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Influence of Sources of Seed on Varietal Adoption Behavior of Wheat Farmers in Indo-Gangetic Plains of India

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Abstract

Seed is the most crucial input in the crop production cycle. Although new seed varieties are developed and released frequently, they often do not reach the farmers because of underdeveloped and inefficient seed delivery system. This paper is based on the primary survey of 1200 farmers in the five states in the Indo-Gangetic Plains, and has analysed the various factors responsible for the adoption of new wheat seed varieties by the farmers. Besides socio-economic factors, one of the main factors that impact the adoption of new seed variety is the source of purchase of seed. A multinomial logit model has been used for the analysis. As quality control and timely availability of seed is a necessary condition for proper uptake of new varieties, the paper has emphasized on the need to strengthen public-private partnership in production and distribution of seed. The study has suggested wide disseminatation of information on new seed varieties along with their benefits through appropriate institutional mechanims.

Key word: Indo-Gangetic Plains, multinomial logit, sources of seed, wheat seed variety, seed adoption, seed sources

JEL Classifications: Q10, Q12, Q13, Q16

Introduction

The availability of quality seeds of modern varieties is the base to increase grain production in land-scarce developing countries like India. The varietal development in wheat has contributed towards improving its productivity and production in the country. The All India Coordinated Wheat and Barley Improvement project has released 373 wheat varieties for different environmental and production conditions (Waddington *et al*., 2012). Out of these, only a few varieties cover a significant area (Nagarajan, 2005) and the rate of shifting from one variety to other is slow even in the states like Punjab (Smale *et al*., 2008) where wheat seed delivery system is well-developed. Even the varieties with superior traits are not becoming popular because the state machinery is ill equipped or is not able to appreciate the value of technology (Yadav *et al*., 2010).

Farmers' decisions on adopting a new variety or continuing with the old variety are guided by many factors like market forces, economic status, government programme or policies, etc. Based on some such specified set of variables, it is possible to estimate the probability of farmers' decision on adoption of a particular type of variety. This paper has tried to understand the farmers' perspective towards adoption of new varieties of wheat with the following specific objectives:

- To identify the pattern in adoption of different wheat varieties used by farmers.
- To find the relationship between varietal adoption and sources of seed, and

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- To estimate the role of different factors in influencing farmers' decisions on adoption of a particular variety.

Data and Study Area

For this study we have used the data collected by CIMMYT-India through a primary survey of 1200 farming households of which 1070 were wheat growers from the Indo-Gangetic Plains (IGP) of India. The IGP is the food bowl of India with five major states, viz. Bihar, Haryana, Punjab, Uttar Pradesh, and West Bengal. It contributes about 51 per cent (2009-10) to the total foodgrain production of the country (Ministry of Agriculture, 2011). The survey was conducted during January-March 2011 in selected villages of these five states. This area of IGP shares common characteristics of fertile soil, availability of irrigation water and rice-wheat cropping pattern. This track has been the sheet of green revolution, of which one of the major features was the development and diffusion of high-yielding varieties (HYVs) of cereal crops, mainly of rice and wheat.

The multi-stage sampling technique was used for selecting states/district/villages and households. Four districts were chosen in each state based on their geographical locations. In each district, six villages and in each village, ten households were randomly selected. The survey collected information mainly related to three major crops, viz. wheat, rice and maize. In addition, information related to demographics, landholdings, crops being cultivated, area allocated to different crops, and sources of seed and inputs was collected using a structured questionnaire. In this paper, we have used data related to wheat cultivation. A brief description of the socio-economic indicators of the selected states is given in Table 1.

There are wide inter-state disparities across states in India. Punjab and Haryana are the most prosperous states considering the standard of living proxied by per capita income level, whereas Uttar Pradesh and Bihar are the highly populated states. The contribution of West Bengal to total agricultural Gross Domestic Product (GDP) of India is the least among these five states.

The study area is a heterogeneous mixture of farmers with different socio-economic characteristics. The demographic characteristics, land ownership and area under wheat are presented in Table 2. The average age of respondent-farmers was found to be 43 years on overall basis; it was maximum in Bihar (45 years) and minimum in Punjab (40 years). Regarding literacy levels, most of the farmers were literate with minimum secondary and high school education; only 13 per cent of them were illiterate.

