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Land use and technology adoption analysis of paddy (*Oryza sativa*) cv. Basmati 370 in irrigated sub-tropics of Jammu district

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ABSTRACT

Basmati rice (*Oryza sativa* L.) of Jammu district especially Basmati-370 variety is world famous among the different Basmati varieties grown in the region due to its delicious taste, superior aroma and distinct flavour.The present productivity level of rice is far from potential level.Thus in order to ascertain the impact of various cultivation practices adopted by the Basmati growers and different factors affecting its productivity, a research pursuit was undertaken in Jammu district with 120 randomly selected farmers. The study reveals that majority of farmers transplanted their paddy crop in second week of July, only 6% adopted seed treatment practice and none of the farmers adopted seedling treatment, 85% applied DAP after transplanting and urea was the only fertilizer - applied by almost all the growers. Butachlor was applied as pre emergence herbicide by about 65% of the farmers immediately after transplanting and 52 per cent farmers applied bispyric sodium herbicide for the control of post emergence weeds. None of the farmers used any type of pesticides in Basmati 370 in the study area. The average productivity of Basmati 370 paddy cultivar of respondent farmers was to the tune of 2.841 tonnes/ha. Multiple linear regression model so applied shows that use of DAP fertilizer significantly affected the productivity of Basmati 370 variety of paddy. Low use of agro-chemicals in Basmati 370 cultivation, indicate scope for promotion of good agricultural practices (GAPs) or organic cultivation of Basmati 370 for increasing its sustainability both at national as well as international level which may result in appropriate return in addition to environmental benefits.

Key words: Adoption, Basmati rice, Inputs, Production, Productivity

India is the second largest producer of rice (*Oryza sativa* L.) after China. It grows large number of varieties across the regions. Basmati-370 is regarded as super specialty rice variety with highest export demand and a good earner of foreign exchequer for the country in general and state of Jammu & Kashmir in particular. It is one of the India's great national treasures, like that of saffron of Kashmir, pepper of Kerala and tea of Darjeeling. Traditionally, it is a crop of north-west Himalayas in India and this area is blessed with potential of producing extra-long slender aromatic ricewhich elongate atleast twice to that of their original size coupled with soft and fluffy texture upon cooking. Besides being known as king of rice, basmati uses less water and fertilizer, and its straw is used as fodder for livestock, and usually not burnt in the field to create pollution (Tuteja 2015). Basmati rice is strength of India since its quality in terms of grain length and aroma can hardly match any other variety of rice in the world. There has been commendable increase in the production of basmati in the country due to area expansion and yield enhancement. The steady increase in production and growing demand in the world market has made India a leading exporter in the world with potential to further increase production of basmati rice primarily through yield enhancement. Production of basmati rice is concentrated in north-west Indian states (GI areas) –Haryana, Punjab, Western Uttar Pradesh and to a limited extent in Uttrakhand, Himachal Pradesh and Jammu and Kashmir. Haryana is the leading producer of basmati in India.The main varieties of Basmati rice as notified under the Seeds Act, 1966 are Basmati 386, Basmati 217, Ranbir Basmati, Karnal Local/Taraori Basmati, Basmati 370, Type-3 (Dehradun Basmati), Pusa Basmati 1, Pusa Basmati 1121, Punjab Basmati 1, Haryana Basmati 1, Kasturi and Mahi Sugandha.The country has exported 40 45796.22 MT of Basmati rice to the world for the worth of ₹ 22718.44 crores during the year 2015-16. In Jammu and Kashmir, the total basmati area is 62250 ha out of which, Pusa Basmati 1121 has 8400 ha, Pusa Basmati 1509 has 250 ha and Basmati 370 has 53600 ha. Basmati is mainly grown in Jammu, Samba and Kathua districts of Jammu division of J&K state. Total area under Basmati in Jammu

