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Maize Composites Enhance Economic Returns from Dry Land Farming: Evidences from Uplands of Kashmir Valley

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ABSTRACT

The present study is conducted in dry uplands of Kashmir region to assess the potential of three location-specific maize composites, C_6, KG_1 and C_8 respectively in the Central, South and North regions of Kashmir valley for enhancing the economic returns and sustenance of livelihood of rural masses under the dry land conditions. The study forms part of NAIP project, "Visioning Policy Analysis and Gender (V-PAGe)" undertaken at SKUAST-K, Shalimar during 2009-11 and is based on the cross sectional survey data collected from 240 farm households cultivating maize under dry land conditions in the upper belts of Kashmir valley. The adoption of dry land maize composites and its determinants were examined by employing regression function. Economic surplus model and economic feasibility tests were employed to assess the economic gains from research and extension investment involved in the development of maize composites under the study. The bi-variate Probit model was fitted to identify the factors responsible for probability of adoption of maize composites. The study revealed significant yield gains of 32.20, 27.10 and 27.80 q/ha respectively in C_6, KG_1 and C_8 maize composites which increased the marketable surplus significantly. The labour productivity was the highest in C_6 followed by C_8 and KG_1. The net change in partial budget to the tune ₹ 20,916 per hectare indicated capability of commercial orientation of maize composites and also high B-C ratio of maize composites held the view that maize seed technology could prove a boon for sustenance of farm families of dry lands maize growers in Kashmir valley. The Probit model estimates revealed that the average size of land fragments, educational level, experience of maize growing and yield risk in local varieties were positively significant, while negative significance of average size of land holding suggested that non-fragmentation could help in the adoption of composite maize seed technology. The study concludes that cultivation of maize composites has the potential to secure and sustain livelihood of stake holders under dry land conditions.

Keywords: Maize seed technology, Maize composites, Partial budgeting technique.

JEL: O32, D61, C83

I

INTRODUCTION

In India a major proportion of the area under agricultural production (more than 60 per cent), is either rainfed or under dryland farming. However, the regions may vary with respect to the proportion of area under dry land farming contingent with various climate variables and resource endowments. Mountainous states, owing to various specificities, have dominance of dry land farming system. Only 41 per cent of the cropped area in Jammu & Kashmir, a northern Himalayan state, has assured

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irrigation facilities and the rest is to be cultivated under rainfed or dry land conditions. Dry land farming supports around 10-12 per cent of the state's population (Wani *et al.,* 2012) residing in the upper belts of Kashmir province. The predominance/backwardness of agriculture, under-developed socio-economic overheads and poor scope of non-farm employment opportunities characterising this farming system, demand exploration of sustainability within the existing chunk of supporting and adversarial factors. Since maize occupies an important place in the cropping pattern of dry uplands of Kashmir, improvement/husbandry of this crop would be crucial for strengthening its agricultural economy and livelihood of the stakeholders.

Maize is one of the important cereal crops, of which about 65 per cent is used as animal feed, 27 per cent as human food and rest 8 per cent as non-food industrial products and seed (Chahal and Kataria, 2005). This crop has the potential to meet the food demand and influence the growth of allied sectors, viz., poultry and livestock production. It is the major staple grain in various regions of India (Anupama *et al.*, 2005, Munda *et al*., 2007, Shiyani and Pandya, 1998) and plays a vital role in the country's food security and income to the smallholders. In India it is considered a promising option for diversifying agriculture in uplands. Development of improved varieties would give commercial orientation to its cultivation; substantiated with the fact that demand for maize in the developing world alone is expected to increase from 282 million tonnes in 1995 to 504 million tonnes in 2020 of which 60 per cent would be in demand in Asia (Chahal and Kataria, 2005). Use of improved seeds with complementary inputs may lead to productivity improvement (Prasher and Bahl, 1998). The cropping systems that include new maize technology are reportedly risk-efficient relative to local maize varieties (Ames, *et al*., 1993). Accordingly the households with high degree of hybrid maize adoption have by and large better dietary intake (Kumar, 1994). Adoption was found greater and more rapid in high-potential zones compared with the semi-arid zone and lowland tropics (Hassan *et al*., 1998). Despite the dire need to evolve, disseminate and diffuse such germplasm, the adoption of maize technologies has shown an inconsistent behaviour across nations/regions. The incidence of concealed tenancy (60 per cent) and high land fragmentation (Jha and Viswanathan, 1999), restricts the scarcity of inputs in the local market and diffusion of modern technology to a large extent (Martinez *et al*., 1991). However, demonstration of improved maize was found to have a significant impact on their rate of adoption (Sharma and Jha, 1997). Since micro-climate changes with distance necessitating diffusion of location-specific improved varieties, this paper comprehensively analysed the adoption of three maize composites specific to dry land conditions of Kashmir in relation with various livelihood indicators. The study also assessed the overall social/economic returns/gains from research investment involved in the development of these varieties. The paper confirms the hypothesis that improved maize composites have raised the livelihood status of farmers cultivating maize under dry land conditions in the uplands of Kashmir valley.

