Agricultural Economics Research Review
Vol. 26 (Conference Number) 2013 pp 165-171

Has Adoption of Improved Rice Technology Enhanced Economic and Livelihood Security in Kashmir Valley?§

M.H. Wani[a]*, S.H. Baba[a], P. Rama Sundaram[b], Shoaib Yousuf[a] and Shahid Yousuf[a]

[a]Rajiv Gandhi Chair in Contemporary Studies on Livelihood and Food Security,
Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar Campus,
Srinagar-191 121, Jammu and Kashmir
[b]National Centre for Agricultural Economics and Policy research, New Delhi-110 012

Abstract

The paper has estimated the extent of adoption of an improved rice seed technology in the Kashmir valley and has studied its impact on the economic and the livelihood security of adopters of this technology. The determinants inducing farmers towards adoption of new technology have been identified and technological gaps in its adoption have been estimated. For presenting a comparative picture, 130 adopters and 122 non-adopters of improved technology were identified from six districts , two each from the three regions of Kashmir valley. The study has revealed, based on data collected for the agricultural year 2010-11 that by adoption of improved technology, both gross returns and net returns have increased considerably, while the cost of production has decreased. The study has clearly brought out that adoption of new technology has provided better economic and livelihood security at the household level in the study area. The age, education and land size have been identified as the major determinants of technology adoption. By presenting statistics obtained through economic surplus model , the study has presented a strong case for higher investments on R&D , extension services delivery and dissemination of improved technology in the Kashmir valley.

Key words: Livelihood security, economic security, technology impact, Shalimar rice-1 , Kashmir valley

JEL Classification: Q16, Q12

Introduction

In India, rice production is mainly concentrated in Eastern states of Assam, Bihar, West Bengal, Jharkhand, Chhattisgarh and Odisha. Besides being a major consumer of the rice, India is the largest exporter and producer of basmati rice in the world (NABARD, 2007). The consumption curve of rice for India is also moving upwards, as there has been about 2.6-times increase in rice consumption by 2006 over 1960 (USDA, 2007).The current population growth rate projects an additional requirement of 2.33 million tonnes of rice per annum in India. Meeting growing demand for rice and such other crops in national and international markets has caused huge stress on natural resources, primarily on land and water. Since these resources have almost been exhausted, the productivity of existing crop land needs to be improved without compromising health of agricultural ecosystem. In this context, development of improved seed technology seems the only emergent measure available for raising the ceiling of yield potential. For example, by adopting new varieties, China produces additional 300 Mt of rice due to higher yield by about 20 per cent over the conventional varieties (Yuan and Fu, 1995; Hussain 2001; Yuan, 2004).

* Author for correspondence
Email: rgckashmir@gmail.com

§ Part of work done under NAIP sponsored Research Project, Visioning Policy Analysis and Gender (VPAGe).

In Jammu and Kashmir, rice is a priority crop and is grown on 259 thousand hectares of land with an overall production of 5574 thousand quintals (Anon., 2008-09). The most popular rice variety, 'Jhelum' has replaced the earlier 'K-39' variety since 1995. These varieties did increase rice productivity in the Kashmir valley, but their susceptibility to blast later contributed to a significant decline in area and productivity.

To combat the attack of blast, cold tolerance, good adaptability and to increase the productivity of rice in the state, an improved variety known as, Shalimar Rice-1 (SR-1) was developed and subsequently released in 2005 by the state Varietal Release Committee for the valley basin irrigated areas of Jammu and Kashmir. The improved variety , SR-1 was derived through a cross between blast-resistant 'Rasi' and cold- tolerant 'China 1007' varieties and has a yield potential of 6 t/ha. This variety has shown wide-spectrum resistance to the IC-17 and ID-1 races of blast diseases, which were prevalent in approximately 80 per cent of the rice-growing areas of Kashmir.

In this backdrop, the present study has estimated the extent of adoption of improved rice seed (SR-1) technology in the Kashmir valley and has identified the factors associated with its adoption. The main objectives of the study were: (a) to find the adoption pattern and technological gaps in improved rice seed technology, (b) to study the impact of improved rice seed technology on its economics and performance at farmers field, and (c) to examine the technical efficiency of input-use in improved rice technology and identify their determinants.

