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Determinants of Adoption of Modern Sorghum Production Technology - The Experience of Karnataka State

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I

INTRODUCTION

With an area of about 11.44 million hectares and a production of 9.55 million tonnes (during 1995-96), India is the second largest producer of sorghum in the world and has the largest share (30 per cent) of the global area under sorghum. Sorghum, one of the major coarse cereals produced in India, stands third among foodgrains in respect of area and production in the country after rice and wheat. Karnataka is the second largest sorghum producing state in the country covering a cultivated area of 1.98 million hectares (ha) with a production of 1.74 million tonnes (during 1995-96), accounting for nearly 29 per cent and 20 per cent of the area and production of foodgrains in the state.

The introduction of high-yielding cereal varieties under the High-Yielding Varieties Programme launched during 1966-67 in the country in general and in Karnataka State in particular, ushered new hopes and dimensions in agriculture. Under this programme, the fertiliser-responsive, photoperiod-insensitive and short duration high-yielding varieties (HYVs) of rice, wheat, sorghum, maize and pearl millet were released. During 1966-67 to 1995-96, the sorghum area in the state has decreased from 2.77 million ha to 1.98 million ha while its production during the same period stepped up from 1.31 million tonnes to 1.74 million tonnes. Thanks to the Green Revolution, this could be possible due to the rapid strides made on the technology front which has reflected in the productivity enhancement from 497 kg/ha to 880 kg/ha during this period.

An earnest effort has been made by the Government through various agricultural public policies to bring more sorghum area under the HYVs. Unfortunately, its results have been far from satisfactory. The proportion of sorghum area under HYVs increased from 0.79 per cent in 1966-67 to about 24 per cent in 1995-96. What are the farm level factors that could influence the adoption of modern sorghum production technology? Given certain socio-economic characteristics of a farmer, what is the probability that he adopts the modern technology?

Owing to the indisputable importance of the sorghum crop and the prevalence of technological dualism in its production in the Karnataka's economy, the present micro (farm)

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level study was undertaken to understand the farmers' behaviour with respect to the adoption of modern technology and determinants thereof. The term 'modern technology' (MT) used in the study is defined to include production practices associated with the modern cultivars (hybrids and improved open pollinated varieties) or popularly known as the HYVs of sorghum, while the 'traditional technology' (TT) refers to the production practices associated with the traditional or local varieties.

II

DATA AND METHODOLOGY

The present study is based on primary data pertaining to the year 1988-89 collected from 180 sorghum cultivators spread across 12 villages of four talukas of Dharwad district, Karnataka State during the year 1989. The respondents were selected using multi-stage random sampling design. Dharwad district was purposively selected since it was one of the four major sorghum growing districts in the state and also it had the highest area under MT of sorghum in the state (20 per cent of the state total).

Secondly, four out of 17 talukas of Dharwad district, viz., Dharwad, Shiggaon, Haveri and Ranebennur belonging to the predominant sorghum growing agricultural zone of the district, namely, Northern Transition Zone, were chosen. At the third stage, 12 villages, three per taluka were selected at random. In all, 180 sorghum farmers were randomly selected, while representing equally all the size groups of farms, thus including 36 farmers from each of the five farm size categories, namely, marginal farms (<1 ha), small farms (1-2 ha), semi-medium farms (2-4 ha), medium farms (4-10 ha) and large farms (>10 ha).

The characteristic features of the two technologies and of the adopters and non-adopters of MT were studied using tabular analysis before actually identifying the factors responsible for adoption of MT. This gave a general understanding of the environment in which diffusion of MT could take place.

The Logit Model

The influence of various socio-economic factors on the willingness of the decision makers to adopt new technologies has been investigated by a number of studies (Roe, 1983; Shakya and Flinn, 1985; Thomas et al., 1990). In most of the studies on adoption behaviour the dependent variable is constrained to lie between 0 and 1 and the models used are exponential functions (Kebede *et al.*, 1990). However, the decision to adopt a new technology can be very effectively captured using binary choice models. Binary choice models are appropriate when the choice between two alternatives depends on the characteristics of the problem. Application of a linear probability model to this type of problem, however, suffers from a number of deficiencies (Capps and Kramer, 1985), particularly, the one associated with the estimated probabilities in some cases being greater than one or lesser than zero as a result of neglecting significant interaction effects (Mingche, 1977). These deficiencies could be circumvented through the use of a monotonic transformation (probit or logit specification) which guarantees that predictions lie within the unit interval (Capps and Kramer, 1985).

