ELSEVIER

Agricultural Economics 27 (2002) 33–39

AGRICULTURAL ECONOMICS

www.elsevier.com/locate/agecon

Adoption of improved chickpea varieties: KRIBHCO experience in tribal region of Gujarat, India

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Received 4 April 1998; received in revised form 14 December 2000; accepted 1 January 2001

Abstract

The study aims to track adoption of improved chickpea varieties, and assess their on-farm benefits in some remote and backward tribal villages in Gujarat, India, where few newly developed varieties were introduced by a non-government organization. It also determines key factors which were influencing their adoption. The study found that adoption of improved chickpea varieties was gradually increasing by replacing a prominent local variety. Duration of crop maturity, farm size, yield risk, and farmers' experience of growing chickpea crop were significantly influencing their adoption. The on-farm benefits as a result of improved varieties were realized in terms of increased yield levels, higher income and labor productivity, more marketable surplus, price premium and stabilized yields in fluctuating weather. Breeding short duration varieties with stable yield levels under varying weather, and organizing seed multiplication and dissemination in regions, where moisture stress is a problem during maturity of chickpea, are the major suggestions.

Keywords: Adoption; Chickpea; Varieties; Yield

1. Introduction

Appropriate strategies to harness potential benefits of improved varieties in diverse agro-ecological and socio-economic environments are essential. 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 improved chickpea varieties in few remote and backward tribal villages of Gujarat state in India. Though India is a leading producer of chickpea in the world accounting for about 68% of the total production, the yield levels remained stagnant around 800 kg/ha. Similar trend was noted in tribal region of Gujarat (Panchmahals district), where chickpea area expanded from 20,000 in 1980 to 46,000 ha in 1999, yields vacillated around 860 kg/ha (Government of Gujarat, 1999). Although a large number of improved varieties are developed and released for cultivation (Sethi and van Rheenen, 1994), no sincere efforts were initiated to disseminate them on farmers' fields either by private or public seed sectors. A lead was taken by the Krishak Bharati Cooperative Limited (KRIBHCO) [1] to disseminate improved chickpea

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[1] KRIBHCO is basically farmers' cooperative on fertilizers 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.

0169-5150/02/$ – see front matter
PII: S0169-5150(01)00057-3

varieties in 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, namely, ICCV 1, ICCV 2, ICCV 10, ICCC 37 and ICCV 88202 were identified and introduced in 1992 in six tribal villages adopted by the KRIBHCO. In the process, ICCV 2 and ICCV 10 were rated high by the farmers, and found promising for adoption. 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 1993–1994 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 examine adoption extent 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.

2. Methodology

2.1. Sampling framework

Data for this study came from 96 farmers selected from Limkheda block of Panchmahals districts in Gujarat. This block was purposively selected, because improved chickpea varieties were introduced in this tribal dominated block by the KRIBHCO. Four villages were randomly selected from Limkheda block. In each village, the list of chickpea growers 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 in a pre-tested questionnaire by survey method for the year 1995–1996 crop season.

2.2. Analytical technique

To study the adoption behavior, 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.

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

or

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

where Y_i is the probability of adopting and extent of adoption of improved chickpea varieties, i^* a non-observable latent variable, b a $k \times 1$ vector of parameters to be estimated and u_i 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 Eq. (1).

2.3. 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 farmers' perception on technology specific characteristics. The model assumes that the dependent variable which is

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[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.

Table 1
List of independent variables used in Tobit model along with their units and hypothesized sign

Variable	Unit	Hypothesized sign
Size of land holding	Hectare	±
Education level	Score	+
Experience of growing chickpea	Years	+
Duration of crop maturity	Days	−
Yield risk of local variety	Percent	+
Market distance	Kilometer	−
Village dummies	Binary	±

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 hypothesized signs is given in Table 1. On relationship between size of land holding and adoption of improved technologies, there are two school of thoughts. 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; Sarap and Vashist, 1994). Another argument advocates that small farmers utilize 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 later argument is hypothesized.

The level of education of the farmer is measured as 0 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 hypothesized to be positively related with the adoption of improved varieties as it provides an opportunity to 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, farmers' experience of growing chickpea is expected to be related to the ability of the farmer 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 hypothesized. 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 hypothesized that longer the duration of chickpea varieties, lower will be the adoption.