Data and Methodology

The study is based on secondary as well as primary data. The secondary data on area, production and yield of rice crop were collected from diverse sources like FAO Statistics and other governmental and non-governmental publications. The primary data on different aspects of improved rice cultivation and its adoption were obtained from the selected farmers .For data collection, the Kashmir province was divided into three regions, viz., Central, South and North and two districts were chosen from each region. From each district one block and from each block a cluster of 2-3 villages was chosen and a sample of 252 farmers,130 adopters and 122 non-adopters of SR-1 was drawn. A specially-prepared interview schedule was used to collect data from the selected households during the agricultural year 2010-11. The majority of farmers belonged to the marginal farm category, constituting a higher proportion of both adopters and non-adopters.

Analytical Tools

For data analysis, tabular and statistical/mathematical tools were employed as given below:

Regression Analysis — The determinants of technology adoption index (TAI) were examined by employing regression function of the following form:

TAI = (AGE, DIST, LIT, FMS, CFRM, AHS,WRK, E)

where,

TAI = Tech. Adoption Index [(1/4) * {(Actual seed used/recommended seed rate) + (Actual nitrogen used/recommended nitrogen) + (Actual phosphorus used/recommended phosphorus) + (Actual potassium used / recommended potassium)}* 100]

AGE = Age of family head (years),

DIST = Distance to the nearest town / city (km),

LIT = Family literacy (%),

FMS = Family size (No.),

CFRM = Capital formation on farm (₹ / farm),

AHS = Average holding size (ha),

WRK = Agricultural workers (%), and

E = Error- term.

Economic Surplus Model — The economic surplus model was used to estimate the economic benefits of Shalimar Rice-1 adoption. The model was applied in a closed economy framework with the assumption of no spill over 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 [e.g., Alston *et al*.,1995]. This model was used to measure the rate of returns to the research under various projects. Research benefits were computed as change in economic surplus as follows:

Change in total surplus = $K_t P^o Q^o (1+0.5 Z_t)$

where,

Z_t = K_t {e/(e+h)},

K = Vertical shift in supply function,

e = Elasticity of supply,

h = Elasticity of demand,

P^o = Base year output price, and

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 (NPV)

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

Internal Rate of Return (IRR)

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

Benefit-Cost Ratio (BCR)

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

where,

R_t = Return in the period 't',

C_t = Cost in the period 't',

i = Discount rate, and

T = Project time.

Besides, simple tabular analysis like production efficiency and crop yield index, etc. was extensively employed in this study.

Results and Discussion

Rice occupies an important place in the cropping pattern of Jammu and Kashmir. Though rice production is lower in this state than other states of India, yet it is the most important crop of the state, especially in the Kashmir valley. Rice alone contributes about 1/3rd to the total foodgrain production of the state, though since 1970 its share has decreased from about half of the total state's production. The decline could probably be due to better performance of other cereals like wheat and maize in Jammu and Ladakh divisions of the state.

The data reflected in Table 1 reveal that the area under rice in the state has steadily increased from about 240 thousand hectares in 1970 to about 273 thousand hectares in 1995, and then declined to 244 thousand hectares in 2000 but has again risen to about 258 thousand hectares in 2008. Such a decline was due to diversification towards horticultural crops and shifting of agricultural land to non-agricultural purposes. This trend has been reflected in area under rice as percentage of total net sown area (TNSA) (Table 1). The production and productivity have also shown fluctuations during the reference period. In the year 2000, the production had decreased even below the 1971-level, despite recording marginal increase in area, probably because of decline in productivity levels. The fluctuating production could also be attributed to occurrence of frequent natural calamities like draughts, floods, and hailstorms.

Cropping Pattern

The Kashmir province dominates in production and consumption of rice by contributing, respectively 55 per cent and 61 per cent to its total area and production in the state (Anon., 2008-09). The area allocated to rice by both adopters and non-adopters of new technology was higher than other crops. Across regions, the southern region dominated in diverting the highest area to rice by both adopters (76.2%) and non-adopters (76.6%), while central Kashmir diverted more area towards vegetables. Most of the farmers were observed to practise double cropping on a certain proportion of land which raised the cropping intensity. The cropping intensity with respect to cropped area (CI^1) was observed highest (152.8%) in adopter-farmers of northern region, followed by the central region and the lowest (126.27%) in southern region.

