Varietal Developments and Technology Adoption: An Econometric Approach for Haryana Paddy Production

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ABSTRACT

Haryana state has attained a significant position in overall rice production of India. Past decade has witnessed noticeable change on the front of Varietal Developments and Technology Adoption. In this regard present study is an attempt to see that how Haryana paddy producers have responded to the technological changes and to what extent these advancements have affected the yield potential of paddy in the region. In the present study a sample of around 150 respondents from more than 15 villages from the Kaithal and Kurukshetra districts of Haryana was taken since these two areas contribute around one fourth of the total paddy production in Haryana. Data analysis showed that over the last decade, farmers in this region have showed inclination towards growing hybrid and high yielding varieties instead of conventional varieties having lower yield. It is empirically found that that adoption of improved paddy technologies and practices increases the paddy yield. The study does not find the significant impact of package of practices (POPs). The possible reason is that the measurement of POPs is based on input usage of fertilizers and pest controls. Lower usage of these inputs combined with higher use of mechanization is considered as enhanced POPs. Present study finds negative effect on yield for POPs. It is regarded that Haryana has been exposed with high usage of fertilizers which might have degraded the soil fertility.

I. INTRODUCTION

Agriculture sector has been the major contributor in economic fundamentals for Indian economy. The sector absorbs around 60 percent of manpower, and contributes about one fifth of the national output. Its prominence is heightened when ensured food security has remained the focal point of development economics. Herein the sustained agriculture growth is of paramount need to attain the food security targets along with the improvement in the livelihood of the large chunk of human resources. In order to accelerate the pace of agricultural production, the major thrust for national policies was directed towards enhancing the cereals output. A significant attention has been paid to improvise the technology in the field of agriculture. In the economic literature the role of technology in agricultural production is witnessed in terms of enhanced yield, higher profits, sustained production, etc. As per the OECD literature, technological change is considered to be most

influential factor for agricultural productivity and development.[1] The adoption of System of Rice Intensification (SRI) method for paddy production has been visible across globe as approximately 4-5 million farmers are using this method. This has possible implications for alleviating the farmers' risks through lower input cost and enhanced yields, ultimately dealing with the issues of food security, obtain surpluses, and avoid indebtedness.[2] As per the Indian Council of Agricultural Research (ICAR), the packages of technologies have increased the yield by 15-20 percent, coupled with reduced cost of cultivation led to an overall higher net profit of minimum Rs.12500 per hectare.[3] Present study gets motivation from the above facts and tries to quantify the adoption of technology among paddy farmers at micro level and also aims to assess the impact of new technologies launched in terms of varietal development and enhanced package of practices.

As per Ministry of Agriculture estimates, total Food grain production in India reached to 272 million tonnes in 2016-17 which is higher by 7 million tonnes than the previous record production of foodgrain of 265.04 million tonnes achieved during 2013-14. Amid cereals output, paddy occupies significant position and has experienced transformation in India through rapid technological advancements. India is the world's largest producers of white rice and brown rice, accounting for 20% of all world rice production. The rice production in India reached to a record high of 109 million tonnes in 2016-2017 crop year. However, a wide variation has been noticed in paddy production across regions of India. As a case, state Haryana is primarily an agricultural state absorbing about 70 % of residents and attaining second position in food grain production in the country even if covering less than 2 percent of the total geographical area of the country. Haryana is blessed with irrigated facilities as net irrigated area to the net sown area stands at 80 percent compared to 32 percent of national average. In case of food grain production, the state has enjoyed the exceptional growth from production of 2.59 million tons in 1966-67 to 16.2 million tons in 2010-11. Rice production in Haryana crossed 4 million tonnes in 2014-15.[4] Also, basmati rice is the pride possession of the state. According to Kisan Ayog[5], the paddy favorable zones includes the districts of Kaithal, Karnal, Kurukshetra, Ambala, Yamunanagar, Panipat, Sonipat, Panchkula, Sirsa, Fatehabad, Hissar, Jind, Rohtak, Mewat and Faridabad. Kurukshetra and Kaithal combined produced around one fourth of the state's total paddy cultivation (0.943 million tonnes) in 2014-15.