Distance to the product market is measured in kilometers. This is an important variable particularly in the study area where tribal farmers do not have easy access to markets. Therefore, market distance is hypothesized 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 interview. 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 personality interviewed to provide chickpea yields obtained during normal, bad and good years. It is hypothesized that in case the yield risk from a variety is high, it will be substituted by another variety which has probability of low risk.

To understand the role of spatial characteristics like soil type, cropping pattern, rainfall, etc. in adoption of improved varieties, village dummies were used. The village dummies were used as binary variable, i.e. 1 for representing village and 0 otherwise.

3. Results and discussion

Chickpea is one of the most important winter crops which was grown in more than 40 and 50% of the total cropped area by the adopters and non-adopters of the improved varieties, respectively.

Table 2
Frequency distribution on the extent of adoption of improved chickpea varieties in study area, Panchmahals district[a]

Adoption range (%)	Sample farmers (%)					
	Adopters of ICCV 2			Adopter of ICCV 10		
	1994	1995	1996	1994	1995	1996
Up to 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	52.60	52.60	5.30
60–80	0.00	10.35	51.70	10.50	10.50	42.10
Above 80	0.00	0.00	10.35	0.00	0.00	47.40

[a] Survey on chickpea in Gujarat.

3.1. Adoption of improved varieties

It is observed that about 60% of the farmers adopting ICCV 2 and ICCV 10 were sowing these varieties in about 20% of the chickpea area in 1994 (Table 2). A conspicuous increase in the adoption of these varieties was noticed in subsequent years. About 90% farmers growing ICCV 10 variety expanded its area to more than 60% in 1996. Similarly, 62% of the ICCV 2 adopters sown it in more than 60% of the chickpea area in the same year. It is worth mentioning that KRIBHCO played an important role in disseminating the improved chickpea varieties in the tribal region of Gujarat.

3.2. Benefits of improved varieties

The results of on-farm benefits of improved chickpea varieties revealed that ICCV 2 and ICCV 10 provided considerable yield gains over the local chickpea variety (Table 3). It was much higher for ICCV 10 (55%) than ICCV 2 (34%). Higher yields of these chickpea varieties resulted in declining unit cost of production and increasing profitability. The net returns for ICCV 10 and ICCV 2 were 84 and 68% higher than the local varieties, respectively. The unit cost of production due to ICCV 10 over local variety declined by 23% (rupees 560 per tonne). The corresponding figure for ICCV 2 was about 5% (rupees 110 per tonne). Higher labor productivity was another benefit emanated due to adoption of improved chickpea varieties. The average labor productivity was found maximum for ICCV 10 (88.4 kg per day), followed by ICCV 2 (75.8 kg per day) and local variety (43.5 kg per day). Table 3 also showed that the marketable surplus of those who adopted ICCV 2 was the highest (61%), followed by ICCV 10 (21%). The marketable surplus was very low (3%) 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, farmers sold maximum quantity of this

Table 3
On-farm benefits of improved chickpea varieties[a]

Benefit indicator	Unit	ICCV 2	ICCV 10	Dahod Yellow
Yield level	Kilogram/hectare	1470	1700	1096
Grain price	Rupee/kilogram	12.16	11.18	10.26
Gross returns	Rupee/hectare	17875	18960	11245
Cost of cultivation	Rupee/hectare	3360	3120	2625
Net income	Rupee/hectare	14515	15840	8620
Cost of production	Rupee/tonne	2290	1840	2400
Labor productivity	Kilogram per day	75.80	88.40	43.50
Marketable surplus	Kilogram per farm	472	176	19.00

[a] Survey on chickpea in Gujarat.

Table 4
Frequency distribution of coefficient of variation in chickpea yields (% of sample farmers)[a]

Coefficient of variation in chickpea yield (%)	Adopter of improved varieties	Adopter of local (Dahod Yellow) variety
Up to 20	16.70	0.00
20–40	27.10	10.40
Above 40	56.20	89.60

[a] Survey on chickpea in Gujarat.

variety in the market to earn more profit, and to meet their consumption, the locally preferred variety is purchased at a lower price.