The cropping intensity with respect to operational area (CI^2) was highest in the central region due to highest proportion of area under horticultural crops. The fodder yield (by-product) had, however, decreased marginally by 5 to 6 per cent in central and northern

Table 1. Area and production of rice in J&K: 1970-2008

Year	Area ('000 ha)	Production ('000 q)	Yield (q/ha)	Area as % of total net sown area	Production as % of total foodgrain production
1970	239.95	4578	19.08	34.58	55.80
1975	237.00	4560	19.24	34.16	45.14
1980	264.58	5464	20.65	36.99	41.82
1985	265.55	5871	22.11	36.26	41.83
1990	274.49	5769	21.02	37.56	42.22
1995	273.08	5050	18.49	37.20	34.26
2000	244.05	4153	17.02	32.61	37.09
2005	259.01	5574	21.52	35.30	37.11
2008	257.63	5637	21.88	34.88	32.83

Table 2. Domination of rice in cropping pattern of Kashmir province: 2011

Farmers	Rice	Oilseeds	Vegetables	Oats	Others	TCA	CA	OA	CI^1	CI^2
	As percentage of TCA					ha			per cent	
Central region										
Adopters	59.81	9.59	6.56	12.95	1.35	0.89	0.60	0.82	147.78	108.63
Non-adopters	59.71	8.13	7.98	15.44	0.90	0.66	0.46	0.65	145.92	102.55
Northern region										
Adopters	61.99	14.25	1.46	18.12	2.00	1.10	0.72	1.34	152.80	81.89
Non-adopters	66.42	9.65	1.32	21.21	1.06	1.36	0.94	1.62	145.35	84.37
Southern region										
Adopters	76.25	10.77	1.49	7.82	1.49	1.37	1.09	1.7	126.27	80.87
Non-adopters	76.59	10.01	1.31	10.67	1.11	0.99	0.78	1.36	126.60	72.93

TCA-Total cultivated area; CA-Cropped area; OA-Operational area; CI^1-Cropping intensity w.r.t cropped area; CI^2-Cropping intensity w.r.t operational area

regions. The additional doses of inputs, labour and irrigation provided substantial overall gains in yield, but raised the cultivation cost by 13-23 per cent across the regions.

Adoption of New Technology and its Impact

The adoption of new seed technology of Shalimar rice-1 (SR-1) has changed the crop economics. It has led to changes in input-use pattern and labour-use. The grain yield of SR-1 has shown a considerable increase of 85-89 per cent across different regions of Kashmir (Table 3). With the adoption of SR-1, the gross returns had increased by 61-65 per cent, net return swelled by 200-400 per cent and cost of production decreased by 26-29 per cent. Besides these economic benefits, the adoption of SR-1 had other non-farm advantages leading to the betterment of livelihood at the household level. Labour productivity, for instance, had increased by 24 per cent in south Kashmir to 60 per cent in north Kashmir. Similarly, higher marketable surplus and 18-50 per cent additional employment depicted improved livelihood and economic security for adopter farms in the area.

Partial Budget Estimates

To summarize the impact of technology adoption in terms of net economic gains, partial budgeting technique was used which revealed that SR-1 required more costs on human labour and other inputs besides losing about one quintal of fodder per hectare, amounting to the loss of ₹ 9752/ha on adopter farms (Table 4).

Table 3. Impact of adoption on economics of improved rice seed (SR-1) over local rice

Particulars	Central Kashmir		North Kashmir		South Kashmir	
	SR-1	Change (%)	SR-1	Change (%)	SR-1	Change (%)
Grain yield (q/ha)	73.89	85.61	75.49	89.53	71.53	85.12
Fodder yield (Grain equivalent) (q/ha)	13.71	-5.90	13.86	-5.07	11.70	0.17
Gross returns (₹/ha)	113887	61.09	116154	64.14	108197	65.40
Cost of cultivation (₹/ha)	71849	13.08	62982	16.75	59856	23.08
Net return (₹/ha)	42039	487	53172	216.2	48340	187.9
Cost of production (₹/q)	820	-29.78	739	-29.37	756	-26.42
Return per rupee invested (₹/ha)	1.59	43.24	1.84	40.46	1.81	34.07
Labour productivity (kg/ha)	45.3	36.00	52.2	60.4	52.6	23.8
Domestic consumption (q/ha)	9.92	-13.89	10.78	-2.18	10.42	-4.58
Marketable surplus (q/ha)	16.08	2072.97	9.71	169	16.80	272
Employment (human-days/ha)	162.9	36.43	144.7	18.17	136.1	49.53

