varieties, the lower will be the adoption.

Distance to the product market is measured in kilometres. This is an important variable particularly in the study area where the tribal farmers do not have easy access to markets. Therefore, market distance is hypothesised to be negatively related to the adoption of improved varieties, i.e., nearer the output market, higher the adoption. Similarly, risk also influences the adoption pattern of improved technologies. However, empirical studies have rarely included this factor due to its measurement difficulty. O'Mara (1980) and Binswanger *et al.* (1980) proposed a measure of farmers' risk aversion through direct interviews. Following the same approach, the yield risk is measured as coefficient of variation of the chickpea yields in normal, bad and good years. Farmers were personally interviewed to provide data regarding chickpea yields obtained during normal, bad and good years. It is hypothesised that in case the yield risk from a variety is high, it will be substituted by another variety which has a probability of low risk.

To understand the role of spatial characteristics like soil type, cropping pattern, rainfall, etc., in the adoption of improved varieties, village dummies were used. The

village dummies were used as binary variables, i.e., 1 for representing village and zero otherwise.

RESULTS AND DISCUSSION

Characteristics of Sample Farmers

Table 1 presents the important features of the sample farmers. Chickpea is one of the most important winter crops which was grown in more than 40 and 50 per cent of the total cropped area by the adopters and non-adopters of the improved varieties, respectively. A majority of the farmers who adopted improved varieties do not grow chickpea continuously in the same plot. There is a general tendency of rotating chickpea cultivation over time in different plots to enhance soil fertility and increase productivity of subsequent rainy season crop. However, only about 19 per cent of the non-adopters have grown chickpea continuously in the same plots. A majority of the sample farmers (95 per cent) follow maize-chickpea rotation, while only 5 per cent cultivate rice-chickpea rotation.

TABLE 1. CHARACTERISTICS OF SAMPLE FARMERS IN THE STUDY AREA, PANCHMAHALS DISTRICT

Characteristics (1)	ICCV 2 (2)	ICCV 10 (3)	Non-adopters (4)
Size of land holding (ha)	1.25	1.22	1.28
Total operated area (ha)	1.08	1.19	1.18
Chickpea area (per cent)	42.40	40.33	50.16
Land parcels (Nos.)	1.34	1.37	1.30
Experience of growing chickpea (years)	28	36	28
Chickpea rotation in same plot (per cent farmers)	3.50	0.00	18.75
Crop rotation (per cent farmers)			
Maize-chickpea	93.00	95.00	96.00
Rice-chickpea	0.00	5.00	4.00

Source: Survey on Chickpea in Gujarat, 1996.

Adoption of Improved Varieties

Figure 1 presents the extent of adoption of improved varieties in the study area. The figure shows that the extent of adoption of ICCV 2 and ICCV 10 was almost the same (20 per cent) during 1994. In the subsequent years, their adoption increased significantly by substituting the most popular local variety (viz., Dahod Yellow). The adoption rate of ICCV 10 was faster than ICCV 2. The area under ICCV 10 reached to about 79 per cent of the total chickpea area of the sample farmers in 1996. The corresponding adoption of ICCV 2 in 1996 was about 71 percent of the total chickpea area. Expansion in area under improved varieties is an indication that these are preferred by the tribal farmers in comparison to the local variety.