II

DATA AND METHODOLOGY

The present study was planned in the uplands of Kashmir valley characterissed by an average rainfall of less than 150 mm during growing season, thus making farmers of the study area practice dry land farming. Multistage stratified random sampling technique was used to draw a sample of 240 maize growers, 40 each (20 adopters and 20 non-adopters of maize composites) from six selected districts, two each from Central (Budgam and Srinagar, South (Anantnag and Kulgam) and North (Kupwara and Baramulla) regions of Kashmir Province. The data was collected from the respondents through a specifically structured pre-tested interview schedule during 2009-11, under NAIP project," Visioning Policy Analysis and Gender (V-PAGE)". Three location-specific maize composites viz., Maize Composite C_6, Maize Composite C_8 and Shalimar Maize KG_1 were selected for economic evaluation and impact analysis, respectively from central, south and north Kashmir. One block each from the selected districts of three regions was chosen purposively on the basis of majority of the farmers involved in maize cultivation. The cluster of 2 to 3 villages from each block was selected randomly to obtain the ultimate sampling units of maize composite adopters and non-adopters. The selected farmers were mostly small farmers and constituted higher proportion of both adopters and non-adopters.

To analyse and interpret the data, statistical/mathematical tools were employed as follows:

Technology Adoption Index

To study the level of adoption of maize seed technology and other associated management practices technological adoption index worked out by using the following formula (Anonymous, 2003):

Technology Adoption Index (TAI) = (1/4)* ((Actual seed used/recommended seed rate) + (Actual nitrogen used/recommended nitrogen) + (Actual phosphorus used/ recommended phosphorus) + (Actual potassium used/recommended potassium))* 100

The determinants of TAI were examined by employing regression function of the following form:

TAI = (AGE, DIST, LIT, FMLIT, LIVSTCK, CFRM, AHS, IRR, ROCE, E)

Where,

TAI	=	tech. adoption index
AGE	=	age of head of family (yrs)
DIST	=	distance to the nearest town/city (kms)
LIT	=	family literacy (per cent)

FMLIT	=	female literacy (per cent)
LIVSTCK	=	capital stock in the form of livestock (₹/farm)
CFRM	=	capital formation on farm (₹/farm)
AHS	=	average holding size (ha)
IRR	=	cultivated area irrigated (per cent)
ROCE	=	return from other crop enterprises (₹/farm)
E	=	error term.

Economic Surplus Model

Economic surplus model was used to estimate the economic benefits of the maize composites techniques developed under various projects. The model was applied in a closed economy framework with the assumption of no spillover effects on international market. It was assumed for ease of analysis that the output supply function was unitary elastic and linear with a parallel research-induced supply shift, and the demand function was linearly inelastic. The assumptions of a simple case of linear supply and demand functions with parallel shift have been applied in most of the earlier studies on research benefits (Alston *et al.*, 1995). The economic surplus model (Alston *et al.*, 1995) was used to measure the rate of returns to the research under various projects. The research benefits were computed as change in economic surplus as follows:

Change in total surplus = $K_t\, P_o\, Q_o\, (1+0.5\, Z^{-th})$

Where,

Z_t = Kt {e/(e+h)}

K= Vertical shift in supply function

e= Elasticity of supply

h= Elasticity of demand

P_o =Base year output price

Q_o=Base year output quantity

Economic Rates of Return

Using the above measure of total benefits from research, the different measures of economic rates of returns were estimated as follows:

