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Multidimensional Impact of HUW-234 in Eastern Uttar Pradesh

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ABSTRACT

Background: In view of the need for stronger accountability in agricultural research in recent years, present study was undertaken to assess the multidimensional impact of HUW 234, a pioneer wheat variety of Eastern Uttar Pradesh since 1986. The present work was carried out with the objective to study the adoption pattern of HUW 234 and estimate its impact on inputs' demand and crop productivity.

Methods: The primary data was collected from 160 farmers with the help of pre-tested questionnaire for the crop season 2016-17 from Azamgarh and Bhadohi district. The impact of HUW 234 on inputs' demand and crop productivity was estimated by using translog profit function approach and Cobb-Douglas production function approach.

Result: The estimated demand function equations imply that the variety is resource saving *viz*. water, fertilizer and labour saving. The net yield disadvantage of HUW 234 over other wheat varieties evaluated at sample means was around 11.52 per cent. The likeliness of farmer-consumer towards its taste can create new opportunities to increase profitability through premium prices. The results indicate the need for focused breeding efforts in old genotype as per the preferences of the farmers.

Key words: HUW-234, Impact, Input demand, Productivity, Wheat.

INTRODUCTION

Wheat is an important food crop grown mainly in northern and central India. The meeting future food demand due to the rising population will be a major challenge. Since the scope for area expansion is limited, raising yield level is the only viable option which could be achieved by improving resource use efficiency, adopting better crop management and focusing on breeding efforts. However, the wheat production in the country is facing several other challenges of shrinking cooling period, increasing terminal heat stress and growing threat from diseases like wheat rusts and spot blotch (Joshi *et al.*, 2007a; Singh *et al*., 2007; Sharma *et al*., 2002; Rane *et al*., 2000).

Adoption of improved technology by the farmers is one of the major means to increase production and thereby meeting the need of future demand. In India, wheat breeders on an average develop nearly 60 varieties annually and of this, hardly one or two cultivar(s) only become popular among growers and covers substantial (30% of wheat area) area (Nagarajan, 2009). This implies that in spite of development of large number of varieties, only a few meets the farmers' need. In a study of major wheat growing states of India also reported similar findings that 42 per cent of area under wheat was covered by top five wheat varieties which were released 10 years ago (Pavithra *et al*., 2017). Thus, the popularity of older varieties indicates that probably greater breeding efforts are needed to develop high yielding/ improve the yield potential of existing varieties popular among wheat growers and consumers. This requires a strong extension linkage among breeders, farmers and consumers along with committed public spending for need-based research. To attract funding, researchers are needed to provide credible evidence of past investment, because of limited funding and have demand for alternative uses (Anandajayasekeram, *et al*., 1996). Keeping these issues in view, the present study attempts to quantify the benefits of a popular wheat variety (HUW-234), which will add further evidence in justifying the future funding for wheat breeding programmes.

Thus, the present study assesses the adoption pattern of the wheat cultivar HUW 234 in eastern Uttar Pradesh and estimates its impact on cost-returns, input demand and crop productivity.

About wheat variety HUW 234

The bread wheat cultivar, HUW 234 (popularly known as Malviya 234) was developed by the Breeding Department of Agriculture faculty in 1984 and was notified for release in 1986. This variety is suitable for sowing under late and poor irrigated conditions and gives an average yield of 31-35 Qtls/ha. The variety normally matures in 126-134 days, contains 10-11 per cent protein with good chapatti making quality. The

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HUW 234 is popular variety in eastern Gangetic plains in late sown conditions and during mid-1990s it was its peak of adoption level and had occupied around 4–5 million hectares (Joshi *et al*., 2010). However, the area coverage substantially declined and remained to 2 million hectares in 2008 (Fig 1).