Univariate logit and probit models and their modified forms have been used extensively to study the adoption behaviour of farmers and consumers (Schmidt and Strauss, 1975; Garcia *et al.*, 1983; Shakya and Flinn, 1985; Harper *et al.*, 1990). According to Hanushek and Jackson (1977), the choice between logit and probit models is largely a matter of convenience. However, Maddala (1983) and Shakya and Flinn (1985) have recommended probit models for functional forms with limited dependent variables that are continuous between 0 and 1, and logit models for discrete dependent variables.

In the present study, the presence of partial adopters apart from complete adopters and non-adopters, made the dependent variable to be continuous. However, the partial adopters, meaning those having area under both MT and TT sorghum in a given season, were a few in number (7, that is, 3.89 per cent of the sampled farmers). Hence, a farmer was considered as either a complete adopter or non-adopter depending on the proportionate area planted with MT on his farm in relation to the corresponding mean value of the study area.[1] This was done since no meaningful analysis could be possible with only seven observations. Hence, the dependent variable became a discrete variable with mutually exclusive and exhaustive values. Thus the univariate logit model, as specified below, was used for the present analysis. The logit model was estimated using the maximum likelihood method.

$$\ln [\{P(m/X)\} / \{P(t/X)\}] = XB + E \quad ....(1)$$

or

$$\ln [\{P(m/X)\} / \{1-P(m/X)\}] = XB + E \quad ....(2)$$

where X = vector of explanatory variables;
P(m/X) = probability of an individual farmer adopting MT, given the level of X;
P(t/X) = 1 - P(m/X)
= probability of an individual farmer adopting the TT (or not adopting the MT) given the level of X;
[{P(m/X)} / {P(t/X)}] = [{P(m/X)} / {1-P(m/X)}]
= the relative odds of adopting versus not adopting the MT;
B = vector of response coefficients; and
E = vector of random disturbances.

The specific logit model estimated to predict the 'odds' of a farmer being an adopter of MT is specified as follows:

$$\ln [P_i/(1-P_i)] = \beta_0 + \beta_1 SEAS_i + \beta_2 AGE_i + \beta_3 EDN_i + \beta_4 LIT_i + \beta_5 WKGMEM_i + \beta_6 OPHOL_i + \beta_7 LINLDi + \beta_8 FMCON_i + \beta_9 FODREQ_i + \beta_{10} INCOME_i + \beta_{11} DEBT_i + \beta_{12} SOCPN_i + \beta_{13} NRET_i + u_i \quad ....(3)$$

where P_i = the probability that the i-th farmer will adopt MT;
$(1-P_i)$ = the probability that the i-th farmer will not adopt MT;
SEAS = season dummy, 1 if kharif, 0 if rabi;
AGE = age of the farmer in years;
EDN = education of the farmer in number of schooling stages, taking values 0, 1, 2, 3, 4, 5, 6 if illiterate, completed primary education, secondary education, matriculation, pre-university education graduation and post-graduation respectively;
LIT = number of literates in the family;
WKGMEM = number of on-farm working members of the family;
OPHOL = size of operational holding in ha;

LINLD = net leased-in land in ha measured as total leased-in land minus total leased-out land;
FMCON = quantity of sorghum grains required for family consumption per annum in quintals;
FODREQ = quantity of fodder (sorghum straw) required for feeding owned cattle per annum in quintals;
INCOME = total family income of the farmer from farm and off-farm sources in the previous year in rupees;
DEBT = total debt outstanding against the farmer at the start of the current agricultural year in rupees;
SOCPN = social participation index[2] (number);
NRET = net returns per ha of sorghum crop in rupees;
β_j = logit coefficients (j = 0,1....13); and
u_i = random disturbances (i = 1,180).

To interpret the effect of a change in the value of j-th explanatory variable (Xj) on the probability of a farmer being an adopter of MT, the change in probability Pi was calculated as follows:

$$\Delta \ln [P_i/(1-Pi)] = \beta_j \Delta X_j \qquad ....(4)$$

Now, since for any variable X,

$$\Delta \ln X = \Delta X/X, \text{ and } \ln (X/Y) = \ln X - \ln Y;$$

it follows that

$$\Delta \ln [P_i/(1-P_i)] = [1/P_i + 1/(1-Pi)] \Delta P = [1/\{P_i(1-P_i)\}] \Delta P_i \qquad ....(5)$$

Assuming ΔXj = 1, it follows that

$$\Delta P_i = \beta_j P_i (1-P_i) \qquad ....(6)$$

This shows that the change in probability is a function of probability itself. The most useful single value of Pi to choose for this interpretation is the mean (Bagi, 1984). Thus the derivative at mean was calculated as follows:

$$\Delta\bar{P} = \beta_j\bar{P}(1-\bar{P}) \qquad ....(7)$$

where $\bar{P}$ = mean probability of adoption.