In the study area, the maximum number of farmers fell in the semi-medium farm-size category (4.94 -9.88 acres) with average landholding of 5.75 acres. Among

Table 1. Socio-economic indicators in the selected states of IGP

State	Population (in millions)[1]	Per capita income (₹)[2]	Rural literacy rate (per 100 persons)[1]	Share of agriculture in total GSDP (%)[2]	Wheat[3]			
					Area (million acre)	Production (Mt)	Yield (q/acre)	Irrigated area in 2009-10 (%)
Bihar	103.80	14654	43.92	18.29	5.42	4.57	8.27	91.7
Haryana	25.35	77878	63.19	18.13	6.16	10.50	17.77	99.3
Punjab	27.70	61035	64.72	28.53	8.70	15.17	18.06	98.6
Uttar Pradesh	199.58	22558	52.53	23.20	23.88	27.52	12.15	97.8
West Bengal	91.35	36322	63.42	17.00	0.78	0.85	10.08	74.0
All India	1210.19	46117	43.92	14.7	70.29	80.80	11.77	91.3

Note: Per capita income is at current price, GSDP= Gross state domestic product

Sources: 1. Census of India (2011)

2. Central Statistical Organization (2010)

3. Ministry of Agriculture (2011)

Table 2. Socio-economic characteristics of wheat-growing farmers surveyed in IGP

Variable	All states	Bihar	Haryana	Punjab	Uttar Pradesh	West Bengal	P-value
Age category (years)							
Less than 25	126	11	20	46	35	14	
26 - 40	394	100	93	100	62	39	
41 - 55	343	80	87	54	78	44	
More than 55	203	48	40	40	60	15	
Mean age	43	45	43	40	44	41	0.00
Educational level (years of schooling)							
Illiterate	136	11	34	38	44	9	
Primary schooling	188	32	41	61	29	25	
Secondary & high school	609	141	146	122	134	66	
Graduate & above	134	56	19	19	28	12	
Landholdings (acres)							
Marginal (less than 2.47 acres)	341	80	32	24	127	78	
Small (2.47-4.94 acres)	331	81	55	109	59	27	
Semi-medium (4.94-9.88 acres)	229	58	76	55	33	7	
Medium (9.88-24.7 acres)	135	20	62	39	14	0	
Large (more than 24.7 acres)	31	1	15	13	2	0	
Mean size of landholdings (acres)	5.75	4.42	9.64	7.19	3.42	2.07	
Average No. of plots	2.92	3.99	2.40	1.33	2.80	5.40	0.00
Average area under wheat (acres)	4.06	2.41	6.80	6.54	2.08	0.64	0.00
Average area of largest plot under wheat (acres)	4.89	1.25	7.51	5.37	2.39	0.46	0.00
Number of information sources used	4.00	2.63	6.22	4.83	3.25	1.96	0.00

Note: P-value has been derived from Kruskal –Wallis test
Source: CIMMYT Survey (2011)

Table 3. Gini coefficient for inequality in total land area and area under wheat

Area	Bihar	Haryana	Punjab	Uttar Pradesh	West Bengal	Overall
Total area (acres)	0.39	0.49	0.45	0.52	0.35	0.51
Area under wheat (acres)	0.29	0.53	0.41	0.51	0.37	0.53

Source: CIMMYT Survey (2011)

these states, largest landholding was in Haryana (9.64 acres), followed by Punjab (7.19 acres). West Bengal had the smallest size of landholding with average area of 2.07 acres. A wide difference was also observed in age, number of plots and area under wheat. The Kruskal Wallis test also indicated a significant difference among the socio-economic characteristics of the studied states ($p < 0.00$), confirming prevalence of disparities across the studied region.

Adoption of agricultural technology including modern varieties is influenced by the resources available with farmers, the land being an important resource. In the study area, the land resource is unequally distributed and was confirmed by the Gini coefficient (GC) presented in Table 3. It can be inferred from Table 3 that the inequality in land distribution was maximum in Uttar Pradesh (0.52), followed by Haryana (0.49) and Punjab (0.45). The land was found

to be more equally distributed in West Bengal with Gini coefficient of 0.35.