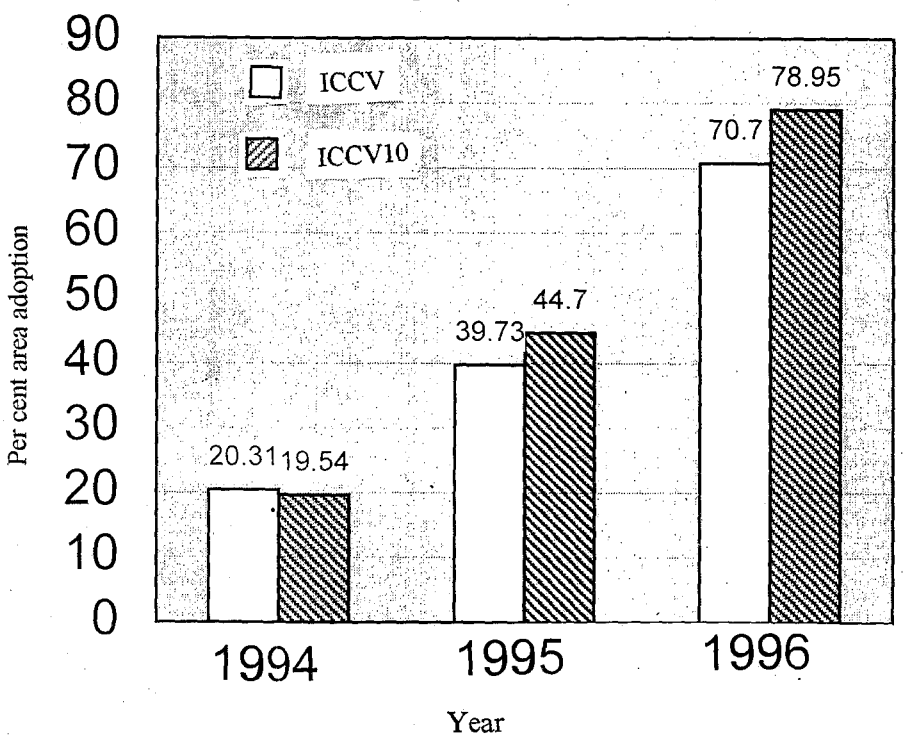

Figure 1. Extent of Adoption of Chickpea Cultivars in Panchmahals District of Gujarat

Table 2 presents the frequency distribution on the extent of adoption of improved chickpea varieties by the sample farmers in the study area. It is noted that about 60 per cent of the farmers adopting ICCV 2 and ICCV 10 have sown these varieties in about 20 per cent of the chickpea area in 1994. There was conspicuous increase in

adoption of these varieties in subsequent years. In 1996, about 90 per cent of the farmers who cultivated ICCV 10 variety expanded its area to more than 60 per cent. In 1994, only 10 per cent of the farmers had grown ICCV 10 in more than 60 per cent of the chickpea area. Similarly, 62 per cent of the ICCV 2 adopters had sown it in more than 60 per cent of the chickpea area. This overwhelming success was as a result of the critical role played by KRIBHCO in disseminating the improved chickpea varieties in the tribal regions of Gujarat.

TABLE 2. FREQUENCY DISTRIBUTION ON EXTENT OF ADOPTION OF IMPROVED CHICKPEA VARIETIES IN STUDY AREA, PANCHMAHALS DISTRICT

	Distribution of sample farmers (per cent)					
Adoption range (per cent)	Adopters of ICCV 2			Adopters of ICCV 10		
	1994	1995	1996	1994	1995	1996
(1)	(2)	(3)	(4)	(5)	(6)	(7
Upto 20	58.62	17.25	0.00	63.15	5.25	0.00
20-40	34.50	34.50	6.90	31.60	31.60	5.30
40-60	6.90	37.90	31.00	2.60	52.60	5.30
60-80	0.00	10.35	51.70	10.50	10.50	42.10
80 and above	0.00	0.00	10.35	0.00	0.00	47.40

Source: Survey on Chickpea in Gujarat, 1996.

Benefits of Improved Varieties

The on-farm benefits of improved chickpea varieties were assessed and the results are given in Table 3. It was observed that ICCV 2 and ICCV 10 provided considerable yield gains over the local chickpea variety. It was much higher for ICCV 10 (55 per cent) than ICCV 2 (34 per cent). Higher yields of improved varieties resulted in declining per unit cost of production and in increasing profitability levels.The net returns for ICCV 10 were 84 per cent higher than the local varieties. The corresponding figure for ICCV 2 was 68 per cent. Higher profitability seems to be the most important reason for rapid adoption of ICCV 10. The unit cost of production due to ICCV 10 over local variety declined by 23 per cent (Rs.560/ tonne). The corresponding figure for ICCV 2 was about 5 per cent (Rs. 110/tonne).