Discriminant Analysis

Further, in order to assess the relative importance of the factors included in the logit model (equation 3), the discriminant analysis was carried out. The specific form of the discriminant function used to evaluate the relative contributions of different factors to the total distance measured between the two groups, viz., adopters and non-adopters of MT, is given below:

$$Z = L_1SEAS + L_2AGE + L_3EDN + L_4LIT + L_5WKGMEM + L_6OPHOL + L_7LINLD + L_8FMCON + L_9FODREQ + L_{10}INCOME + L_{11}DEBT + L_{12}SOCPN + L_{13}NRET \qquad ....(8)$$

where Z = total discriminant score for the two groups, i.e., adopters and non-adopters of MT;
L_i = linear discriminant coefficients (i = 1....13) ;

and the explanatory variables are as defined earlier in equation 3.

III

RESULTS AND DISCUSSION

1. *Farm Level Diffusion Environment*

For effective diffusion of any technology there must be compatibility between the technology and the target group (farmers). In other words, the technology so developed should be farmer-friendly and must be acceptable to the farmers as such, or with minor adjustments. To understand the existing diffusion environment, the characteristic features of the technologies and the target group of farmers in the study area were examined.

Characteristics of modern and traditional technologies: The average levels of major economic features of the MT in comparison with those of the TT are presented in Table 1. It could be observed from the table that the average yields of grain and fodder per ha in the case of MT sorghum were much higher (17.63 quintals and 26.14 quintals respectively) as compared to the TT (8.14 quintals and 20.70 quintals). Since the grain yield differential was larger than the fodder yield differential between MT and TT, the fodder:grain ratio in the case of MT sorghum (1.48) was lower than that in TT sorghum (2.54). Contrastingly, the prices of both grain and fodder were relatively high for the TT sorghum, thus reflecting the better quality of grains as well as fodder of the TT sorghum. However, the price differential between the two technologies was over-compensated by the yield differential resulting in the higher gross returns for MT (Rs. 4,216 per ha) than for TT (Rs. 3,467 per ha). Similarly, the per ha cost of production of MT sorghum was relatively high (Rs. 2,740) due to comparatively higher levels of inputs used in the case of MT, particularly fertiliser, human labour and capital. The net returns (gross returns less cost of production) per ha of MT sorghum (Rs. 1,476) again scored over that of the TT sorghum (Rs. 1,173). It is the net returns per ha that was expected to exert considerable influence on MT adoption.

TABLE 1. CHARACTERISTICS OF MODERN AND TRADITIONAL TECHNOLOGIES OF SORGHUM

Arithmetic means of selected characteristics	MT		TT	
	Per ha	Per qtl†	Per ha	Per qtl†
(1)	(2)	(3)	(4)	(5)
1. Grain yield (qtl)	17.63	-	8.14	-
2. Price of grains (Rs.)	-	164.38	-	230.92
3. Fodder yield (qtl)	26.14	-	20.70	-
4. Price of fodder (Rs.)	-	52.37	-	77.81
5. Fodder : Grain ratio	1.48	-	2.54	-
6. Gross returns (Rs.)	4,216	239	3,467	426
7. Input requirements:				
(a) Fertiliser (qtl)	2.02	-	1.63	-
(b) Human labour (man-days)	97.47	-	87.32	-
(c) Capital (Rs.)	970.21	-	856.56	-
8. Cost of production (Rs.)	2,740	155	2,294	282
9. Net returns (Rs.) [Item 6 - Item 8]	1,476	84	1,173	144
10. Gross returns per rupee invested	1.58		1.52	

† Per quintal of grain yield except in the case of price of fodder.

As regards the cost and returns profile on per quintal basis, the TT invariably scored over the MT in terms of gross returns, cost of production as well as net returns. It was due to the higher prices of grain and fodder of TT sorghum. However, the returns per rupee invested was slightly higher (1.58) in the case of MT as compared to TT (1.52).

Characteristics of adopters and non-adopters of modern technology: Table 2 presents the characteristic features of the sampled farmers grouped into adopters and non-adopters of MT. A perusal of the table reveals that the adopters scored over the non-adopters in case of all the characteristics considered barring age, size of operational holding and area under sorghum crop.