Empirical Specification

To assess the role of different socio-economic factors in farmers' adoption behaviour towards different seed varieties, we deployed multinomial logit model. Multinomial logit models comprise multi-equations which allow consideration of several discrete alternatives at the same time. If there are 'n' different alternatives, we need 'n-1' dummy variables to describe the choice, with each dummy equalling one only when that particular alternative is chosen (Studenmund, 2011). One of the underlying assumptions of multinomial logit models is independence of irrelevant alternatives, i.e. error-terms of the choice equations are mutually exclusive (Greene, 2003). In a multinomial logit, one alternative is selected as the 'base or reference' alternative, and then every other possible choice is compared to this base alternative with a logit equation. We considered farmers' adoption behaviour towards three different categories of wheat seed variety, the reference category used here was 'intermediate seed variety'. The probability of a farmer adopting a specific wheat seed variety (Y = 1) from a particular seed variety category estimated using multinomial logit model can be specified according to Greene (2003) as:

$$P_{ji} = P\,(Y_i=j|X_i \text{ given } S)=\frac{e^{X'\beta}}{1+\sum_{j=1}^{J} e^{X'\beta}} \text{ , for } j = 1 \qquad \ldots(1)$$

where,

P = Probability that a seed is used from a particular seed variety category,

i = Individuals, i.e. farmers (1, ..., 1067),

j = Category of seed variety (1,...,3),

S = Base category, i.e. intermediate seed variety category,

â = Vector of parameters, and

X = A set of core explanatory variables such as age, educational level, farm-size used for wheat area (in acre), number of information sources (such as television, krishi vigyan kendra, radio, mobile phone based models, etc.), and different sources of seeds (viz. own source, market or government). The description of the explanatory variables is presented in Appendix I.

Differentiating Equation (1) with respect to each explanatory variable provides marginal effects of the explanatory variables. Marginal effects, often used to assess the impact of exogenous variables on explanatory variable, can be represented as:

$$\frac{\partial P_j}{\partial x_j} = P_j(1-P_j)\beta_{ji} \qquad \ldots(2)$$

where, Pj is the probability of selecting seed of a particular category variety. The marginal effect of x on alternative j involves not only the parameters of j but also the ones of all other alternatives. Hence, the marginal effect need not have the same signs of β_{ji}.

Farmers' Adoption Behaviour of Different Seed Varieties

Farmers responded on the use of varieties in the year 2010, land allocated to a particular seed variety, production from allocated land, source of seed of that variety, and number of years since they were using this variety. The farmers were cultivating up to three varieties of wheat. In overall, 27 wheat varieties were being cultivated by the sample farmers. Among the 1067 sample farmers, 254 farmers had adopted two varieties and only 36 farmers had opted for three wheat varieties. The brief profile of varieties and number of farmers adopting it is given in Table 4.

Although the surveyed farmers were using 27 varieties of wheat, among these a few varieties were being used by one or two farmers only. For statistical analysis of behaviour pattern, we considered only those varieties which were being used by at least 15 farmers and information about only their largest plot was used for the further study.

With this limitation, we were left with only 11 varieties of wheat. To assess the farmers' adoption behaviour towards different varieties, we further grouped them into three categories according to the year of their release till 2010: Old variety (Category I : more than 25 years old), intermediate variety (Category II: between 25 and 10 years old) and modern variety (Category III: less than 10 years old). These are presented in Table 5.