Net Present Value

$$\text{Net present value} = \frac{R_t - C_t}{(1+i)^t}$$

Internal Rate of Return (IRR)

$$IRR = \sum_{t=0}^{T} \frac{R_t - C_t}{(1 + i)^t} = 0$$

Benefit-Cost Ratio

$$BCR = \frac{\sum_{t=0}^{T} R_t /(1 + i)^t}{\sum_{t=0}^{T} C_t /(1 + i)^t}$$

where,

R_t = Return in period 't',
C_t = Cost in period 't'
i = Discount rate
T = Project time

Probit Analysis: Structural Form and Specification

Technology adapter was measured as a discrete choice variable (yes or no). A lot of research has been carried out on the influence of socio-economic variables on farmer's adoption decision. In most cases, the use of Probit, Trobit or Logit was applied (Kebede *et al.*, 1990, Nkamleu and Adesina, 2000, Rausom *et al.*, 2003, Adesina and Zinnah, 1993, Shiyani *et al.*, 2002). Given agriculture as an occupation which is capital embodied, the various **s**ocio-economic and demographic characteristics of the farm household may influence the level of adoption of maize composite technology. A Probit model was used to capture the participation process. Defining Y_i is the function of the socio-economic and demographic characteristic of farm household $Y_i = 1$ for maize composite adopter household and $Y_i = 0$ for non-adopters of maize composites technology, then

$$Y_t^* = \beta_0 + \sum (\beta_1 X_{ki} + \varepsilon_i) \text{ (k ranges from l to k)}$$

$$E(\overline{X}) = 0, E(\varepsilon) = 0 \text{ var } (\overline{X}) = 1, \text{ var } (\varepsilon) = 1$$

Where Y* is the latent or unobservable variable. The observable variable is a dummy representing the adoption of technology by farmer. Y=1 if Y* > 0 otherwise Y= 0, otherwise 'i' is the respondent, X_{ki} : k = 1 through k independent variables explaining the phenomenon of respondent, i, β_i is the parameter that explains the effect of X_i on Y^*_i, β_o is the intercept that shows the expected value of Y* when all X_k have a value of zero. ε_i is the stochastic error term for respondent 'i', E = the expected value and var = variance $\bar{x}$ = the mean of X. As such $Y^*_i \sim N(0, 1)$. Since utilities are random, the i-th farmer will agree to adopt maize composites if and only if $U^a_i > U^b_i$. For the i-th farmer therefore, the probability of adoption of technology is given by the utility maximisation function.

$$P(Y=1/X_{ij}) = P(U^a_i > U^b_i)$$
$$= P(\beta_1 X_i + \varepsilon^a{}_i > \beta_o X_i + \varepsilon^b{}_i)$$
$$= P(\varepsilon^b{}_i - \varepsilon^a{}_i < \beta_1 X_i - \beta_o X_i)$$
$$= P(\varepsilon_i < \beta_i X_i)$$
$$= \varphi(\beta_1 X_i - \varepsilon_i > 0)$$

Where ø is the cumulative distribution function for εi. The functional for φ depends on the assumptions of εi. Since $Y^*_i \sim N(0,1)$, then probability of the i-th technology of the i-th farmer in maize cultivation is given by:

$$P(y=1)/X_{ij}) / = \varphi(Z_i)\ 1 / \sqrt{2\pi} \int_{-\alpha}^{zi} e^{-(½) z2}\, dz$$

Where $Z_i = \beta X$

The theoretical model discussed above suggests many important hypotheses related to the adoption of maize composite varieties. The model is derived from the equation, which was developed using the farm and farmer specific factors, and farmers' perception on technology specific characteristics. The model assumes that the dependent variable which is defined as the adoption or non-adoption of maize composites depends on explanatory variables, viz., average size of land holding (hectares), average size of land fragments (hectares), education level of the farmer (0 for illiterate, 1 for middle, 2 for secondary classes, 3 for graduation and 4 for higher education), farmer's experience of growing maize (years), market distance (km), and yield risk (percentage of production).

The relationship between size of land holding and adoption of improved technologies may be positive (as large farmers generate more income which provides a better capital stock and improve risk bearing capacity) or negative (as small farmers utilise the limited resources more efficiently and adopt new technologies at a faster rate. This variable has been included to ascertain whether land holding has negative or positive impact on the adoption of maize composites. Since the holding of farmers are scattered in small fragments, some may be of larger size than others, therefore, the average size of land fragments has been included as one of the explanatory variables in the function as a proxy of number of fragments of holdings. Contrary to average size of holdings, which may have both positive or negative, adoption of maize composite varieties is expected to go positively with more average size of land fragments. In other words it could be said that smaller number of land fragments is expected to enhance the adoption of maize composite technology. The farmers' education is expected to have positive influence on the adoption behaviour of farmers. Length of experience of growing maize is hypothesised to encourage farmers in making better use of technology. Nearness to the markets is expected to encourage adoption process. In similar fashion, if the yield risk from a variety is high in previous years, it will be substituted by another variety which is expected to have low risk.