TABLE 2. CHARACTERISTICS OF ADOPTERS AND NON-ADOPTERS OF MODERN TECHNOLOGY OF SORGHUM

Arithmetic means of selected characteristics (1)	Adopters (2)	Non-adopters (3)	Overall (4)
1. Age (years)	41.72	42.19	41.91
2. Education (number of schooling stages)	2.14	1.53	1.89
3. Family size (number)	9.27	8.44	8.93
4. Number of literates in the family	4.43	4.15	4.31
5. Number of on-farm workers in the family	4.72	3.82	4.36
6. Size of operation holding (ha)	5.11	5.99	5.47
7. Size of net leased-in land (ha)	0.98	0.88	0.94
8. Area under sorghum crop (ha)	1.11	1.84	1.41
9. Quantity of sorghum grains required for family consumption (qtl)	9.47	7.57	8.70
10. Quantity of sorghum fodder (straw) required for owned cattle (qtl)	18.54	16.99	17.91
11. Farm income in the previous year (Rs.)	10,727	10,198	10,512
12. Off-farm income in the previous year (Rs.)	5,599	5,107	5,399
13. Debt outstanding (Rs.)	5,977	5,835	5,919
14. Social participation index (number)	4.58	2.63	3.79
Sample size	107	73	180

The adopters were younger in age than the non-adopters. It is generally accepted that the younger farmers are more innovative than the older ones. However, the difference in age was not considerable in the present context. The size of operational holding was smaller (5.11 ha) in the case of adopters when compared to the non-adopters (5.99 ha). That is, relatively small farmers could adopt the MT while the larger farmers could not. Then, does it mean that the adoption of MT of sorghum was 'size negative'? This inference cannot be drawn from the foregoing discussion based on the arithmetic mean values of the attributes, but the results of logit analysis (which shall be discussed later in the paper) might help in this regard. Similarly, the average area planted with MT was smaller (1.11 ha) as against 1.84 ha under TT. This might be due to higher doses of inputs required for the MT and also the limited resource base of the adopters.

The mean levels of all other attributes, particularly, education, number of literates in the family, number of on-farm workers in the family, quantity of sorghum grains required for family consumption, farmer's farm and off-farm income in the previous year, and social participation index were predictably higher in the case of adopters as compared to the corresponding figures for the non-adopters.

However, based only on the mean levels of various attributes selected for the study, one cannot ascertain as to which are the most important variables conditioning MT adoption. These attributes are used in the logit analysis to examine the strength and direction of their influence on the probability of adoption of MT.

2. *Factors Conditioning the Adoption of Modern Technology at Farm Level*

Adoption of MT, as could be derived from the survey data, is influenced by a wide range of economic and social factors apart from agro-climatic factors. However, with a view to study the influence of socio-economic factors alone on technology adoption in greater detail, the agro-climatic factors were constrained to be constant by way of selecting the respondents from a single agro-climatic zone.

The results of logit analysis (Table 3) show that the estimated model (Model I) was a good fit as indicated by the per cent-correct predictions (92.78 per cent) of the binary (0,1) dependent variable. The root mean squared error of this prediction was as low as 0.22, and hence the prediction was highly reliable. The goodness of fit of the model was also confirmed by the low negative log likelihood (NLL) value (28.42), as it is known that NLL is always positive and measures the lack of fit between data and model; the smaller the value, the better the model fits the data (Darlington, 1990).

TABLE 3. MAXIMUM LIKELIHOOD ESTIMATES OF THE LOGIT MODEL FOR A FARMER'S DECISION TO ADOPT MT OF SORGHUM (MODEL I)

Explanatory variable (1)	Variable notation (2)	Expected sign (3)	Coefficient (Bj) (4)	Asymptotic 't' value (5)
1. Constant			-17.4686*	3.3033
2. Season (dummy)	SEAS	+	16.2652*	3.4058
3. Age	AGE	-	-0.0600***	1.6954
4. Education	EDN	+	-0.2344	0.6442
5. Number of literates in the family	LIT	+	0.1015	0.7010
6. Number of on-farm workers in the family	WKGMEM	+	0.0306	0.1773
7. Size of operational holding	OPHOL	+	-0.6290*	3.0062
8. Size of net leased-in land	LINLD	+	0.3068***	1.6906
9. Quantity of sorghum grains required for family consumption	FMCON	+	0.3173**	2.4844
10. Quantity of sorghum fodder (straw) required for owned cattle	FODREQ	+	0.0832	1.1980
11. Total income from farm and off-farm sources in the previous year	INCOME	+	0.00006	1.1283
12. Debt outstanding	DEBT	+	-0.00004	0.6897
13. Social participation index	SOCPN	+	1.1517*	3.4442
14. Net returns per ha of sorghum crop	NRET	+	0.0007***	1.8876
Log-likelihood			-28.42	
Per cent-correct classification			92.78 (0.2226)‡	
Number of observations (N)			180	

Note: *, ** and *** Significant at 1, 5 and 10 per cent probability level respectively.
† Based on a 50-50 classification scheme.
‡ Root mean squared error of classification.