Notwithstanding the release of several improved wheat varieties, HUW-234 is still popular among farmers of eastern Uttar Pradesh and grown by them. The main reasons for large success and popularity of HUW-234 among farmers include its adaptation to low resource environment, ability to perform better under abiotic stresses of terminal heat, limited irrigation and variable fertilizer doses and its suitability for planting even after early potato harvesting (Arun *et al*., 2003). Despite having several positive features and popularity among farmers, the impact of this variety is not studied, leaving some anecdotal evidences brought out by the breeders. In an experimental study at Banaras Hindu University, in which several wheat varieties were grown in both normal (on 25th November) and late sown (on 25th December) for three consecutive years (2003-05) evinced that though all cultivars showed significant decline in late sown condition, the HUW-234, DBW-154, HD-2643 and Raj 3765 performed better in terms of yield than the popular cultivars like PBW-343, HD-2733 and HUW-468 (Joshi *et al*., 2007a). In other study, comparison of wheat cultivars was done in conventional and zero tillage conditions for three years (2002-2004) and reported that the cultivars PBW-343 and HUW-234 performed equally good under both the tillage conditions (Joshi *et al*., 2007b). It is worth noting that HUW-234 was developed for conventional tillage condition but adapted well under zero tillage condition as well. The HUW 234 also gave 25 per cent higher yield in weedy conditions, while yield of other slow growing varieties declined by 35 per cent as compared to normal condition. Therefore, its adaptability in all odd conditions makes HUW 234 popular even after 30 years of its release.

METERIALS AND METHODS

Data and sampling

Both secondary and primary data have been used in this paper to meet the stated objectives. The secondary data on area, production and yield of wheat for eastern[1] Uttar Pradesh was collected from Jila Sankhiyiki Patrika published by Directorate of Economics and Statistics, Government of Uttar Pradesh for the period 1995-96 to 2017-18. The primary data on socio-personal attributes of sample households and area under wheat variety and cost of cultivation of treatment and popular check variety was collected from a field survey conducted during agricultural year 2016-17. A multistage sampling technique was used in the selection of districts, blocks, villages and farmers. Eastern Uttar Pradesh consists of 28 districts, out of which 2 districts were selected purposively *i.e.* one with highest proportion of area (Azamgarh) and another one with lowest proportion of area (Bhadohi) under wheat cultivation. Two Development Blocks were selected randomly from each district at second stage of sampling. At third stage of sampling, two villages from each selected block were chosen. At final stage of sampling, 20 farmers were selected randomly from each selected village. Thus, a total of 4 blocks, 8 villages and 160 farmers[2] were selected, of which 120 were adopters and 40 were non-adopters.

Analytical techniques

The adoption pattern of wheat varieties was examined by using indicators reported by Ahmed (1981) and Lipton (1978). The factors determining the adoption were identified using the logit model. The model used is as follows:

$$Ln\left[\frac{pi}{1-pi}\right] = \beta_o + \beta_1 X_{1i} + \beta_2 X_{2i} + ... + \beta_n X_{ni}$$

Where,

p_i = Probability that i^{th} farmers has cultivated HUW 234.

β's = Slope of parameters.

X's = Explanatory variables *i.e.* age, household size, education, farm size and multi-variety grower.

The impact of HUW 234 on input demand was analyzed with the help of demand equation derived from profit function. The demand equation derived is as follows:

$$\frac{d\pi^*}{dP_L} = \beta_2 + \beta_{y2} \ln (P_Y) + \beta_{L2} \ln (P_L) + \beta_{F2} \ln (P_F) + \beta_{12} \ln (P_I) + \beta_6 D_V$$

$$\frac{d\pi^*}{dP_F} = \beta_3 + \beta_{y3} \ln (P_Y) + \beta_{L3} \ln (P_L) + \beta_{F3} \ln (P_F) + \beta_{13} \ln (P_I) + \beta_7 D_V$$

$$\frac{d\pi^*}{dP_I} = \beta_4 + \beta_{y4} \ln (P_Y) + \beta_{L4} \ln (P_L) + \beta_{F4} \ln (P_F) + \beta_{14} \ln (P_I) + \beta_8 D_V$$

Where,

P_{Yi} = Price of output.