TABLE 3. ON-FARM BENEFITS OF IMPROVED CHICKPEA VARIETIES

Benefit indicator (1)	ICCV 2 (2)	ICCV 10 (3)	Dahod Yellow (4)
Yield level (kg/ha)	1470	1700	1096
Grain price (Rs./kg)	12.16	11.18	10.26
Gross returns (Rs./ha)	17,875	18,960	11,245
Cost of cultivation (Rs./ha)	3360	3120	2,625
Net income (Rs./ha)	14,515	15,840	8,620
Cost of production (Rs./ton)	2,290	1,840	2,400
Labour productivity (kg/day)	75.80	88.40	43.50
Marketable surplus (kg/farm)	472	176	19.00

Source: Survey on Chickpea in Gujarat, 1996.

Another benefit which emanates due to adoption of improved chickpea varieties was higher labour productivity. The average labour productivity was found maximum for ICCV 10 (88.4 kg/day), followed by ICCV 2 (75.8 kg/day) and local variety (43.5 kg/day). Generating additional marketable surplus due to cultivation of improved varieties was yet another significant benefit. Table 3 shows that the marketable surplus of those who adopted ICCV 2 was the highest (61 per cent), followed by ICCV 10 (21 per cent). The marketable surplus was very low (3 per cent) for those who cultivated local varieties. Higher marketable surplus of ICCV 2 was due to its *kabuli trait* which is less preferred for consumption by the tribal farmers. Therefore, the farmers sold maximum quantity of this variety in the market to earn more profit, and to meet the family consumption, the locally preferred variety is purchased at a lower price.

Minimisation of yield risk has also emerged as an important benefit of improved varieties. Table 4 presents the frequency distribution of farmers and the coefficient of variation in yield of improved and local varieties. About 44 per cent of those who adopted improved chickpea varieties have observed less than 40 per cent coefficient of variation in yield, whereas only 10 per cent of the non-adopters have this coefficient of variation in yield. It is observed that about 90 per cent of the farmers cultivating local varieties faced more than 40 per cent yield risk. This shows that improved varieties minimised yield risk, and indicated the potential for insurance coverage under adverse climatic situation.

TABLE 4. FREQUENCY DISTRIBUTION OF SAMPLE FARMERS AND COEFFICIENT OF VARIATION IN CHICKPEA YIELDS

Coefficient of variation in chickpea yield (per cent)	Distribution of sample farmers (per cent)	
	Adopters of improved varieties	Adopters of local local (Dahod Yellow) variety
(1)	(2)	(3)
Upto 20	16.70	0.00
20-40	27.10	10.40
40 and above	56.20	89.60

Source: Survey on Chickpea in Gujarat, 1996.

Factors Influencing Adoption

An attempt was made to study the factors influencing adoption of improved chickpea varieties. It is obvious that farmers' critically compare the characteristics of new varieties with those of prevailing varieties. The process of adoption begins with farmers experimenting with new varieties.The decision in favour of a new variety is expected if its performance is viewed superior over the local varieties. While technology specific traits are important, farmers' own traits, resource endowments, and market facilities equally influence the adoption of new technologies. To identify the factors which determine adoption of new chickpea varieties in the tribal villages, Tobit model with a number of explanatory variables was estimated. The description of the variables is given in Table 5, and the maximum likelihood estimates of the Tobit model are presented in Table 6. It may be noted that the estimated model has strong explanatory power, as the included variables explained about 88 per cent of the variation in the adoption decision of improved chickpea varieties.