III

RESULTS AND DISCUSSION

Maize occupies an important place in the cropping system of upper belts of Kashmir valley. Despite its lower productivity, maize is an important crop, after rice and wheat, especially in the upper belts of Kashmir valley. Maize is grown on wide range of agro-climatic regimes under dry land conditions and the cropping intensity in these belts is 125 per cent which is lower compared to state average. Cropping system was less intensified in South (142.21 per cent) followed by Central (127.81 percent) regions of Kashmir. Poor intensification, lower labour employment opportunities in farming sectors and poor scope of industrialisation necessitated development and dissemination of low cost, location-specific technologies for better remuneration to maize growers in upper belts.

In consonance with this all India Coordinated Research Improvement Project (AICRP) on maize was established in 1957 and later extended to the State of Jammu & Kashmir (J&K) in 1998. Investment under AICRP, since its inception in the state, paid off handsomely in the form of new genotypes. SKUAST-K released 12 location specific improved maize composites which were sharpened/evolved under various research projects. Of the 12 genotypes three, C_6, KG_1 and C_8 evolved for dry land conditions were taken up for impact analysis in their domain area. The various attributes of maize composites selected for impact analysis in this study are presented below:

- Maize Composite (C_6): Recommended for lower belts of Kashmir Valley and higher reaches of Jammu region (1500-1800 m amsl), is resistant to *Turcicum blight* under field conditions. It has a yield potential of 45-50 q ha^{-1} under suitable management conditions. The plant does not lodge and escapes stem breakage under high fertility conditions. Matures within 155-160 days in temperate zone and 125-130 days in the intermediate zone.
- Maize Composite (C_8): Recommended for foot hills of Kashmir Valley and higher reaches of Jammu region (1500-1800 m amsl) and mid elevations (600-1000 m amsl) of Poonch, Rajouri and Udhampur districts of Jammu region. Matures in 150-155 days in valley/higher altitudes of Jammu and in 110-115 days in intermediate zone. The variety is resistant to *Turcicum blight* under field conditions, has yield potential of 45-50 q ha,$^{-1}$ under suitable management conditions.

- Maize Composite (Shalimar KG_1): Recommended for cold hills of Kashmir (above 6500 ft. amsl) especially Machil and Gurez areas. The variety matures within 120-125 days. It is tolerant to leaf blight, downy mildew and resistant to stem rot. It is also moderately tolerant to maize stem borer and Angoumois grain moth. The variety has a yield potential of 45-50 q $ha.^{-1}$

Adoption Patterns of Maize Composites Under Dry Land Conditions

The technology/innovations are of no use until they reach the farmers' fields. To streamline the extension services in the state, the Frontline Demonstrations (FLD's) were introduced in 1998 in the valley to disseminate the latest technologies among the farmers wherever economically/technically feasible. The adoption of improved seed technologies have increased the yield levels to a great extent, but its full potential could not be harnessed due the fact that maize crop is exclusively grown under dry land conditions that hinders the use of other critical inputs like fertiliser technologies. To study the adoption of improved maize seed technology along with other inputs, a technology adoption index was developed, which could be considered as a catch-all measure of technology adoption practices by the farmers. It revealed that more than 80 per cent of adopters fall within the category that adopt technology between 80-100 per cent in C_6 and C_8 growing areas (Table 1). However, the adoption level was lower in KG_1 growing area indicating higher technological gaps in the application of inputs at adopter farms, thereby giving an idea that maize production can further be augmented if required facilities like irrigation, weeding, etc. are provided to bridge the technological gaps.