Table 4 presents the frequency distribution of farmers and the coefficient of variation in yield, i.e. yield risk of improved and local varieties. About 44% of those adopted improved chickpea varieties have observed less than 40% coefficient of variation in yield, whereas only 10% of the non-adopters have this coefficient of variation in yield. It is observed that about 90% of the farmers cultivating local varieties faced more than 40% yield risk. This shows that improved varieties are minimizing yield risk, and showing potential for insurance coverage under adverse climatic situation.

3.3. Factor influencing adoption

This section intends to determine 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 favor of 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 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 87.86% variation in the adoption decision of improved chickpea varieties.

Table 5
Description of the variables used in estimating Tobit model[a]

Variable	Unit	Average value	S.D.
Adoption of improved varieties	Percent	36.85	36.27
Size of land holding	Hectare	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	Percent	45.32	14.00
Market distance	Kilometer	12.75	3.72

[a] Survey on chickpea in Gujarat.

The results showed that all explanatory variables, except market distance and level of education, were significant and have expected signs. Among variety traits, time duration to mature the variety was found the most important determinant influencing adoption of new chickpea varieties. The variable was found significant at 1% probability level with negative sign. It means that adoption of new variety is expected to be higher if time taken for its maturity will be shorter than the prevailing varieties, ceteris paribus. 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

Table 6
Maximum likelihood estimates of Tobit model explaining factors affecting adoption of improved varieties[a]

Variable	Coefficient	S.E.	T-statistics
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	–	–

[a] Based on the survey on chickpea in Gujarat.
** Significant at 1% probability level.
++ Significant at 10% probability level.
+ Significant at 15% probability level.

ICCV 2 and ICCV 10 chickpea varieties preferred by the farmers in the study area mature earlier than the existing local variety.[4]

The coefficient of size of land holding was found to be negatively related with the adoption of new chickpea varieties, and was significant at 1% 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, and lagged behind in 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 organized seed agency to supply new seeds. Later, the sources of improved seeds for 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 organized seed sector.

The variable representing distance to output market was not found significant. This variable was expected to have strong influence on the adoption of improved varieties but due to assured output marketing facility within the village through the KRIBHCO, it was not found significant. It will be worth mentioning that market prospects of improved varieties certainly influence their adoption decision. Though education plays a significant role in the adoption decision, this variable was not found significant in adoption decision of new varieties. 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. The coefficient of yield risk was positive and significant at 10% probability level. This suggests that chickpea growers who were observing high yield variability between good, bad and average crop years, were the early adopters of improved varieties with the expectation that these would minimize the variability in yield. The results also suggest that the non-adopters were more risk averters, whereas risk taking attitude of the adopters facilitated adoption of improved varieties in the study area. Villages dummies were significant which suggests that 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.

4. Conclusions

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

The results revealed that adoption of improved chickpea varieties was quite impressive. Their area was gradually increasing in the study area by prominent local variety, namely, Dahod Yellow. Important factors which influenced 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 labor productivity of these varieties in comparison to the local variety. Other benefits of improved varieties in comparison to local variety were higher marketable surplus, price premium on grain, and lower unit cost of production. Short duration of improved varieties is one of the preferred traits by the farmers to escape 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

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

conditions, and introducing them in areas where there is problem of moisture stress during maturity of chickpea, and risk of crop damage due to high probability of pest infestation and climatic variations.

Availability of seeds of new varieties is also a major constraint particularly in areas where organized 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 farmers' needs about different variety traits and identifying specific varieties were indeed played commendable role for wider acceptance and accelerating the adoption of improved chickpea varieties. However, the large farmers are still facing relatively more shortage of seed of improved chickpea varieties due to area under chickpea cultivation. Tribal farmers are also facing the problem of selling their produce in the absence of KRIBHCO. To overcome these problems, KRIBHCO is planning 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' cooperatives for marketing of output. It is expected that the adoption rate of improved varieties would be much faster if such mechanisms are institutionalized.

Acknowledgements

The research presented in this paper is based on a collaborative research between the Gujarat Agricultural University and the International Crops Research Institute for the Semi-Arid Tropics. The authors are grateful to the KRIBHCO team, particularly A. Joshi and S. Sodhi for their excellent cooperation in conducting the survey; and to H.A. van Rheenen for providing necessary support to conduct this study. Authors also appreciate Ch. Vijay Kumar and M.V. Patat for their assistance in data processing. Helpful comments received from S.C. Sethi and N.P. Saxena are also acknowledged.

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