TABLE 5. DESCRIPTION OF THE VARIABLES USED IN ESTIMATING TOBIT MODEL

Variable	Average value	Standard deviation
(1)	(2)	(3)
Adoption of improved varieties (per cent)	36.85	36.27
Size of land holding (ha)	1.26	0.59
Education level (score)	0.71	0.65
Experience of chickpea growing (years)	29.30	10.14
Crop maturity duration (days)	104.00	14.80
Yield risk (per cent)	45.32	14.00
Market distance (km)	12.75	3.72

Source: Survey on Chickpea in Gujarat, 1996.

TABLE 6. MAXIMUM LIKELIHOOD ESTIMATES OF TOBIT MODEL EXPLAINING FACTORS AFFECTING ADOPTION OF IMPROVED VARIETIES

Variable (1)	Coefficient (2)	Standard error (3)	t-statistics (4)
Constant	412.900	33.030	12.50**
Size of land holding	-4.729	1.636	-2.89**
Education level	2.665	3.187	0.84
Experience of chickpea growing	0.421	0.276	1.52†
Crop maturity duration	-3.821	0.304	12.54**
Yield risk	0.313	0.181	1.73‡
Market distance	0.543	1.073	0.51
Village 1	-45.820	10.470	-4.38**
Village 2	-26.415	7.490	-3.53**
Village 3	-14.565	5.687	-2.56**
F statistics	14.802	1.557	9.51**
Adjusted R^2	87.76	-	-

Source: Based on the Survey on Chickpea in Gujarat, 1996.
**, ‡ and † Significant at 1, 10 and 15 per cent level respectively.

The results showed that all the explanatory variables, except market distance and level of education, were significant and have the expected signs. Among variety traits, time taken to mature was found the most important determinant influencing adoption of new chickpea varieties. The variable was found significant at 1 per cent probability level with negative sign. It means that the adoption of a new variety is expected to be higher if time taken for its maturity is, *ceteris paribus*, shorter than the prevailing varieties. Such a trend is obvious because early maturing varieties escape terminal drought caused due to receding soil moisture and pod-borer infestation. It may be mentioned that ICCV 2 and ICCV 10 chickpea varieties preferred by the farmers in the study area mature earlier than the existing local variety.[4]

The size of land holding was found to be negatively related with the adoption of new chickpea varieties, and its coefficient was significant at 1 per cent probability level. The results verify the hypothesis that small farmers in comparison to large farmers replace local varieties with new varieties at a faster rate if additional gains are substantial. In the tribal villages, such a pattern was visible on two counts: (i) small farmers live at subsistence level that attracts them to adopt new varieties, which yields better than local variety, *ceteris paribus*, and (ii) limited availability of improved seed compelled large farmers to partly continue with the local varieties, resulting in slow pace of adoption of new varieties. The results support the earlier findings of Allauddin and Tisdell (1988) that small farmers adjust quickly and adopt new inventions at a faster rate than large farmers. It may be mentioned that seeds of improved varieties in the tribal villages were initially distributed by the KRIBHCO project, and there is no formal organised seed agency to supply new seeds. Later, the sources of improved seeds for the next season were (i) own seed stored from previous harvest, and (ii) farmer-to-farmer seed distribution. The results call for multiplying

and supplying seeds of improved varieties to meet the demand in remote and backward tribal areas which lack an organised seed sector.

The variable representing distance to output market was not found significant. This variable was expected to have strong influence on adoption of improved varieties but due to assured output marketing facility within the village through the KRIBHCO it was not found significant. It is worth mentioning that market prospects of improved varieties certainly influence their adoption decision.

Experience of growing chickpea was significant with positive sign. This indicates that more the experience of growing chickpea, higher the adoption of new varieties, *ceteris paribus*. Such a pattern is expected because more experienced farmers may have better skills and access to new information about improved technologies through extension services. Though education plays a significant role in the adoption decision, this variable was not found significant in this study since a majority of the sample farmers were either illiterate or had education upto primary schooling.