TABLE 1. CLASSIFICATION OF ADOPTERS ON THE BASIS OF TECHNOLOGY ADOPTION INDEX

Region (1)	Up to 60 (2)	60-80 (3)	80-100 (4)
Central (C_6)	3.22	9.68	87.1
North (KG_1)	10.50	26.31	63.2
South (C_8)	3.57	14.29	82.1

To identify the factors responsible for differential adoption of maize composites in the study area, an exponential function was fitted for each region separately and estimates are presented in Table 2. The estimated function revealed that distance to the nearest town/city was positive significant determinant of technology adoption. The distance to the nearest market indicates travel distance that a farmer needs to cover to sell his maize surplus and purchase inputs. The educated farmers can best understand the possible benefits of technology adoption and may put farming on scientific lines. The regression coefficient of literacy turned out to be positive indicating its significant contribution in the adoption of technology though its coefficient for south Kashmir was statistically insignificant. Since most of the intercultural operations are done by family labour especially female labour, therefore, female education was found to have direct positive influence on technology adoption. In central Kashmir the proportion of area that is irrigated also turned positive thus emphasised upon expansion of irrigation capacities to uplands. The value of coefficient of regression indicated functions to be a best fit.

TABLE 2. ESTIMATES OF EXPONENTIAL FUNCTION OF TECHNOLOGY ADOPTION INDEX

	Regression coefficient		
Variable	Central (C6)	South (C_8)	North (KG_1)
(1)	(2)	(3)	(4)
CONSTANT	3.22	6.30	3.00
AGE	-0.136 (0.188)	-0.03 (0.36)	0.694* (0.320)
DIST	0.346 (0.507)	0.143* (0.04)	0.067* (0.039)
LIT	0.112* (0.005)	-0.029 (0.033)	0.186* (0.052)
FMLIT	0.016* (0.002)	0.041* (0.014)	0.022 (0.049)
LIVSTCK	0.109* (0.016)	-0.136 (0.121)	0.539* (0.24)
CFRM	0.140*(0.014)	0.041* (0.011)	0.245* (0.107)
AHS	0.255*(0.115)	-0.118 (0.166)	0.0122 (0.062)
IRR	0.066* (0.025)	-0.118 (0.136)	-0.027* (0.001)
ROCE	-0.004 (0.012)	0.013*(0.001)	0.010* (0.002)
$\overline{R}^2$	0.831	0.799	0.746

* Significant at 5 per cent level.
Figures in parentheses indicate standard errors.

Adoption of Improved Maize and Livelihood Indicators

The economics of maize production for adopters in comparison to non-adopters of various maize composites in different uplands of Kashmir are presented in Table 3. The cultivation of maize composites involves lot of investment on its package of practices without which it is rendered uneconomical. The data highlight that the additional cost required to be incurred on the cultivation of maize composites has benefited the adopters in the form of higher productivity.

On an average, yield levels of maize composites were approximately 2 to 2.5 times higher than those of the local varieties. The average yield of local varieties ranged from 19.98 q/ha to 23.28 q/ha compared to 49.98 q/ha to 52.05 q/ha in composite varieties and these yield levels are comparable with global averages. In central Kashmir, local maize 'Safed local' is common. The adoption of C_6 in some parts of this region led to the yield gain of 161 per cent (32 qtls) and 119 per cent gain each in C_8 and Shalimar KG_1 in south and north Kashmir, respectively over traditional varieties. It was observed that composites out performed local cultivars in selected areas of Kashmir. The scenario indicated that although the adoption of improved maize technology and complimentary inputs raised the input costs but the benefits accrued to the farmers resulted in low unit cost of production of composites, due to higher yield levels (Table 3). The adoption of maize composites led to the decline in unit cost of production by 43.71, 31.15 and 32.01 per cent and increased the returns per rupee invested by 76, 44 and 47 per cent, respectively in C_6, KG_1 and C_8. Therefore, strong seed sector and technology dissemination mechanisms need to be developed to achieve widespread use of improved technologies and composites.

TABLE 3. COMPARATIVE ECONOMICS, EMPLOYMENT GENERATION AND FOOD SECURITY OF COMPOSITE AND LOCAL MAIZE GROWERS

		Central Kashmir (C6)		North Kashmir (KG1)		South Kashmir(C8)	
Particulars (1)	Unit (2)	C6 (3)	Local (4)	KG1 (5)	Local (6)	C8 (7)	Local (8)
Yield*	(q. ha^{-1})	52.2	20	50	22.9	51.1	23.3
Gross returns	(₹ ha^{-1})	52050	19980	49980	22860	51070	23280
Cost of cultivation	(₹ ha^{-1})	25899.7	17506.4	26985.3	17926	26971.4	18084.1
Net return	(₹ ha^{-1})	26150.3	2474	22995	4934	24099	5196
Cost of production	(₹ ha^{-1})	498.07	875.32	539.71	782.79	527.82	776.14
Returns per rupee invested	(₹ ha^{-1})	2.01	1.14	1.85	1.28	1.89	1.29
Gender involvement	Female/male ratio	0.73	0.70	0.58	0.48	0.60	0.43
Labour productivity	(₹ ha^{-1})	627.10	317.14	595.00	336.17	600.82	350.08
Marketable surplus	(q. ha^{-1})	8.16	1.06	10.00	0.00	8.11	0.00
Employment (man-days)	Man-days ha^{-1}	83	63	84	68	85	66.5

*this includes fodder yield converted into grain equivalent.