Source: Field survey, 2010-11

Table 4. Partial budgeting of Shalimar Rice-1 in Kashmir

Debit		Credit	
Particulars	Amount (₹/ha)	Particulars	Amount (₹/ha)
Increase in cost per hectare		**Increase in income per hectare**	
Human labour 31.9 mandays @ ₹ 250 per day	7975	Grain yield of 30.9 quintals @ ₹ 1300/q	40170
Inputs	490		
Decrease in income per hectare		**Decrease in cost per hectare**	
Fodder @ 0.99 quintal. @ ₹1300 (Grain eq.)	1287	Bullock labour (1.41 hours @ ₹ 150/hour)	210
Total	9752		40380
Net changes		30628	

However, the credit side shows considerable gains in the form of increased grain yield to the tune of 30.9 quintals/ha and reduced costs on bullock labour by about 1.4 hours/ha amounting to the total credit of about ₹ 40380/ha. The net change in returns in cultivation of SR-1, therefore, led to an increased amount of ₹ 30628/ha. Therefore, it could be concluded that the adoption of new rice technology had not only given additional yield to improve food security at household level but had also improved their livelihood by generating additional employment of about 32 humandays per hectare plus additional income through sizeable surpluses.

Technological Gap and Estimates of Technology Adoption Index

For a better extension services delivery and to disseminate latest technologies among farmers in the state, Frontline Demonstrations (FLDs) are being funded since 1998 in the valley. The impact of extension services delivery on technology adoption by farmers was estimated and is presented in Table 5. A perusal of Table 5 reveals the existence of technological gaps in the application of inputs at both adopter and non-adopter farms. Besides inappropriate seed rates, both adopter and non-adopter farms had given under-dozes of N and P, and over-doses of K, causing a yield gap of about 25 per cent in adopter farms and 45 per cent on non-adopter farms. It shows that rice production can be augmented further by bridging the technological gaps.

Since adoption of improved seed technology has increased the yield levels on rice farms to a considerable extent, the determinants of technology adoption, were identified by fitting an exponential function for each

Table 5. Extent of technological gaps on adopter and non adopter farms

Region		Technological gap (%)				
		Seed	N	P	K	Yield
Central	SR-1	87.02	-21.23	-1.71	21.4	-26.11
	Local	114.08	-22.54	-5.63	15.81	-45.62
North	SR-1	100.5	-13.16	28.01	45.86	-24.51
	Local	92.8	-24.36	-15.47	11.58	-45.57
South	SR-1	68.65	-23.44	-6.57	2.35	-28.47
	Local	84.16	-28.4	-16.51	5.35	-49.68

region separately. The results revealed that the age of farmers was a positive significant determinant of technology adoption along with education and land-holding size of the farmers in all the regions.

The regression coefficients of literacy were found positive, indicating its significant contribution to adoption of new technology. The landholding size of the farmers also emerged to be a significant factor in all the regions and showed that if the landholding size increases, it will increase the adoption level of improved seed technologies.

Table 6. Estimates of exponential function of technology adoption index in Kashmir valley

Variable	Regression coefficient		
	Central region	Northern region	Southern region
CONSTANT	-21.95	19.88	-16.43
AGE	0.39*	-0.088*	0.64*
	(0.18)	(0.08)	(0.27)
DIST	-0.76*	-0.85*	0.97
	(0.27)	(0.36)	(1.15)
FAMLIT	0.35	0.15	-1.45*
	(0.84)	(0.39)	(0.40)
LIT	0.098*	0.04*	0.11*
	(0.018)	(0.03)	(0.02)
WRK	0.076*	-0.05	0.04
	(0.017)	(0.06)	(0.207)
CFRM	0.009*	-4.49	6.37*
	(0.0001)	(2.89)	(0.001)
AHS	1.18*	0.56*	0.77*
	(0.34)	(0.11)	(0.27)
R^2	0.6721	0.6658	0.6289
F	12.62	15.12	12.23
DF	19	41	46

Notes: * Significant at 5 per cent or better level
Figures within the parentheses indicate standard errors

Estimates of Economic Surplus Model

An attempt was also made to capture the economic gains from investment on research / dissemination costs in relation to supply and demand elasticities by employing economic surplus model. The price elasticities of demand and supply of rice were estimated by employing secondary and primary information by functional analysis. The estimates of demand and supply elasticity worked out to be 0.51 and 0.53, respectively (Table 7). The analysis showed a significant improvement in yield level in the study area on adoption of new technology. Since the starting of R&D efforts on development of SR-1, about ₹ 42 crore were invested for evolution and release of this new new seed technology. Estimates of the ESM model revealed that R&D investment has resulted into the higher returns of 4.69 on each rupee invested.