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district is 49080 ha, out of which Basmati 370 has 47680 ha (97.1 %) and Pusa Basmati 1121 has 1400 ha (APEDA 2015-16). Basmati 370 variety is grown mainly in R S Pura and Suchetgarh blocks of Jammu district. Basmati 370 which is locally called as *Purani Basmati* in Jammu is the first wonder Basmati variety released during pre independence era and is still preferred because of its taste and aroma which no other variety has been able to match. Basmati 370 is regarded as geographical indicator of R S Pura region of Jammu district. Price fluctuation and non-availability of input, especially the quality seeds, have been the major hurdles in Basmati-370 production (Saha and Bharti 2014). The associated government institutions, various supporting agencies like BEDF, APEDA and number of private players are playing active role in promoting this wonder grain but still lot has to be done for the most important in this chain that is farmer, as still the productivity level of this most promising variety is below the attainable figure.

MATERIALS AND METHODS

The study was conducted in Jammu district purposively because of maximum area under Basmati rice in Jammu district. Further from Jammu district two blocks namely R S Pura and Suchetgarh were taken up due to maximum area under world renowned Basmati-370 paddy falls in these two blocks. Four villages from each block were selected randomly. A list of 400 farmers having Basmati area at least 0.5 ha was prepared from these villages. Fifteen farmers growing Basmati from each village were selected randomly with the help of random number generator. Thus a total of 120 farmers (60 from each block) were interviewed with the help of interview schedule containing open and close ended questions. The data so collected was analyzed with the help of SPSS software. Multiple linear regression model was applied for statistically analyzing the factors affecting the productivity of Basmati 370 paddy crop.

RESULTS AND DISCUSSION

Socio-personal profile of the sampled farmers was analyzed and presented in Table 1 which show that overall average age of the interviewed farmers was 55.29 years and average number of schooling years completed was 8 years. Average operational land holding was 1.28 ha which was higher than the average state land holding of 0.76 ha and average area under Basmati cultivation was 1.21 ha. Average Basmati area was higher in Suchetgarh block as compared to R S Pura block. Overall average family size was five members, whereas overall average farming experience was 35 years. Social participation was very less as only 10% sampled farmers reported having some sort of social participation and that too in village panchayats. In addition to their own decisions, private input dealers were the main source of information regarding various basmati cultivation practices. It was interesting to note that none of the farm household was exclusively dependent upon agriculture as occupation for their livelihood although they reported that agriculture is one of the major sources which contribute significantly in their household income. It indicates that farmers are in the stage of diversifying their source of households' income. P-value indicates that there was significant difference regarding average number of schooling years completed, operational land holding, area under Basmati and social participation between sampled farmers of R S Pura and Suchetgarh Block.

Data presented in Table 2 show the cropping pattern prevalent in the study area. Paddy was the main crop grown in *kharif* season, whereas wheat was the major grain and berseem (*Trifolium alexandrium*) as main fodder crop in *rabi* season. However 12.5 and 4% farmers also reported that they had grown pea and oat crop in *rabi* season also. Thirty five per cent farmers reported that they had grown summer vegetables mainly of cucurbitaceae family in *zaid*

Table 2 Cropping pattern prevalent in study area

Season	Crop	R S Pura (60)	Suchetgarh (60)	Overall (% age)*
Kharif	Paddy	60(100)	60(100)	120(100)
Rabi	Wheat	60(100)	60(100)	120(100)
	Berseem	40(66.66)	48(80)	88(73.33)
	Oat	5((8.33)	0	5(4.16)
	Pea	10(16.66)	5(8.33)	15(12.50)
Zaid	Summer vegetables	25(41.66)	18(30)	43(35.83)