The yield improvement due to adoption of maize composites in dry land areas and declining costs of production have added to net returns of maize growers (Table 3). This has enhanced productivity of agricultural labour by 98, 77 and 72 per cent, respectively in C_6, C_8, and KG_1.These indicators are reflective of better livelihood opportunities for the adopters of maize composites under dry land conditions of uplands of Kashmir valley.

Different activities of maize cultivation under dry land conditions are mostly carried out by family members, though fewer casual labourers were also hired in weeding and harvesting. The cultivation of maize composites demands yet more number of human labour for various activities, which is evident from Table 3. As high as additional 20 labour man days/ha are required for cultivation of maize composites. Notably this increase has been in favour of women labour, because the ratio of female to male labour has increased from 0.70 to 0.73, 0.48 to 0.58 and 0.45 to 0.60 in C_6, KG_1 and C_8 respectively.

The increased productivity has resulted in increased marketable surplus by 8.16, 10.00 and 8.11 q/ha in C_6, KG_1 and C_8 respectively. Increased surplus therefore, will lead to zero distress sales, thereby pushing up the domestic consumption as animal/human food. This way adoption of maize composites not only gives commercial orientation to this crop but also improves food security, which justified inclusion of improvement of maize in national food security mission.

The debit side of partial budgeting (Table 4) showed more investment on human labour, machine labour and other inputs in various maize composites as compared to locals. Moreover, some loss also accrued to the adopter farmers in the form of lower fodder yield due to less seed use compared to local varieties of maize. The credit side of partial budgeting revealed that farmers got additional benefit due to increased yield and decrease in the cost on bullock labour. The net change in partial budgeting (₹ 20916/ ha)indicated that adopters of maize composites can yield better returns after accounting for loss and gains from adoption of maize composite technologies.

TABLE 4. PARTIAL BUDGETING OF MAIZE COMPOSITES IN KASHMIR

Debit			Credit		
Particulars (1)		Amount (₹/ha) (2)	Particulars (3)		Amount (₹/ha) (4)
A. Increase in cost per hectare			A. Increase in returns per hectare		
(a) Human labour 20.03 md @150/day	=	3004.50	(a) Grain yield of 32.34qtls @ 1000/qtl.	=	32340.00
(b) Machine labour 0.593 hrs @150/hr	=	89.00			
(c) Inputs	=	5647.83			
B. Decrease in income per hectare			B. Decrease in costs per ha		
(a) Fodder	=	2839.51	(a) Bullock pair 3.15 hrs @ 50/hr.	=	157.50
Total	=	11580.84		=	32497.50
Net changes in ₹ (Credit – Debit)	=	20916.66			

To sum up maize composites varieties have performed better under dry land conditions of Kashmir valley. They have benefitted the maize growers in a number of ways, including yield grain, higher marketable surpluses and better returns. Not only this, adopters of maize composites in the study area were found spending more on food and other expenditure items because of their higher affordability owing to higher remuneration from this crop (Wani *et al.,* 2012). It could be inferred that these findings confirm the hypothesis that maize composites improved livelihood status of maize growers under dry land conditions of Kashmir valley.

Estimates of Economic Surplus Model

Technologies involve research and dissemination costs for its evaluation, dissemination and diffusion in addition to costs on complimentary inputs. An attempt was made in the present study to capture the economic gains from investment on research/dissemination costs in relation to supply and demand elasticities by employing Economic Surplus Model (ESM). The adoption of improved maize seed technologies (C_6, C_8 and KG_1) under dry land conditions not only improved the productivity of maize crop, but also resulted in lower cost of production per unit of output. Although adoption of improved maize is capital intensive and demand higher investment but higher productivity coupled with better utilisation of inputs resulted in lower cost per quintal of maize. The B-C ratio estimates revealed that the investment on research for development / evolution of selected maize composites has higher pay off. On an average each rupee invested on research and extension could earn 23 rupees over the years (Table 5). It could be observed from the analysis that efforts need to be made to streamline the extension activities for replacement of existing area under local maize in the domain area to achieve the expected economic gain from improved maize.