Table 7. Returns from investment on R&D for new SR-1 variety revealed through estimates of economic surplus model (ESM)

Particulars	Values
Price elasticity of supply*	0.53
Price elasticity of demand*	0.51
Change in yield per ha	71.32
PVRC (in crore ₹)	41.96
PVTS (in crore ₹)	196.87
IRR (%)	61.00
B-C ratio	4.69

**Source:* Kumar and Rosegrant (1994)

Considering the economic gains, better food and livelihood security provided by the new SR-1 seed technology adoption, the study suggests that additional investments should be made for the dissemination of this variety.

Conclusions and Policy Implications

The adoption of new rice seed technology (SR-1) has given commercial orientation to rice cultivation in the Kashmir valley. Although the cost of cultivation has increased due to its adoption in almost all the geographical regions of the Kashmir valley, it has benefited its adopters in the form of higher productivity and significant reduction in its cost of production. Higher marketable surplus and involvement of more human labour have been found specific features of the seed technology to address livelihood security issues. The study has further revealed that adopters of the SR-1 could push further their returns by more than ₹ 30,000/ ha over local varieties after accounting for the additional costs. The estimates of economic surplus model have revealed that research/ dissemination cost of SR-1 resulted in attractive returns at farmers field and accounted for about ₹ 42 crores gain since its release in the domain area, thereby, making a strong case for its commercialization and targeting livelihood security in the target region. Following policy implications emerge out of this discussion:

- A well-established and effective seed sector would help farmers to access new varieties and increase rice production by putting more area under improved rice.
- Public-private partnership and cooperatives could benefit individual members by way of providing timely inputs associated with the cultivation of SR-1 at fair price and help them to dispose off their surpluses.
- Micro irrigation schemes need to be launched to reduce water stress and achieve potential benefits from improved rice technologies.
- Land reform measures need to be implemented strictly in the state, to encourage capital formation and generate other necessary factors for improving technology adoption of input-use at the farm.
- The extension network should be streamlined for effective transfer of technology with wide spread publicity through electronic and print media.

Acknowledgements

Authors are thankful to ICAR for sponsoring this study through NAIP funding under VPAG-e Analysis and Gender project and are grateful to Professor Ramesh Chand, Director, NCAP, New Delhi and Professor P. Kumar, formerly at IARI, New Delhi, for their valuable suggestions, continuous support and encouragement during the course of investigation.

References

Alston, J.G. Norton and Pandey, P. (1995) *Science under Scarcity*. Cornell University Press, Ithca.

Anonymous (2008-09) *Digest of Statistics,* Planning and Development Department, Government of Jammu and Kashmir, Srinagar.

FAO (1995a) *World Rice Information*, Issue No.1. Food and Agriculture Organization, Rome, Italy.

Fredericksen, H.D., Berkoff, J. and Barber, W. (1995) *Water Resources Management in Asia*, Vol. 1. World Bank Technical Paper No. 212. World Bank, Washington, D.C.

Husain, A. M. Muazzam (2001) *Socio-economic Assessment of Hybrid Rice Adoption by Farmers in Bangladesh*. Agricultural Research and Extension Network Newsletter No. 44.

Kumar, P. and Rosegrant, M.W. (1994) Productivity and sources of growth for rice in India. *Economic and Political Weekly,* **29**(53): A-183-188.

NABARD (2007) *Model Banking Scheme for Organic Cultivation of Basmati Rice*. Mumbai.

Khatak, Naeem-ur-Rehman and Hussain, Anwar (2008) An analysis of socioeconomic profile of rural rice farmers in district Swat, *Sarhad Journal of Agriculture*, **24**(2): 377-390.

USDA (2007) International Rice Research Institutes Information on rice statistics. *World Food Prize International Symposium*, 15 October, 2004.

Yuan, L.P. and Fu, X.Q. (1995) *Technology of Hybrid Rice Production*. FAO, Rome, Italy.

Yuan, L.P. (2004) Hybrid rice technology for food security in the world. *The World Food Prize International Symposium,* 15 October, 2004.