P_{Li} = Price of labour (Rs/ mandays).

P_{Fi} = Price of fertilizer (Rs/ kg of nutrients).

P_{Ii} = Price of irrigation (Rs/ irrigation).

D_V = Varietal dummy variable (1 for HUW 234 and 0 otherwise).

β's = Slope of parameters.

The Cobb-Douglas type production function was used to estimate the impact of the technology on wheat yield. The following production function was used:

$$Ln\ Q = \beta_o + \beta_1 \ln X_{1i} + ... + \beta_9 \ln X_{9i} + \beta_{10} DE + \beta_{11} DV + \beta_{12} DR$$

Where,

Q = Yield.

[1]The eastern region of Uttar Pradesh comprises of 28 revenue districts and more than half (54%) of the total population is directly engaged in agriculture. Rice-wheat system is the dominant cropping pattern in the region and it contributes about 40 per cent of total cereals produced in the state during 2017-18.

[2]The selected farmers consisted of both adopters and non-adopters, who responded on changes in cost and returns and other features. The farmers who planted HUW 234 were termed as adopters, while farmers who cultivatedother wheat cultivars than HUW 234 were treated as non-adopters in the study.

X's = Inputs used in the production process like seed, fertilizer, manures, irrigation, labour, machine labour, plant protection chemicals, wheat area;
DE = Dummy variable for education (1 for high school and above and 0 otherwise).
DV = Dummy variable for variety (1 for HUW-234, 0 otherwise).
DR = Dummy variable for region (1 for Azamgarh and 0 for Bhadohi).

RESULTS AND DISCUSSION

Status of wheat production in eastern Uttar Pradesh

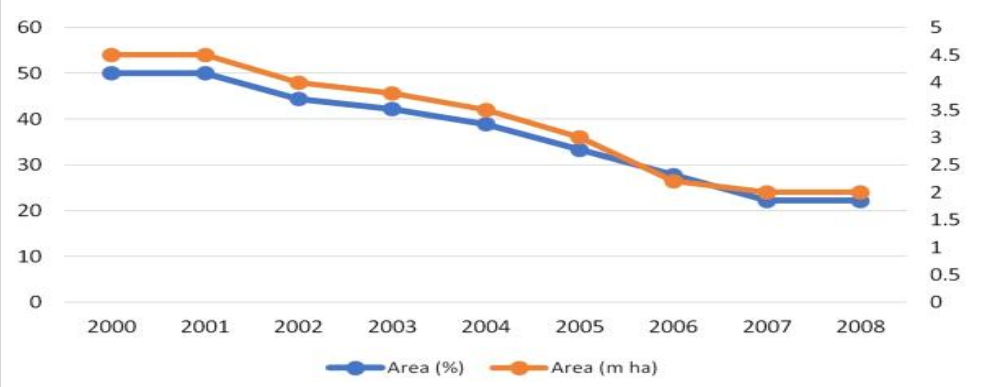
Uttar Pradesh is the largest producer of wheat in India with a production of 31.88 million tonnes (Mt) contributing around 32 per cent to total production in 2017-18 (Agricultural Statistics at a Glance 2018). Wheat is an important crop of the state occupying 37 per cent of the gross cropped area in 2015-16. Although wheat is the major cereals of Uttar Pradesh, the average yield was lower by 15-16 q/ha, when compared to major wheat producing states of Haryana and Punjab in northern India. This gap can be bridged by adoption of high-yielding improved varieties, better crop management practices and improving resource use efficiency.