TABLE 5. ECONOMIC SURPLUS MODEL (ESM)

Particulars (1)	Values (2)
Price elasticity of supply*	0.65
Price elasticity of demand*	0.50
Change in yield / ha.	133.00
PVRC (₹ in crores)	48.95
PVTS (₹ in crores)	608.85
IRR (per cent)	72.00
B-C ratio	23.36

**Source*: P. Kumar, 3-stage frame work Quadratic AID System.

Estimates of Probit Model

An attempt has been made in this section to identify the factors determining the adoption of maize composites. Maximum likelihood estimates of parameters of the univariate Probit model characterised the adoption of maize composite varieties are presented in Table 6. The results revealed that all explanatory variables included in the model were significant and have expected signs. The average size of holding was found to be a positive significant determinant of adoption of maize composites. As expected small farmers are keen to harvest much from their limited resources and are innovative in adoption of new technologies. Accordingly the regression coefficient of average size of holding turned negative and significant at 1 per cent level of significance. It is interesting to note that coefficient of average size of land fragments was positive and significant determinant of adoption of maize composite varieties indicating persuading role of less number of fragments in the adoption decision. The variable representing distance to market was not found significant though it will be worth mentioning that market prospects of improved varieties certainly influence their adoption decision. Education plays a significant role in the adoption decision and this variable was found statistically significant with positive sign. The experience of growing maize was significant and positive indicating that more experience of growing this crop would make them to adopt composite varieties. Favour impact of experience is expected because more experienced farmers may have better understanding of possible gains from technologies and access related information through extension services. The coefficient of yield risk in previous varieties was positive and significant at 5 per cent probability level indicating that more yield risk in existing varieties grown by the farmers would persuade them to go for adoption of new varieties. Since majority of resource poor farmers are more risk averters, and hence they adopt maize composites.

TABLE 6. MAXIMUM LIVELIHOOD OF PROBIT ESTIMATES OF MAIZE COMPOSITE VARIETIES ADOPTION

Variable (1)	Coefficient (2)	T calculated (3)
Constant	2.569*	6.887
Average size of land holding	-1.089*	3.502
Average size of land fragments	0.101*	8.417
Education level of farmer	0.412*	4.120
Experience of maize growing	1.542*	4.283
Yield risk in local varieties	0.131*	4.367
Market distance	-0.261	0.839

*Denotes significance at 5 per cent or better level.

IV

CONCLUSION AND POLICY SUGGESTIONS

The results revealed that adoption of improved maize varieties was quite impressive and there was substantial increase in yield levels, income and labour productivity of these varieties compared to the local variety. The other benefits of improved varieties in comparison to local variety include higher marketable surplus, labour absorption and lower unit cost of production. The estimates of partial budgeting indicated significant economic gains from the adoption of maize composite varieties, moreover, results of economic surplus model showed that research and extension costs involved in the development/dissemination of maize composite varieties under study has paid off handsomely. These results impressed upon concrete measures for development of location-specific maize varieties and their timely dissemination for imparting commercial orientation to maize crop under fragile ecosystem of dry lands. The estimates of Probit function, highlighted that the adoption of maize composites could be enhanced if the estimated signs of regressors are taken care of rationally. It could be concluded from the findings that adoption of maize composite has a potential to secure livelihood of stakeholder under dry land conditions. On the basis of findings of the study following policy suggestions emerge:

A well structured seed sector for multiplying and supplying seeds of improved varieties of maize to meet the demand in remote and backward dry land areas which lack an organised seed sector would help farmers to adopt new technologies. There is a need for breeding of short duration varieties with stable yield levels under varying weather conditions, and introducing them in areas with problems of irrigation. The participatory approach of understanding the farmers' needs for different variety traits and identifying specific varieties have indeed played commendable role for wider acceptance and in accelerating the adoption of improved maize varieties. It is expected that the adoption rate of improved varieties would be much faster if such mechanisms are institutionalised. The extension facilities should be streamlined to make farmers aware of the benefits of location-specific maize composites. Formal education and capacity building programmes for stakeholders would definitely enhance quick diffusion of technologies.

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