*Multiple response

Table 1 Descriptive statistics of respondent farmers

Parameter	R S Pura (60)	Suchetgarh (60)	Difference	(p-value)	Overall
Average age of famers (in years)	54.62(±10.18)	55.95(±12.66)	1.33	0.457	55.29 (±11.46)
Average schooling years (No. of years)	6.40 (±3.96)	9.75(±3.73)	3.35	.000**	8.13 (±4.15)
Average operational land holding (ha)	0.97(±0.74)	1.57(±1.20)	0.60	.001**	1.28 (±1.04)
Average area under Basmati (ha)	0.90 (±0.73)	1.50(±1.20)	0.60	.000**	1.21 (±1.05)
Average family size (no.)	5.20	5.13	0.07	.911	5.16
Average farming experience (in years)	33.37(±10.26)	34.13(±13.51)	0.76	.654	33.75 (±11.95)
Social participation (yes/no)	3(5)	9(15)	10	0.067	12(10)
Input dealers as the major source of information	45(75)	40(67)	8.0	0.332	85(70.83)

Table 3 Reasons for preference of Basmati 370 variety cultivation

Preference reasons for Basmati cultivation	Frequency (percentage)
High economic returns	102(85)
Less use of chemical fertilizers	92(76.66)
Less use of plant protection chemicals	104(84.16)
More tasty in eating as compared to other Basmati varieties	120(100)
Basmati straw is palatable and nutritious for live-stocks feeding	85(70.83)

season. Thus paddy-wheat, paddy-berseem, paddy-vegetable were the main crop rotation followed by sampled farmers in study area.

Sampled farmers in study area were asked to cite their reasons for preferring Basmati 370 cultivation as compared to other varieties and have been analyzed and presented in Table 3. Hundred per cent farmers reported that more taste as compared to other varieties was the main reason for its preferred cultivation followed by high economic return (85%), less use of plant protection chemicals (84.16%), less use of chemical fertilizers (76.66%) and straw being palatable and nutritious for livestock feeding (70.83%).The farmers' preference for this is in line with the attributes of innovation (Rogers 2003), whereby the relative advantage (economic) is a predominant variable for adoption of farm technology.

Regarding adoption of various cultivation practices of Basmati 370, data presented in Table 4 shows that almost 80% farmers used last year's harvest of their farm as seed for sowing nursery.This result is in conformity with the study conducted by Peshin *et al.* (2013). Practice of seed treatment is not much popular among farmers as only 6% farmers adopted seed treatment of Basmati 370 before sowing. The present study is in conformity with the production oriented survey by Directorate of Rice Research (IIRR 2016), whereas only few farmers adopted seed treatment practice in rice cultivation in Jammu district. None of the farmers reported to use two to three seedlings per hill for transplanting as recommended. The main reason cited by the sampled farmers for this situation was that transplanting is mainly done by the hired labour and they mostly transplant single plant per hill in order to save time in uprooting the nursery. Almost hundred per cent farmers used urea and 85% farmers applied DAP in Basmati 370 cultivation. However average quantity of urea used was 75.60 kg/ha and of DAP it was 65.80 kg/ha. About 37% farmers reported that they had applied FYM after three to four years gap this year and due to which they reduce the dosages of different chemical fertilizer. The reasons put forth by the concerned farmers for this was that excessive fertilizer use in Basmati 370 causes lodging which results in less productivity.

Regarding use of herbicides, 65% farmers applied Butachlor as pre-emergence herbicide and 52% farmers also sprayed bispyric sodium herbicide for controlling weeds that grow post emergence. Use of herbicides was higher in the study area as farmers reported that weed infestation was very detrimental for rice productivity.This finding is in conformity with the study conducted by Peshin *et al.* (1997), Sheikh *et al.* (2006) and Ragasa *et al.* (2013).However none of the sampled farmers applied any insecticides and fungicides for the control of insects and disease attack as they reported that they did not observe any severe attack of any insect or disease in their Basmati 370 crop.This depicts the scope for promotion of GAP (Good Agricultural Practices) in Basmati production, as concluded by Pandit *et al.* (2017) that if benefits of adoption of GAPs are well understood by the prospective adopters, the level of awareness and the infrastructural and technological issues need to be handled in a systematic way through policy interventions in order to establish and maintain ourself in international market of basmati rice. P-value indicates that there is no significant difference between uses of different inputs in Basmati cultivation between two study blocks.