II. REVIEW OF LITERATURE

The role of technology adoption in agriculture has been observed in terms of increased production and income (Nweke and Akorhe, 2002), ending poverty and food insecurity (Besley and Case, 1993); Mendola (2007). The effect of agricultural technology is also identified in terms of catch-up effect for developing countries (Foster

[1] OECD (2001). Adoption Of Technologies For Sustainable Farming Systems Wageningen Workshop Proceedings, Organisation For Economic Co-Operation And Development

[2] Jonathan Latham (December 3, 2012). How Millions of Farmers are Advancing Agriculture for Themselves, Independent Science News, A publication of Bioscience Resource Project

[3] ICAR-Central Plantation Crops Research Institute, Kasaragod

[4] Ministry of agriculture, Government of Haryana

[5] Kisan Ayog – Haryana State Agricultural Policy – A Draft (Government of Haryana)

and Rosenzweig, 2010). Datt and Ravallion; 1996 and Hossain; 1992 highlighted the role of improved technologies in enhancing the yield of crops. New technology adoption enhances the technical and economic efficiencies in terms of maintaining the same output from reduced inputs and attaining higher output with lower production costs.

The prominent studies capturing the adoption of agricultural technology include Rogers, (2003); Sunding and Zilberman, (2001); Feder and Umali, (1993). Adoption of agricultural technology depends on a range of personal, social, cultural and economic factors as well as on the characteristics of the innovation itself (Pannell *et al.*, 2006; Prokopy *et al*., 2008; Challa and Tilahun, 2014). The rate of adoption of a new technology depends on its profitability, the degree of risk associated with it, capital requirements, agricultural policies, and socio-economic characteristics of farmers.[6] Other factors for technology adoption include credit facilities, rice farm size, extent of commercialization, etc. Shidded (2005) measured the technology adoption rate, degree of adoption and intensity of adoption for Iraq and concluded that farm size and profitability, among others, play the most important role for performance indicators of technology.[7] Aslam (2015)[8] utilized the regression model on cross section data collected through sample survey in Ampara district in Sri Lanka and found that factors such as labor use, field extension, fertilizer usage, pesticide usage, seeds, weedicides and quality of seeds significantly affects the paddy output. Abdullah and Samah (2013) considered the role of education and perception of crop producers, extension management and geographical conditions for technology adoption. Bhatia (2016)[9] highlighted the contribution of livestock in organic paddy cultivation for districts Kaithal, Kurukshetra and Karnal. It was also concluded that variables like age, education, land holding, occupation, innovative-ness jointly contributes the three fifth variation in adoption of organic paddy cultivation in Haryana.

New crop varieties have two parallel impacts one is to enhance the yield and second is to reduce the costs through optimal input combinations[10], and thereby making the crops profitable. Lin (1994) has utilized the Cobb-Douglas function approach[11] due to its ease of estimation and interpretation, and explained that the productivity improvements are associated with the varietal developments. Thus, an understanding of the effect of new varieties on crop output puts forth ample scope for enquiry for potential diffusion of the technology among farmers. A new technology will not be acceptable to farmers unless it raises productivity. In this study, we attempted to examine to what extent yield has increased by the introduction of improved varieties and

[6] Kamil H. Shideed and Mohammed El Mourid (2005).Adoption and Impact Assessment of Improved Technologies in Crop and Livestock Production Systems in the WANA Region, International Center for Agricultural Research in the Dry Areas

[7] https://ispc.cgiar.org/sites/default/files/pdf/297.pdf

[8] Al. Mohomed Aslam(2015), An econometric analysis pf factor affecting on th paddy cultivation in ampara district, second Internation symposium.

[9] Rajesh Bhatia (July 2016) A study of organic paddy farming in Haryana, International Journal of Agricultural Sciences

[10] Lower usage of inputs such as seed rate, less pest controls, lower fertilizers

[11] Translog production has limitations of constant returns to scale and possibility of multi-collinearity problem.

package of practices, and also to estimate the econometric model to substantiate the argument. The study examines the impact of improved technology and package of practices on yield potentials for paddy growers.

III.SOCIO-ECONOMIC STATUS OF PADDY PRODUCERS

Before explaining the technology adoption and technology impacts, study presents the socio-economic profile of rice producers in Haryana. In the present study a sample of around 150 respondents from more than 15 villages from the Kaithal and Kurukshetra districts of Haryana was taken since these two areas contribute around one fourth of the total paddy production in Haryana. Socio-economic variables such as age, education and household size play vital role for adoption of new technology. Younger farmers may be more receptive to newer technology, and older farmers may have rich experience and possibility to make the right decisions on adoption of new technology (Langyintuo and Mungoma, 2008). Education helps with the ability to understand and manage new and unfamiliar technology. Sometimes higher education may result into exploration of more off-farm activities and hence negative relation with adoption of technology (Uematsu and Mishra, 2010). Farm size has significant effect as large farmers have much ability to realize the new technology (Doss, 2006). Sometimes smaller farmers may also adapt the technology fast as they are under pressure for subsistence.