The estimates of the logit model reveal that the probability of a farmer's decision to adopt MT was positively influenced by all the variables included in the model, barring age (AGE), education (EDN), size of operational holding (OPHOL) and debt outstanding (DEBT). The signs of the estimated coefficients are as expected for all the explanatory variables excepting education (EDN), size of operational holding (OPHOL) and debt outstanding (DEBT). Though the coefficients of EDN and DEBT were unpredictably negative, they were non-significant as indicated by their asymptotic 't' values. However, the effect of education on MT adoption in the present study is not consistent with the positive and significant relationships found by Rahm and Huffman (1984) and Putler and Zilberman (1988).

The size of operational holding has a significant but unexpectedly negative influence on technology adoption. This means, with an increase in the size of farm there was a decrease in the probability of a farmer being an adopter of MT. This result confirmed the observation made earlier in the paper that the MT sorghum adoption might be 'size negative'. The reason is that in the study area in general, every farmer had allocated some fraction of his farm to sorghum crop to meet the grain and fodder requirements of his family and livestock respectively. A small farmer, with limited *land* holdings, attempted to achieve this objective through cultivation of MT sorghum, since it, with its higher yield levels, required relatively small piece of land to yield a given quantity of sorghum grains and fodder. On the other hand, a large farmer, with limited *labour* resources per unit of land (including hired labour, owing to labour scarcity during critical stages of crop growth), preferred to go for TT sorghum which was less labour intensive. On the other hand, he had to allocate more land for sorghum to meet his given home requirements owing to lower productivity of TT sorghum. This finding was consistent with the study by Kiresur (1992) on the adoption of MT sorghum at the macro (state) level.

Of the thirteen factors analysed, the probability of sorghum producers adopting MT was significantly associated with seven factors, namely, season (SEAS), age (AGE), size of operational holding (OPHOL), size of net leased-in land (LINLD), quantity of sorghum grains required for family consumption (FMCON), social participation index (SOCPN) and net returns per ha of sorghum crop (NRET). The coefficients of the remaining variables are not significant even at 20 per cent level. Hence, a step-down logit model was run eliminating the most insignificant variable in each step so as to retain the most important variables in the final model. Ultimately, the variables retained in the final model were season (SEAS), size of operational holding (OPHOL), quantity of sorghum grains required for family consumption (FMCON), social participation index (SOCPN) and net returns per ha of sorghum crop (NRET). Table 4 presents the maximum likelihood estimates of the step-down logit model (Model II) and the derivative at mean (change in probability) for the selected parameters.

It could be seen from the table that the model was a good fit as indicated by the low negative log-likelihood (32.99) and high per cent-correct predictions (96.26). The measures of 'sensitivity' and 'specificity' indicate that the model classifies better when the decision is to adopt, rather than to not adopt the MT. All the variables included in the model were significant at 1 per cent level, with the exception of net returns per ha of sorghum crop (NRET) which was significant at 5 per cent level. Further, all these factors exerted positive influence on the probability of a farmer adopting the MT, barring the size of operational holding (OPHOL). A plausible explanation for the negative influence of operational holding size on the probability of MT adoption is given earlier.

TABLE 4. MAXIMUM LIKELIHOOD ESTIMATES OF THE LOGIT MODEL FOR A FARMER'S DECISION TO ADOPT MT OF SORGHUM (MODEL II)

Explanatory variable (1)	Variable notation (2)	Coefficient (B_i) (3)	Asymptotic 't' value (4)	Test of significance† (5)	Derivative at mean (ΔP_i) (6)
1. Constant		-16.3881*	3.3119	0.001	
2. Season (dummy)	SEAS	14.8411*	3.2808	0.001	3.5782
3. Size of operational holding	OPHOL	-0.2784*	3.4521	0.001	-0.0671
4. Quantity of sorghum grains required for family consumption	FMCON	0.2455*	3.0296	0.002	0.0592
5. Social participation index	SOCPN	0.8097*	3.6560	0.000	0.1952
6. Net returns per ha of sorghum crop	NRET	0.0006**	2.1570	0.031	0.00014
Log-likelihood		-32.99			
Per cent-correct classification		92.78	0.2368@		
Sensitivity#		96.26			
Specificity‡		87.67			
Number of observations (N)		180			
Forecast probability of adoption (180 farmers)		0.2414			

Note: * and ** Significant at 1 and 5 per cent probability level respectively.
† Critical level of probability at which the null hypothesis that $B_i=0$ is just rejected.
@ Root mean squared error of classification.
# Proportion of adopters who were predicted correctly.
‡ Proportion of non-adopters who were predicted correctly.