Table 4. Profile of wheat seed varieties used by farmers surveyed in IGP

Name of wheat seed variety	Plot 1	Plot 2	Plot 3	Year of release
K-68	2			1962
SHARBATI			1	1967
SONALIKA	60	4		1967
UP 262	106		1	1977
LOK 1	3		1	1981
HD 2285	2			1984
HD 2329	9	5	1	1985
KUNDAN DL-153-2	17			1985
PBW 154	22	7		1988
HD 2380	1		1	1989
PBW 226		1	1	1989
WH 542	5	6	2	1992
WH 896	1			1994
PBW 343	529	58	4	1995
RAJ 3765			1	1995
PBW 373	16	23	3	1996
HD 2687	9	7		1999
HD 2733	22	3	1	2001
WH 711	78	33	4	2001
PBW 502	102	51	7	2004
PBW 509		2		2004
HD 2851	1	5		2005
DBW 17	44	19	4	2006
HD 2894	7	1	2	2008
HD 2932		8	1	2008
PBW 527	10			2008
PBW 550	24	21	1	2008
Total	1070	254	36	

Source: CIMMYT Survey (2011), Personnel communication with scientist in Directorate of Wheat Research, Karnal

A perusal of Table 5 reveals that the variety PBW 343 was most popular in the Indo-Gangetic Plains. More than 50 per cent of farmers were cultivating this variety and it covered around 53 per cent of total area under wheat. In the seed variety category I (> 25 years old), UP 262 was being cultivated by the maximum number of farmers (105) and it covered around four per cent of the wheat area. The seed variety category III (< 10 years old) covered around 35 per cent of the wheat area and PBW 502 was the variety most popular, which was being opted by more than 10 per cent of farmers and covered area of 9 per cent under it.

Empirical Results

The predicted probabilities estimated using multinomial logit regression and the marginal effects of explanatory variables are reported in Table 6. The intermediate wheat seed variety category II (10-25 years old since release) were taken as the "reference category." The results revealed that explanatory variables in the model significantly explained the determinants of adaptation behaviour of farmers to different varieties in the study area. The Chi-square value of 273.58 associated with the log likelihood ratio was significant ($p < 0.01$), suggesting strong explanatory power of the model.

The study has found that most of the socio-economic and cultivation-related variables were significantly and negatively related to Category I, implying that an increase in such variables will decrease the probability of farmers choosing these varieties for production. Also, the marginal affect of variables showed a clear pattern across the two varieties, i.e. Category I and Category II.

Socio-economic Factors

Age of the farmer was positively related to adoption of a new variety but negatively to old variety, suggesting that as farmers' age advances they are more likely to adopt a new seed variety. This is different from the conventional/expected results. A similar finding was reported by Samal *et al*. (2011) for the adoption of modern seed variety of rice. One plausible reason for this could be that our surveyed farmers were in the average age of 43 years. Educational status was another distinguishing variable for judging the farmers' behaviour towards adoption of varieties. The educational status, though not significant, was negative for Category I and positive for Category II, suggesting that the educated farmers are more likely to adopt a new seed variety as education helps them to understand and utilize new/updated information for their yield maximization. These results are in accordance with the observations of Rahm *et al*. (1984) on the adoption of reduced tillage technology.

Farmers' total landholdings always serve as a good proxy for their economic status. The proportion of total land allocated to a specific crop signifies the importance of that crop accorded by a farmer relative to other crops grown. This variable also signifies indirectly the role

Table 5. Wheat seed variety used by farmers and their sources

Wheat seed variety	Used by farmers (No.)[a]	Area (acre)[b]	Sources		
			Own and other farmers[c]	Markets[c]	Cooperative and government agencies[c]
>25 years since release: Category I					
SONALIKA	60	38.74	21	39	0
	(5.94)	(1.15)	(35.00)	(65.00)	(0.00)
UP 262	105	142.00	10	88	7
	(10.40)	(4.22)	(9.52)	(83.81)	(6.67)
KUNDAN DL-153-2	17	77.25	5	10	2
	(1.68)	(2.29)	(29.41)	(58.52)	(11.76)
Between 10 to 25 years since release: Category II					
PBW 154	21	41.20	7	10	14
	(2.08)	(1.22)	(22.58)	(32.26)	(45.16)
PBW 343	520	17844.19	180	281	59
	(51.49)	(52.97)	(34.62)	(54.04)	(11.35)
PBW 373	19	36.12	2	10	7
	(1.88)	(1.07)	(10.53)	(52.63)	(36.84)
<10 years since release: Category III					
HD 2733	21	56.22	3	18	0
	(2.08)	(1.67)	(14.29)	(85.71)	(0.00)
WH 711	84	438.20	39	34	11
	(8.32)	(13.01)	(46.43)	(40.48)	(13.10)
PBW 502	102	313.70	18	79	5
	(10.10)	(9.31)	(17.65)	(77.45)	(4.90)
DBW 17	38	222.44	16	18	4
	(3.76)	(6.60)	(42.11)	(47.37)	(10.53)
PBW 550	23	218.00	7	9	7
	(2.28)	(6.47)	(30.43)	(39.13)	(30.43)