Table 1: Land Holding Pattern for Sampled Paddy Producers

Category	Respondents (No.)	Respondents (%)
Marginal	1	1
Small	25	17
Semi Medium	53	36
Medium	45	30
Large	25	17
Total	149	100

Source: Author's Calculation

It is observed that only 1 respondent was lying under the category of marginal land holdings (holding below 1 hectare); 17% farmers were holding the small land (1-2 hectares); 36% of respondents were in the semi-medium category (2-4 hectare) and 30% farmers were holding the medium land (4-8 hectare). Also, a significant amount of respondents, 17% were holding the land more than 8 hectares. This distribution signifies that majority (around 65%) of farmers hold land in between semi-medium and medium category, which implies that they are the middle class farmers, having agriculture as their main occupation.

Ozor and Madukwe (2005) stated that education helps in adopting improved agricultural technologies. In this regard the educational background of the respondents reveals that very few (less than 3 percent) respondents either had never been to school or could not complete their primary education. Around two fifths farmers have educational qualification up to primary level. Around fifty percent of respondents have education level in between matriculation and graduation. About 15% of the total respondents managed to secure their graduation

certificates also. The education status indicates that majority of the farmers are educated and have capabilities of understanding technological advances.

Table 2: Education and Working Experience of Sampled Paddy Producers

Education			Working Experience		
Classification	Respondents	Respondents (%)	Classification	Respondents	Respondents (%)
Uneducated - 4th class	4	3	0 – 10	15	10
5th class - 9th class	66	44	11 – 20	45	30
10th class – Graduation	77	52	21 – 30	56	38
Above Graduation	2	1	31 – 40	28	19
Total	149	100	Above 40	5	3
			Total	149	100

Source: Author's Calculation

In terms of farming experience 10 % respondents have experience of about 10 years or less, 30% farmers have their experience in between 10 to 20 years, 38% have gained a quite handsome experience of 20 to 30 years and 22% respondents successfully manage to get the experience of more than 30 years. Experience Distribution stated that majority of the farmers around three fifth had an experience more than 20 years which is decent for the seed selection, adopting the new technology (Table 2).

In fact varieties are selected by farmers on ground of better yield, resistance to pests and lower chances of shattering in adverse climatic conditions. On ground of shattering loss, farmers reported that losses vary between 10 to 50 percent. Majority of the respondents (around one third) were experiencing the loss between 21-30% (Table 3). So it can be inferred that paddy production is subject to the risk of adverse natural hazards.

Table 3: Shattering Loss for Paddy across Farmers

Loss Distribution	No of Respondents	Percentage of respondents
0 – 10	1	1
11 – 20	35	23
21 – 30	49	33
31 – 40	40	27
41 – 50	15	10
51 – 60	7	5
Above 60	2	1
Total	149	100

Source: Author's Calculation

Allied agricultural practices also offer the added income to the farmers. It is observed from the below table that farmers have reduced the number animals in their houses in past decade. It is found that around 16 percent farmers used to have milk giving animals during 2005-06 whereas the proportionate has come down to less than 10 percent in 2015-16. It may be linked that farmers might have been benefitted by enhanced yield of technological advancements and accordingly rely less on the allied income mainly generated through milk giving animals.

Table 4: Distribution of Milk Giving Animals

	Respondents (No.)		Respondents (%)	
Range	2005-06	2015-16	2005-06	2015-16
0-5	117	135	78	91
6-10	24	13	16	9
11-15	5	1	3	1
16-20	2	0	1	0
21+	1	0	1	0

Source: Author's Calculation

IV. RESEARCH METHODOLOGY

4.1. Sample Selection

The study is based on primary data for the agriculture year 2015–16 from a sample of 150 farmers using random sampling approach. Data was collated through field survey as it enables to maintain the authenticity of the sample data. Data sample was selected from more than 15 villages in Kurukshetra-Kaithal paddy belt. Since most of farmers in a village grows the similar types of varieties and hence sample size was confined to maximum 7-8 farmers in a village. The survey collected detailed information regarding age, education, working experience, land holding, varieties grown, package of practices etc. Timing of visit in any village was crucial factor as farmers remained busy working during morning and late evenings, which restricted the sample size. Farmers were open in sharing the package of practices for paddy production.