Even though the calculus of probability in logit models is not the same as in linear probability models, the magnitude of the probability is highly influenced by the value of estimated coefficients. Thus it is possible to suggest the direction of the effect on the basis of coefficients (Aldrich and Nelson, 1984). Among the factors which had positive influence on probability of MT adoption, the effect of season (SEAS) was maximum, followed by social participation index (SOCPN), quantity of sorghum grains required for family consumption (FMCON) and net returns per ha of sorghum crop (NRET) as reflected in their respective coefficients.

However, the individual estimated parameters should be interpreted with care, because the dependent variable in the model is the logarithm of the 'odds' of choice, not the actual probability (Bagi, 1984). For example, a unit increase in the farmer's social participation index leads to an increase of 0.8097 in the logarithm of the odds that the individual farmer will adopt the MT. To interpret the effect of change in the values of explanatory variables on the probability of a farmer being an adopter, the change in probability (ΔP, the derivative at mean) was calculated (Table 4).

The probability of adopting MT sorghum was positively and highly dependent upon the season. Mathematically, a unit increase in season would lead to 358 per cent increase in the probability of adoption of MT. In other words, it is highly likely that a farmer adopts MT in the *kharif* season, and he is highly unlikely to do so in the *rabi* season. This was because of the adequate availability and suitability of most of the modern varieties/hybrids of sorghum for the *kharif* season as compared to the *rabi* season. Though enough research investment has gone into the development of improved cultivars for the *rabi* season, the outcome is far from satisfactory in terms of adoption of improved cultivars on the farmers' fields. Thus it raises a very sensible question as to whether it is worthwhile to continue investing in rabi sorghum research?

The probability of adopting the MT was lowered by 6.71 per cent for every one hectare increase in the size of operational holding (OPHOL). The reason for this is mentioned earlier. Similarly, a unit increase in the values of social participation index (SOCPN), quantity of sorghum grains required for family consumption (FMCON) and net return per ha of sorghum crop (NRET) would correspondingly lead to 19.52 per cent, 5.92 per cent and 0.01 per cent increase in the probability of adopting the MT.

This model could also be used for forecasting. Given the specific values of the explanatory variables, the probability of MT adoption could be forecast. Hence, the mean values of these explanatory variables for all the sampled farmers were used to forecast the probability of all the farmers adopting the MT, which worked out to be as low as 24.14 per cent. It should be remembered that this forecast probability (P_i) is based on the specific values of the explanatory variables and is subject to variation due to changes in the values of any of these variables.

3. *Determinants of the Coexistence of Modern and Traditional Technologies at Farm Level*

Constraints in adoption of modern technology: After having identified the factors influencing the adoption of MT, it is appropriate to understand the relative importance of these factors. The discriminant function was estimated in order to find out the percentage contribution of each of the factors in question to the total distance measured between the two groups, i.e., adopters and non-adopters.

A perusal of the results presented in Table 5 reveals that season (SEAS) was the most important factor conditioning the MT adoption, followed by social participation index (SOCPN), operational holding (OPHOL), quantity of sorghum grains required for family consumption (FMCON) and net returns per ha of sorghum crop (NRET). Their respective discriminating powers are 77.64, 11.36, 4.03, 3.25 and 1.56. Therefore, these are the major factors which classified the farmers into two groups, namely, adopters and non-adopters. Also, these were the most important factors influencing the MT adoption as revealed by the results of logit analysis. However, the t-test of significance showed that the differences in the means of the two groups were significant only in the case of season (SEAS), social participation index (SOCPN) and quantity of sorghum grains required for family consumption (FMCON).

The 'season' factor had a lion's share in the total distance measured (78 per cent) indicating again that the *kharif* season was relatively more favourable for MT adoption as compared to the *rabi* season. This is because of the fact that sorghum is a rainfed crop and moreover, the MT of sorghum requires relatively adequate and assured water than for the TT. Thus the MT cannot be efficiently grown with the availability of uncertain residual moisture during the *rabi* season. It may be recalled that most of the HYVs of sorghum released so far for commercial exploitation have been recommended for the *kharif* season.