The perusal of data presented in Table 5 show that

Table 4 Adoption of different cultivation practices of Basmati 370 paddy (% farmers)

Particular	R S Pura	Suchetgarh	Difference	Z and p-value	Overall
Used own seed of Basmati 370 variety of last year harvest	50(83)	45(75)	8	1.075(0.280)	95(79)
Seed treatment	2(3)	5(8)	5	1.201(0.232)	7(6)
2-3 seedlings/hill for transplanting	0	0	0		
Number of farmers used urea	59(98)	60(100)	2	1.101(0.271)	119(99)
Average quantity of urea used (kg/ha)	65.60(±24.40)	58.20(±22.0)	7.4		75.60 (±23.2)
Farmers used DAP	50(83)	52(87)	4	0.631(0.541)	102(85.00)
Average quantity of DAP used (kg/ha)	61.66(±23.80)	68.40(±25.20)	6.74		65.80(±24.8)
FYM used (yes/no)	24(40)	20(33)	7	0.796(0.423)	44(37)
Butachlorherbicide (pre-emergence)	40(67)	38(63)	4	0.459(0.645)	78(65)
Bispyric sodium (post emergence)	30(50)	33(55)	5	0.584(0.582)	63(52.5)
Insecticide spray	0	0	0	0	0
Fungicide spray	0	0	0	0	0

Table 5 Area, production and productivity of Basmati 370 of sampled farmers

Particular	R S Pura (60)	Suchetgarh (60)	Difference	Z and p-value	Overall (120)
Total Basmati area (in ha)	53.30	92.70	39.40	.000**	146
Total production (in q)	1474.28	2673.58	1199.30		4147.86
Productivity (q/ha)	27.66 (±1.35)	28.84± (.95)	1.18	.031*	28.41 (±1.19)

overall average productivity of Basmati 370 in study area was 28.41 q/ha and average productivity was also same in both, R S Pura and Suchetgarh block of Jammu district with a difference of 1.18 q/ha. P-value indicates that there is significant difference in total area and productivity of Basmati 370 between two study blocks. It is interesting to note that some farmers in study area reported that they achieved same productivity even when they lowered the dosages of different inputs especially fertilizers. This aspect should be investigated and promoted to fellow farmers for reducing the cost of cultivation of Basmati 370 which may result in an increase of net return to farmers. Reddy and Sen (2004) conducted their study in the Sone canal command area in the state of Bihar and reported that yield of rice can be considerably improved without increasing the level of inputs in the study area if inefficiency is reduced.

Multiple linear regression model was run to work out various determinants affecting the productivity of Basmati 370. Out of different independent variables such as size of land holding, area under Basmati, seed treatment, manual weed control, total quantity of urea fertilizer used and quantity of DAP used, it was observed that quantity of DAP used significantly affected the productivity of Basamti 370 in the study area. R^2 value of 0.222 infers that 22 per cent variation in productivity of Basmati 370 variety is due to these independent variables. Similarly, Singh *et al.* (2011) reported 12.86% increase in grain yield of rice due to nutrient management only. Kumar and Nain (2013) also reported farmers' need for training in plant protection and nutrient management in rice.

Data presented in Table 7 depict the benefit cost ratio of Basmati 370 cultivation in the study area. However there was large fluctuation in Basmati 370 paddy prices in last three or four years. At the average market rate of ₹ 3500/q of Basmati 370 in study year, there was net return of ₹ 71469 /ha as reported by the sampled farmers. Thus benefit cost ratio shows the profit of 2.55/₹ invested in Basmati 370 cultivation. The present findings are different from study conducted by Dwivedi *et al.* (2011) on economic analysis of Basmati rice production in district Jammu. This difference in net return might be due to difference in market price of Basmati in 2011 and 2016.