4.2. Research Methods

Study employs descriptive approach as well as econometric method to fulfill the stated objectives. Existing literature mentions that technology adoption can be measured through adoption rate- the percentage of farmers adopting the technology; degree of adoption- the proportion of land under the new crop; and intensity- the quantity of modern inputs used, for example, the amount of fertilizers per unit area.

4.3. Technology Adoption: Descriptive Approach

To indicate the technology adoption, the study considers two dimensions- utilization of machines and shown area for the new varieties. In terms of machine usage, it is found that 18% respondents were using machines in the range of 1 to 6 numbers, 55% were using 6 to 8 machines and 27% farmers were utilizing more than 8 machines for paddy production. The machines include like tractor, reaper, cultivator, rotavator, planker, combine, laser leveler. This distribution depicts that majority of the respondents around four fifths are fully equipped with the latest machines which shows the good signs of technology adoption.

Table 5: Distribution of Machines across Paddy Growers

Number of Machines	Respondents (No.)	Respondents (%)
Less than 6	27	18
6 – 8	82	55
More than 8	40	27
Grand Total	149	100

Source: Author's Calculation

Another parameter for technology adoption is the usage of new varieties in place of traditional Basmati or PR varieties. This practice can improve the seed quality, yield and can have the greater income incentives. According to the distribution extracted from our database, only 27% farmers are cultivating the traditional basmati crop. 28% of the respondents are growing the PUSA-1121 and PUSA-1509 varieties which offer higher yield and improves the profit margins.

TableDistribution of Rice Varieties (2015-16)

Varieties	Area (hec.)	Area (%)
Pusa-1121	381.6	19.5
Basmati	272.7	13.9
Basmati-30	241.8	12.3
Pusa-1509	165	8.4
Sava-27	105.2	5.4
Pr-14	100	5.1
Pr-124	76.3	3.9
Pr-127	63.2	3.2
Muchal	57.1	2.9
Basmati Varieties	530.2	27.1
Non Basmati Varieties	1429.1	72.9
Pusa Varieties	546.6	27.9

Source: Author's Calculation

4.4. Impact of Technology Adoption: Econometric Approach

An appropriate technique for determining the impact of varietal developments' technology on productivity is the regression analysis. A Cobb-Douglas production function was identified and estimated. The impact of the improved paddy varieties on the yield was estimated by adding a dummy variable to the function.

The general specification of ordinary least square technique for cross-sectional data is as follows:

$$G_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \varepsilon_i \quad (1)$$

Where i subscript is for each individual unit. G is the dependent variable (paddy yield per hectare) and X_is are explanatory variables. This model assumes orthogonal condition of no correlation between error term and independent variables.

In the present study, varieties grown by respective farmers are classified into three groups- basmati, hybrid and non basmati non hybrid. Hybrid varieties are mainly designed to enhance the yield of paddy and basmati varieties mainly enjoy the market based on their quality rice. Having three categories, study considers two dummy variables to avoid the dummy trap. The functional form for the impact of varietal development is defined as:

Yield = F(Rice area, farming experience, education, dummy for varieties, machine usage, fertilizer usage and pest control)

$$G_i = \beta_0 + \beta_1 X_{1i} + \beta_2 D_{2i} + \beta_3 D_{3i} + \varepsilon_i \quad (2)$$

Two dummy variables are included in the model for hybrid and non-basmati non hybrid paddy varieties. The estimated coefficient of the dummy variable measures the shift in the intercept of the production function as a result of the improved varieties. Here β_0 is the intercept term and covers the yield for basmati yield. X_{1i} is the set of explanatory variables consisting rice area, working experience of farmers, education in number of years, other inputs such as fertilizers usage, pesticide numbers and number of machines.

In order to have the impact of POPs, the study utilizes following functional form:

Yield = F(Rice area, farming experience, education, varietal development and dummy of package of practices)

So far there is no formal index for package of practices, present study has made an attempt to define the package of practices through interaction of utilization of machine, fertilizers and pesticides. A farmer using more than the average number of machines and less than the average number of fertilizer bags and pest control is classified as relatively equipped with better package of practices and assigned value 1 in the dummy variable. For the rest value 0 is assigned.