The state is divided into four economic zones *viz*. Western, Eastern, Central and Bundelkhand. In particular, eastern region of Uttar Pradesh comprised of 28 revenue districts and more than half of the population (54%) is directly engaged in agriculture (Tripathi *et al*., 2010). Rice-wheat system is the dominant cropping pattern in the region and the two crops contribute about 96 per cent of total cereals production in 2016-17. Irrigation status of agricultural land in eastern Uttar Pradesh indicates that about 24 per cent of gross cropped area is rainfed (2014-15).

The eastern region of Uttar Pradesh accounts for about one-third of the total wheat area of Uttar Pradesh. The region contributed about 12 Mt of wheat in 2016-17. The average yield was 32.4 q/ha which is slightly lower than the state's average (35.4 Qtl/ha). Data show that wheat area in the region increased minimally, from 3.1 Mha in 1995-96 to 3.4 Mha in 2017-18, while the production swelled from 6.9 Mt to 12.2 Mt during the same period (Fig 2). The figure shows that wheat area remained almost stagnant in past two decades, while production doubled. This implies that increase in yield contributed mainly to output; yield during the period grew at a rate of 1.3 per cent annually in the region. Further, the decomposition of sources of growth to wheat production in eastern Uttar Pradesh during 1995-2017, showed that yield effect contributed mainly (73.75%) to increasing production, while the share of area effect was minimal (16.71%).

Socio-economic characteristics of sample respondents

The socio-economic attributes of farmers are the deciding factors in adoption of any technology. The farmers who adopted HUW 234 were older than non-adopters and the difference was statistically significant (Table 1). Data shows that non-adopters had higher education than the average adopters and the difference was statistically significant too.



Source: BGRI, 2009.

Fig 1: Area coverage (m ha) and per cent of area occupied by wheat cultivar HUW 234 in the north eastern plains of India: 2000-2008.

Table 1: Socio-economic characteristics of sampled farmers.

Particulars	Unit	Adopters	Non-adopters	Difference
Average age	Years	54.15	48.71	5.44*
Average educational status	Years	9.27	11.25	-1.98*
Average family size	Number	10.15	9.19	0.96
Average farming experience	Years	36.90	30.13	6.77*
Average land holding size	Hectares	1.78	1.21	0.57**
Average area allocated to wheat	Hectares	1.51	1.03	0.48*

Source: Authors' compilation, *Significant at <1%, **Significant at <5%.

The average members in the family of sample households were 10 and 9 on adopter and non-adopter farms, respectively. The adopters of wheat variety had large holding size and farming experience than that of their counterparts. Also, the average wheat area on adopters was higher than non-adopted farms and difference was significant.

Adoption of wheat varieties

To analyze the adoption of wheat varieties, the indicators suggested in the past studies (Ahmed,1981 and Lipton,1978) have been utilized. During the farm survey, a total of 9 wheat varieties were identified which were grown by sample households of the study area. It was noted that the among identified varieties, popular varieties (PBW 343, PBW 154, PBW 502, Kundan and HUW 234) covered large area (74% of total wheat area) at sample farm households. The indicators suggested and their descriptions are noted below:

1. Crude adoption rate: Defined as the ratio of number of farmers cultivating variety "A" to the total number of farmers.

2. Adoption intensity: Defined as the percentage of wheat area under variety "A".

3. Propensity to adopt: Defined as the likelihood of farmer to adopt variety "A".

Table 2 presents the adoption pattern of wheat varieties in the study area. Data show that four wheat varieties *viz*., PBW 343, PBW 154, HUW 234 and PBW 502 occupied more than one-fifth of wheat area on sample households, either singly or in combination, while liking for PBW 343 was highest (30%). The other popular varieties like Kundan and Kedar were grown by 15 per cent of farmers (each). The adoption intensity of PBW 343 was found to be highest (29.6%) followed by PBW 154(17.1%), PBW 502(11.7%) and Kundan (11.2%). The adoption intensity of HUW 234 was low (9.8%).These observations are similar to the findings reported by Pavithra *et al*. (2017) which studied the spatial and temporal diversity in adoption of modern wheat varieties by using the expert elicitation method. The authors reported that the area under HUW 234 in Uttar Pradesh was 6.9 per cent in the year 2013-14.