Constraints reported by the sampled farmers in cultivation of Basmati 370 paddy were analyzed and presented in Table 8. Lodging before maturity and fluctuation in Basmati-370 prices were the main constraints as reported by the hundred per cent of sampled farmers. Other major constraints reported by the 87 and 83% sampled farmers were unavailability of suitable machinery

Table 8 Constraints reported by farmers in Basmati 370 cultivation

Constraint	Frequency N=120
Lack of other high yielding Basmati varieties	80(66.66)
Uncertainty in canal irrigation	90(75)
Lack of subsidy in installation of electric motor pump sets for irrigation	100(83.33)
Lack of suitable machinery for transplanting, harvesting and threshing	105(87.5)
Lodging before maturing or harvesting stage	120(100)
Fluctuation in market prices of Basmati 370 paddy	120(100)

Table 6 Factors affecting productivity of Basmati-370

Dependent variable	Independent variables	β	Std. error	t-value	p-value	Model summary
Productivity of Basmati 370	(Constant)	28.053	.413	67.849	.000	F-value=5.373
	Size of L and holding	-.070	.066	-1.057	.293	R^2 value= 0.222
	Total Basmati area	.068	.066	1.036	.303	Adjusted R^2 value = 0.181
	Seed treatment	-.071	.426	-.166	.868	
	Hand weeding	-.078	.228	-.343	.732	
	Quantity of urea used	.076	.085	-.343	.732	
	Quantity of DAP used	.437	.081	5.416	.000	

Table 7 Benefit cost ratio of Basmati 370 production

Total area of sampled farmers(in ha)	Total production (in q)	Productivity (q/ha)	Cost of cultivation (₹/ha)	Average rate (₹/q)	Gross return (₹/ha)	Net return (₹/ha)	Benefit cost ratio
146	4147.86	28.41	27966	3500	99435	71469	1:2.55

for various operation involved in cultivation of Basmati paddy crop such as transplanting, harvesting and threshing. Uncertainty in canal irrigation and lack of other high-yielding varieties were also the important constraints reported by 75 and 66% of respondent farmers in study area respectively. Grover (2012) reported that price variability and difficulty to access price related information were the most important marketing constraint for basmati rice. Singh and Varshney (2010) also reported that non-availability of high yielding varieties as one of the important constraints faced by the farmers. Kumar and Nain (2012) also reported lack of procurement facility and less selling price as major constraint in their study.

Conclusion

On the basis of results it may be concluded that Basmati 370 paddy is mostly preferred for cultivation over other Basmati varieties cultivated in the area. Despite good network of field extension functionaries, private input dealers are mainly consulted by farmers for obtaining information regarding agriculture. Farmers mostly prefer own saved seed for transplanting next crop. Practice of seed treatment need to be properly encouraged among farmers. Use of herbicides in paddy cultivation is a regular feature in the study area because weed infestation in paddy crop severely reduces its productivity. Use of chemical fertilizers is not very high and application of insecticides and pesticides spray is almost negligible. Except tractor there is almost negligible use of any other farm machinery in paddy cultivation. Further, it may be recommended that field extension functionaries should organize proper awareness and training programmes at proper time of paddy growing season so that farmers may adopt recommended practices and inputs to Basmati 370 cultivation in order to maintain its productivity, as well as quality for which it is world famous. Further it is also observed that use of different chemicals such as fertilizers, insecticides and fungicides except herbicides is on lower side, therefore, with the efforts of concerned stakeholders organic basmati cultivation can be promoted in the study area which will further enhance its future prospects. Thus good agricultural practices (GAPs) for organic cultivation of Basmati 370 may be promoted for increasing its sustainability both at national as well as international level which will result in appropriate return of farmer's expenditure in Basmati 370 cultivation.

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