Note: [a]Figures within the parentheses are percentage to total farmers (1067); [b] Figures within the parentheses indicate percentage to total land under wheat cultivation, and [c]Figures within the parentheses indicate percentage to the total farmers using a particular variety.

Source: CIMMYT Survey (2011)

of a particular crop in farmers' well-being. The results for proportion of land allocated for wheat were found to be significant but had influence in opposite direction on the adoption of seed variety from Category I and Category III relative to Category II. For example, if the proportion of land allocated for wheat increases by one unit, the farmers' likelihood of adopting seed from Category I relative to Category II decreases by 15 per cent but his likelihood of adoption of seed from Category III relative to Category II will increases by 7.5 per cent. This suggests that as farm area allocated to wheat increases, the likelihood of adopting modern wheat varieties increases. In other words, farmers allocating more land to wheat prefer new seed varieties to old ones and these results are in accordance with the findings of Parthasarathy and Prasad (1978) who reported a significant positive relationship between farm size and adoption of high-yielding seed varieties in Andhra Pradesh.

Information Sources

Farmers' exposure to various sources of agriculture-related information is always crucial in influencing their decision and plays a dominant role in adoption of a new technology. The number of sources as well as different types of sources had depicted a

Table 6. Estimated results of multinomial logit regression

Variable	Coefficient	Standard error	Marginal effect
Category I (Age of variety > 25 years)			
Age	-0.006	0.007	-0.001
Education	-0.108	0.074	-0.006
Proportion of wheat area to total area	-2.629***	0.322	-0.150
Number of information sources used	-0.388***	0.059	-0.027
Own source[a]	-18.074***	0.505	-0.990
Market source[b]	-17.753***	0.477	-0.999
Government source[c]	-0.792**	0.388	-0.034
Intercept	20.213		
Category III (Age of variety < 10 years)			
Age	0.001	0.006	0.001
Education	0.025	0.062	0.007
Proportion of wheat area to total area	0.147***	0.381	0.075
Number of information sources used	0.282***	0.049	0.064
Own source[a]	-0.483	0.492	0.244
Market source[b]	-0.151	0.500	0.292
Government source[c]	-0.013	0.340	0.008
Intercept	-1.869***	0.732	
Number of observations	1066		
LR $chi^2(16)$	273.58***		
log likelihood	-929.293		
Pseudo R^2	0.1283		

Note: The reference category was intermediate seed variety i.e. 10-25 years old ; * ,** ,*** indicate significance at 10 per cent, 5 per cent and 1 per cent levels, respectively; [a]Own source includes seed from own farm, seed exchanged from other farmers and purchased from other farmers; [b]Market source includes seed purchased from traders and seed companies; [c]Government source includes seed purchased from cooperatives and government agencies.

Source: CIMMYT Survey (2011)

differential impact on farmers' exposure to risk or potential/perception for new farming methods. Higher the number of information sources a farmer accesses, more likely is its impact on his knowledge and adaptation, resulting in a positive impact on adoption of a new seed variety. This was confirmed by our regression results where the number of information sources was negative and significantly related to old seed variety (Category I) but positively to new seed variety (Category II). Same kind of results were found by Kebede *et al*. (1990) in the case of adoption of fertilizer and pesticides.