To further understand the extent of adoption of HUW 234 on individual farms, the response of the farmers is presented in Table 3. The results show that adopter farmers had also grown other wheat varieties along with HUW 234 to meet their family and other needs. Data show that 15 per cent of farm households allocated entire wheat area under HUW 234 and 18 per cent (each) devoted of 50-75 per cent and 25-50 per cent of total wheat area to HUW 234. Inferring the Tables 1 and 2 together indicate though wheat variety, HUW 234, was grown by large number of the farmers, but in small area. This is possible because the farmers generally grow HUW 234 for home consumption.

To further verify the liking about HUW 234, the selected households were asked to recollect about the wheat varieties they were growing from the past six years. The results show

Table 2: Adoption of wheat varieties on sample farms in Eastern Uttar Pradesh (2016-17).

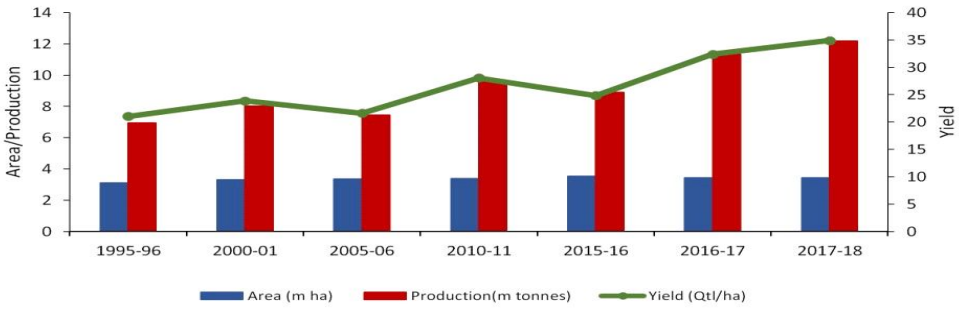
Variety	Crude adoption rate (%)	Adoption intensity (%)
PBW 343	30.00	29.59
PBW 154	25.62	17.09
HUW 234	25.00	9.81
PBW 502	23.12	11.72
Kundan	15.62	11.23
Kedar	15.00	1.50
HD 2967	9.38	7.14
HI 1479 (Swarna)	3.75	1.45
HUW 510	1.87	0.45

Source: Authors' compilation.

Table 3: Extent of coverage of HUW 234 on average sample.

Extent of area coverage (%)	0-25.0	25.0-50.0	50.0-75.0	75.0-100.0	100.0
Per cent of adopters	50.00	17.50	17.50	-	15.00

Source: Authors' compilation.



Source: Directorate of Economics and Statistics, Government of Uttar Pradesh.

Fig 2: Trends in area, production and productivity of wheat in eastern Uttar Pradesh.

a decline in liking among households in the adoption of HUW 234 during 2011-12 to 2016-17. During this period, about 22 per cent of the selected households have given up the planting of HUW 234 (Table 4). About declining likings for HUW 234 among households, survey revealed that providing low yield, development of newer wheat varieties with high yield, difficulty in getting quality seeds and shedding of grains are the main reasons for non-planting. Moreover, the primary reasons for farmers still growing the variety include less irrigation water and fertilizers requirement, dough texture, performs well in late sown conditions with good chapati making quality and tastes. Study by Pavithra *et al* (2017) also reported that the HUW 234 is still being cultivated on a larger area because of its wide adaptability, excellent chapati making quality and suitability for rainfed cultivation.

Table 4: Adoption of HUW 234 over the years (2011-12 to 2016-17).

Year	Farmers planted HUW 234	
	Number	Per cent
2011-12	76	47.5
2012-13	62	38.7
2013-14	51	31.8
2014-15	45	28.1
2015-16	39	18.1
2016-17	40	25.0

Source: Tewari *et al*., 2018.