V. RESULTS AND DISCUSSION

The results revealed that adoption of improved paddy technologies and practices increases the paddy yield. An analysis of the determinants of adoption with multiple regression models showed that hybrid, non-basmati and basmati varieties play important role for enhancing yield of paddy. It is observed that hybrid varieties have about 5.5 qt higher yield than the basmati yield (Table 6). Similarly the non-basmati varieties have higher yield by 12 quintals per acre than the basmati yield. It is noticed that higher price for Basmati in 2013-14 prompted the paddy growers to align the interest with this variety, however with drastic fall in the rates of several basmati varieties discouraged the farmers to go for Basmati varieties 1509 and 1121, rather forced them to go with PR-14, PR-13, 14, 27, 45, 127 and hybrid varieties.[12] Surprisingly the mechanization has not been identified as significant factor for yield though the coefficient value has expected sign. Rice area and education also have positive slope and working experience has negative slop. But both the indicators are statistically insignificant. Factor inputs such as fertilizers and pest control do not influence the yield significantly. In model 5 the impact of improved package of practices has been considered (Table 5). In fact the coefficient value has negative sign though statistically insignificant. It may indicate that the lesser usage of fertilizer inputs and pest control somehow lowers the yield. It can also be concluded that Haryana has been exposed as more usage of fertilizer which might have degraded the soil fertility and in order to get higher yield more input usage is required. From the estimated coefficient of varietal development as proxy of technology adoption in all the models, it can be interpreted that paddy yield has improved considerably for hybrid and non-basmati varieties.

Table 6: Determinants of Paddy Yield

	Model 1		Model 2		Model 3		Model 4		Model 5	
Variable	**Coefficient**	**P-Value**	**Coefficient**	**P-Value**	**Coefficient**	**P-Value**	**Coefficient**	**P-Value**	**Coefficient**	**P-Value**
Rice area	0.012	0.715	0.007	0.834	0.004	0.899	0.017	0.708	0.023	0.482
Experience	-0.027	0.532	-0.033	0.445	-0.034	0.431	0.000	0.997	-0.022	0.609
Education	0.136	0.297	0.146	0.262	0.146	0.266	0.371	0.029	0.142	0.277
Hybrid (D2)	5.511	0.000	5.416	0.000	5.415	0.000	-	-	5.258	0.000
Non-basmati (D3)	12.149	0.000	12.122	0.000	12.105	0.000	-	-	11.780	0.000
Machine	0.524	0.115	0.542	0.103	0.534	0.110	-0.107	0.804	-	-

[12] The price for 1509 and 1121 were Rs 1,300-1,400 and 1500-1600 per quintal, respectively in 2015-16, as compared to Rs 2,500 and Rs 2,300 in 2014-15.

Fertilizer	-	-	0.707	0.233	0.695	0.243	0.779	0.314	-	-
Pest Control	-	-	-	-	0.174	0.771	0.697	0.370	-	-
Constant	11.127	0.001	9.457	0.008	9.189	0.013	15.534	0.001	15.582	0.000
POP									-1.088	0.145
F (6, 243)	30.990		F (7, 242)	26.820	F (8, 241)	23.390	F (6, 243)	1.360	F (6, 243)	30.890
Prob > F	0.000			0.000		0.000		0.231		0.000
Adj R^2	0.420			0.421		0.418		0.009		0.419
Root MSE	5.805			5.800		5.811		7.586		5.809

Source: Author's Calculation

VI.CONCLUSION

India is leading producers of white rice and brown rice in the World, accounting for 20% of all world rice production. The India's rice production reached to a record high of 109 million tonnes in 2016-2017 crop year. Haryana is currently one of India's superior paddy producing states. Agricultural year 2014-15, saw Haryana registering a record 4 million tonnes mark in overall rice production. In the present study a sample of around 150 respondents from more than 15 villages from the Kaithal and Kurukshetra districts of Haryana was taken since these two areas contribute around one fourth of the total paddy production in Haryana. Data analysis showed that over the last decade, farmers in this region have showed inclination towards growing hybrid and high yielding varieties instead of conventional varieties having lower yield. It is empirically found that that adoption of improved paddy technologies and practices increases the paddy yield. The study does not find the significant impact of package of practices (POPs). The possible reason is that the measurement of POPs is based on input usage of fertilizers and pest controls. Lower usage of these inputs combined with higher use of mechanization is considered as enhanced POPs. Present study finds negative effect on yield for POPs. It is regarded that Haryana has been exposed with high usage of fertilizers which might have degraded the soil fertility. In sum up, that paddy yield has improved considerably with varietial developments. The study suggests for utilization better package of practices in paddy production mainly System of Rice Intensification technique to take the full swing advantage of technological advancements.

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