Sources of Seed

Like information sources, farmers' access to different sources of seed played a vital role in adopting seed from different varieties. All the three seed sources were negatively related to farmers' adoption behaviour from Category I and Category III relative to Category II. But, the sources have shown a significant result for Category I only. Also, their impact was higher in Category I. For example, if a farmer uses own sources for seed, then the probability of adoption of seed varieties, which are 25 years old or more, decreases by 99 per cent. This suggests that farmers are in the process of using seed varieties which are less than 25 years old. However, other results suggest that if a farmer uses own sources for seed, then the probability of adoption of varieties which are less than 10 years old increases by 2.4 per cent. These inferences lead us to two suggestions: (a) farmers' preference for old varieties is decreasing, and (b) farmers are not using

the latest released variety. This may be because of two reasons. One, farmers are risk averse and they tend to continue the variety they had adopted 15-20 years back, and two, the released seed varieties have not reached the farmers.

The results have shown that the farmers' probability of buying old variety is negatively influenced by the socio-economic factors. The farmers are ready to use a new variety and they may even completely replace the old variety with a new variety. But for this, some important steps are necessary, such as information about arrival of new variety, delivery of its seed at farm level, and information about using new variety. For this, a proper channel or seed delivery system needs to be developed. The results (Table 5) have identified that the old varieties are mostly delivered via market channel, it means that traders should also be made aware about the new varieties and extension services should be strengthened.

Conclusions

The study has shown that various socio-economic factors like age, land size and educational level impact the adoption of wheat seed varieties. But, the most important factor that impacts the adoption of new seed varieties is the access to seed from different sources. The survey has shown that most of the farmers' access wheat variety from their own sources like self-production or take it from neighbouring farmers and thus usually are not able to adopt new varieties. Joshi *et al*. (2007) have also highlighted that more than 80 per cent of the seed in India and South Asian countries is saved by the farmers, especially for self-pollinating crops like wheat. This is also influenced by the poor availability of new varieties of seed due to weak seed delivery and weak linkages (Joshi *et al*., 2007; Yadav *et al*., 2010).

Although major efforts are being carried out by the government under the national seed project and national seed development policy to strengthen the seed sector infrastructure and provide access to farmers to quality seed material, and varietal adoption, the fact remains that farmers face several constraints in procuring new varieties of seeds. Most of the farmers keep continuing using old varieties of seed for years. The main reason behind this is that the seed production and replication of new varieties is not efficient; the channel of distribution of seed to farmers is weak and the availability of good quality new seed variety in the public domain is not efficient.

Thus, there is need to strengthen public-private partnership in seed production and distribution. Quality control and timely availability of seed is a necessary condition. Knowledge and information about new varieties along with their benefits should be disseminated widely through appropriate extension services.

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Appendix 1

Description of variables used in the analysis

Variable	Type	Description (Value)	Expected relation with farmers' adoption behaviour towards different categories of seed variety
		Economic Factor	
Age	Continuous	Age of farmer	With increase in age, farmers' risk aversion increases and adopting a new technology seems less likely. Since the surveyed farmers are not very old, this variable is expected to positively affect the adoption of a new variety.
Education	Ordinal	Educational level of farmer (0=Illiterate, 1=Primary schooling, 2= Secondary and High school, 3= Graduate and above)	Exposure to education will increase the farmers' ability to obtain, process and utilize information relevant to the adoption of a new seed variety. This variable is expected to be positively related to the adoption of a new seed variety
Proportion of area under wheat crop	Continuous	Proportion of land allocated to wheat crop out of total land owned by a farmer	This variable signifies the importance of wheat to the farmer relative to the others on the farm. This variable is expected to be positively correlated with adoption of a new variety.
		Information Sources	
No. of sources of information	Discrete	Number of information sources (in total 17 such as television, krishi vigyan kendra, private traders radio, mobile phone-based models, etc.	Information from various sources may have a differential impact on farmers' exposure to risk or his potential/perception for new farming methods. More the number of information sources a farmer has access to more likely is impact on his overall knowledge and adaptation, so should have a positive impact on adoption of a new seed variety
		Source of Seed	
Own	Dummy	Farmer using seed from own (may be past stock) and other farmers	These variables are supposed to play an important role in farmers' seed variety adoption behaviour but their influence direction is not visible from the secondary approaches and needs a thorough empirical analysis.
Market	Dummy	Farmer using seed bought from traders	
Government	Dummy	Farmer using seed delivered through government or cooperative agencies	