TABLE 5. CONTRIBUTION OF INDIVIDUAL VARIABLES TO THE TOTAL DISTANCE MEASURED BETWEEN ADOPTERS AND NON-ADOPTERS

(per cent)

Variable (1)	Coefficient (L_i) (2)	Mean difference (D_i) (3)	Calculated 't' value for D_i (4)	Coefficient × mean difference ($L_i \times D_i$) (5)	Percentage contribution $\{(L_i \times D_i)/D^2 \times 100\}$ (6)
1. SEAS	10.1410	0.70*	12.92	7.0848	77.64
2. AGE	-0.0098	-0.47	0.24	0.0046	0.05
3. EDN	-0.0244	0.61*	2.85	-0.0148	-0.16
4. LIT	0.0481	0.77***	1.69	0.0372	0.41
5. WKGMEM	0.0849	0.90**	2.37	0.0762	0.84
6. OPHOL	-0.4218	-0.87	1.02	0.3681	4.03
7. LINLD	-0.0263	0.09	0.33	-0.0025	-0.03
8. FMCON	0.1567	1.89***	1.69	0.2967	3.25
9. FODREQ	0.0413	1.56	0.86	0.0643	0.70
10. INCOME	0.00001	1020.21	0.49	0.0453	0.50
11. DEBT	-0.0001	141.35	0.12	-0.0139	-0.15
12. SOCPN	0.5316	1.95*	4.39	1.0362	11.36
13. NRET	0.0005	302.57	1.31	0.1422	1.56
Total				0.9125	100.00

Note: $D^2 = 0.9125$. $F = 28.405$*

*, ** and *** Significant at 1, 5 and 10 per cent probability level respectively.

Social participation index (SOCPN) also had positive (11 per cent) contribution to the total distance measured. The higher the participation of the farmer in the social and economic institutions, the higher the awareness he acquires and hence the higher the probability that he adopts the MT. Similarly, the family consumption requirements of sorghum grains (FMCON) could contribute positively to the distance between the adopters and non-adopters. The lower the requirement of sorghum grains for family consumption, the less will be the farmer's urge to go in for MT cultivation, because sorghum (or even MT sorghum) is not mainly grown for the market unlike in the case of other cereal crops like paddy, wheat, etc. Therefore, higher requirements of sorghum grains for family consumption would force the farmer to go in for MT sorghum production.

Farmers' perception on the characteristics of modern and traditional technologies: Certain qualitative characteristics of the cultivars also played an important role in the process of decision-making by the farmers in choosing to cultivate either MT or TT of sorghum. The farmers' perceptions on such characteristics were captured through an opinion survey and were processed using the frequency distribution technique.

As regards output characteristics (Table 6), a majority of the farmers were of the opinion that the MT was superior to the TT in terms of quantitative characteristics like grain yield, fodder yield and net returns per ha, whereas the TT was superior to the MT with respect to price of grain, low risk of yield fluctuation and certain quality parameters like cooking quality of grain, fodder quality and storage quality of grain. Therefore, crop improvement in these quality parameters could stimulate MT adoption.

TABLE 6. FARMER'S PERCEPTION ON CERTAIN CHARACTERISTICS OF MT AND TT OF SORGHUM

Characteristics	MT		TT		No difference*	
	Number	Per cent	Number	Per cent	Number	Per cent
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Higher grain yield	163	90.56	15	8.33	2	1.11
2. Better cooking quality of grain	26	14.44	154	85.56	-	-
3. Higher fodder yield	87	48.33	77	42.78	16	8.89
4. Better fodder quality	65	36.11	103	57.22	12	6.67
5. Higher price of grain	-	-	174	96.67	6	3.33
6. Better storage quality of grain	45	25.00	98	54.44	37	20.56
7. Higher risk of yield fluctuation	139	77.22	16	8.89	25	13.89
8. Higher net returns per ha	106	58.89	60	33.33	14	7.78
Number of respondents	180					

* Unable to distinguish between MT and TT with respect to a given characteristic.