The coefficient of yield risk was positive and significant at 10 per cent probability level. This suggests that chickpea growers who were observing high yield variability between good, bad and average crop years, were early adopters of improved varieties with the expectation that these would minimise the variability in yield. The results also suggest that the non-adopters happened to be more risk averters whereas risk taking attitude of the adopters facilitated adoption of improved varieties in the study area.

Villages dummies were significant, suggesting that the adoption decision is influenced by soil type, rainfall pattern and elevation, etc. Therefore, these must be given due importance while delineating target domains for introducing improved varieties.

CONCLUSIONS

The paper has made an attempt to study the extent of adoption of two newly introduced chickpea varieties (ICCV 2 and ICCV 10) and also to assess the on-farm benefits of improved varieties, as well as to identify the factors influencing their adoption in the tribal villages of Panchmahals district of Gujarat. The improved chickpea varieties were launched by KRIBHCO in association with ICRISAT to disseminate the benefits of improved varieties in remote and backward tribal villages.

The results revealed that the adoption of newly introduced chickpea varieties was quite impressive. Their area was gradually increasing in the study region by replacing the prominent local variety, namely, Dahod Yellow. The important factors which influenced the adoption of improved varieties included duration of crop, farm size, yield risk, and experience of growing chickpea crop. There was substantial increase in yield levels, income and labour productivity of these varieties in comparison to the local variety. Other benefits of improved varieties in comparison to local variety

included higher marketable surplus, price premium on grain, and lower unit cost of production.

The results suggested that the short duration of improved varieties is one of the preferred traits by the farmers to protect the crop from terminal drought and pod-borer infestation. Another important characteristic of the variety which hastens the adoption process is related with yield stability under fluctuating climatic conditions. These observations call for breeding short duration varieties with stable yield levels under varying weather conditions, and introducing them in areas where there is moisture stress problem during maturity of chickpea, and risk of crop damage due to high probability of pest infestation and climatic variations. The improved varieties with stable yields and pest resistant characteristics will act as a crop insurance to the farmers who are poor and deprived of insurance coverage.

Availability of seeds of new varieties is also a major constraint particularly in areas where the seed sector does not exist. To overcome this problem, KRIBHCO project has played a key role in disseminating improved varieties in the region. The participatory approach of understanding the farmers' needs about different variety traits and identifying specific varieties have indeed played a commendable role for wider acceptance and in accelerating the adoption of improved chickpea varieties. However, large farmers still faced shortage of seeds of improved chickpea varieties. Tribal farmers also faced the problem of selling their produce in the absence of KRIBHCO. To overcome these problems, KRIBHCO has planned to take up commercial seed production to ensure availability of good quality seeds of improved varieties at right time in adequate quantity, and initiate formation of farmers' co-operatives for marketing of output. It is expected that the adoption rate of improved varieties would be much faster if such mechanisms are institutionalised.

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APPENDIX

LIST OF INDEPENDENT VARIABLES USED IN TOBIT MODEL ALONG WITH THEIR UNITS AND HYPOTHESISED SIGN

Variable (1)	Hypothesised sign (2)
Size of land holding (ha)	+/-
Education level (score)	+
Experience of growing chickpea (years)	+
Duration of crop maturity (days)	-
Yield risk of local variety (per cent)	+
Market distance (km)	-
Village dummies (binary)	+/-

NOTES

1. KRIBHCO, basically a farmers' co-operative on fertilisers, is also actively associated with the British Overseas Development Administration (ODA) to promote participatory natural resources development in the predominantly poor tribal districts of western part of India since 1993.

2.The Farmers' Participatory Varietal Selection is to associate farmers in selecting varieties based on their preferred traits for developing modus operandi for seed multiplication and dissemination.

3.Chickpea is one of the mandate crops of ICRISAT. Research on chickpea includes development of improved varieties, management techniques, resistance parental material, and screening techniques.

4. ICCV 2 matures in 80-85 days, while ICCV 10 in 95 days and local Dahod Yellow in 110 days.

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