With regard to the problems faced by the sorghum cultivators, it could be seen from Table 7 that the most serious problem encountered by the TT growers was the non-suitability of soil, followed by susceptibility of the crop to pests and diseases, and rains during harvesting leading to blackening of grains and fodder. Many farmers opined that red soil coupled with low rainfall was unsuitable for TT, as could be derived from the drastic reduction in their yields. It was interesting to learn that the TT sorghum crop was infested by the pests of MT grown in neighbouring fields. Because of this problem some of the farmers were compelled to opt for MT. The MT sorghum was also susceptible to pests and diseases, but the loss due to this problem was compensated by the higher returns from MT sorghum. Another demerit of the TT was that while it was possible to take another crop after the harvest of MT sorghum crop as expressed by 41 per cent of the farmers, the corresponding proportion of farmers in the case of TT sorghum was very low (7 per cent). This was because of the fact that many MTs were of relatively short-duration. Therefore, MT could enhance the cropping intensity and hence the annual returns per ha in the study area.

TABLE 7. PROBLEMS CONFRONTED BY THE SAMPLED FARMERS IN SORGHUM CULTIVATION

Characteristics	MT		TT		No difference*	
	Number	Per cent	Number	Per cent	Number	Per cent
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Non-availability of adequate labour during critical stages of crop growth	137	76.11	33	18.33	10	5.56
2. Rains during harvest cause heavy losses due to blackening of grains and fodder	125	69.44	41	22.78	14	7.78
3. Soil unsuitable	96	53.33	77	42.78	7	3.89
4. Technology susceptible to pests and diseases	78	43.33	65	36.11	37	20.56
5. Quality seeds not available	67	37.22	-	-	113	62.78
6. Loss due to weed infestation	46	25.56	33	18.33	101	56.11
7. One more crop can be taken up on the same land after sorghum	74	41.11	12	6.67	94	52.22
Number of respondents	180					

* Unable to distinguish between MT and TT with respect to a given characteristic.

Owing to the problems faced in the cultivation of TT sorghum and the superiority of the MT over the TT in certain quantitative aspects, all the farmers should have gone for the cultivation of MT. But it was not the case. There was partial adoption of MT, with only 59 per cent of the sampled farmers cultivating MT in only 47 per cent of the total area under sorghum. This was because of the problems faced by the farmers in the cultivation of MT sorghum apart from superiority of TT sorghum in certain quality parameters (Table 6).

The non-availability of adequate labour during critical stages of crop growth, particularly weeding and harvesting, was the most serious problem faced by MT adopters as opined by 76 per cent of the sampled farmers (Table 7). The other serious problems faced by the MT adopters were the rains during harvesting period resulting in blackening of grains and straw, non-suitability of soils, susceptibility to pests (particularly, the shoot fly) and diseases, non-availability of quality seeds and weed infestation (mainly, the 'striga'). The problem of shoot fly and striga weed arose because of late sowing on account of delayed rains. Therefore, the provision of protective irrigation at times of rainfall failure would facilitate timely sowing and hence overcome the problems of shoot fly and striga infestation.

CONCLUSION

To conclude, the probability of a farmer being an adopter of the MT was significantly influenced by the seasonal factor, size of operational holding, quantity of sorghum grains required for family consumption, social participation index and net returns per ha of sorghum crop. This finding was supported by the results of the discriminant analysis too. All these factors had positive influence on the probability of adoption with an unpredictable exception of operational holding size, thus implying that the adoption of MT of sorghum was 'size negative'. The probability of all the sampled farmers adopting the MT was forecasted to be low (0.2414), thus implying little prospect of its complete adoption.

The evaluation of the farmers' perceptions on certain characteristics of the two technologies revealed that the MT was superior to the TT in terms of grain yield, fodder yield and net returns per ha. However, the farmers opined that the MT was inferior to the TT with regard to quality of grain and fodder. Also, a majority of the farmers were of the opinion that the per hectare net returns of the MT, though relatively higher than that of the TT, could have been still higher in absolute terms, if good quality MT seeds were available. Hence, in order to stimulate and gear up MT adoption, crop improvement in quality aspects of grain and fodder as well as supply of good quality seeds are utmost essential.

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NOTES

1. A farmer was considered as an adopter if the proportionate area under MT of sorghum on his farm was not less than the proportion of area under MT to the total area under sorghum in Dharwad district (39 per cent); and non-adopter otherwise.

2. Social participation index was constructed based on three variables, viz., ordinary membership in socio-economic institutions (V_1), executive membership in such institutions (V_2) and formal training in agriculture imparted by research and development organisations (V_3). The specific formula used for calculating the index is: SOCPN - $V_1 + 2V_2 + 4V_3$. The weightages to the above variables were chosen after thorough discussions with agricultural researchers and extension educationists.

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