Propensity of adoption of HUW 234: Logit analysis

The Logit model was applied to explain the likelihood of the farmers adopting the variety. Here adoption of HUW 234 was taken as dependent variable which is dichotomous in nature *i.e.* (0,1). 1 was used for adoption, otherwise 0, for non-adoption. The estimates of the model are presented in Table 5. The R square statistics were found to be greater than 0.30, this indicates the model is good fit.

Results show that coefficients of two variables *viz.* farmers' age and multi-variety growers had expected sign and were statistically significantly. This indicates that farmers with higher age (*i.e*. older farmers) are more likely to grow wheat variety HUW 234. Further, the reason for introducing MVG (Multi-variety grower) variable is that during the survey farmers reported growing of more than one variety on their farms. The results suggest that farmers growing more than one variety are more likely to adopt HUW 234. Because, farmers grow crop varieties of wheat or other cereals not only for home consumption but for marketing as well to

Table 5: Parameter estimates of logistic regression model.

Variables	Coefficients/β	Standard error	Wald	Exp (β)	Probability
Constant	-7.201	1.488	23.412	0.001	0.001
Age	0.062	0.022	7.740	1.064	0.005
Farm size	0.022	0.032	0.459	1.022	0.498
Education	0.229	0.475	0.232	1.257	0.630
HH	0.092	0.064	2.060	1.096	0.151
MVG	2.535	0.583	18.913	12.616	0.000
Cox and snell R square			0.32		
Nagelkerke R square			0.43		

Source: Tewari *et al*., 2018.

Table 6: Economics of cultivation of wheat varieties on sample farms in 2016-17.

Particulars	HUW 234	PBW 343	Absolute change	Per cent change
Cost Items (Rs./ha)				
(i) Seed	3466	3956	- 490	-12.38
(ii) Fertilizers and manures	3040	3204	- 164	-5.12
(iii) Irrigation	2612	3262	- 650	-19.93
(iv) Machine labour	7590	7562	+ 28	+0.37
(v) Human labour	8530	8817	- 287	-3.26
(vi) Chemicals	1107	1131	- 24	-2.12
Total cost	26345	27932	- 1587	-5.68
Wheat yield (Qtl/ha)	38.3	40.0	1.7	-0.05
Revenue (Rs./ha)				
(i) Value of grain	58331	61000	-3050	-5.00
(ii) Value of straw	20708	21875	-1167	-5.33
Gross revenue	79039	82875	-4217	-5.08
Net revenue (Rs./ha)	52694	54943	-2630	-4.79
Net revenue per rupee of investment	2.00	1.97	-	-

Source: Authors' compilation.

Table 7: Restricted estimates of the coefficients of factor demand function.

Demand Function	Price of irrigation	Price of fertilizer	Price of labour	intercept	Output	Dummy for variety
Irrigation	-0.279 (0.216)	0.049*** (0.009)	0.230*** (0.081)	-9.865 (8.428)	1.720 (2.305)	-0.186*** (0.019)
Fertilizer	-	-0.167** (0.076)	0.118* (0.078)	0.898*** (0.186)	0.0023 (0.017)	-0.014* (0.008)
Labour	-	-	-0.351*** (0.082)	1.136*** (0.185)	-0.005 (0.016)	-0.032*** (0.007)

Source: Authors' estimation; Note: ***, ** and *Stands for significance at 1 per cent, 5 per cent and 10 per cent, respectively. Figures in parenthesis ( ) are standard errors.

Table 8: Variety wise average wheat yield in sampled area.

Wheat varieties	Average yield (q/ha)
HUW 234	38.25
PBW 343	40
Others	38.0

Source: Authors' compilation.

receive better income from other high yielding varieties. Thus, the farmers who are cultivating this variety are either growing for home consumption or having small operational landholdings.

Impact of HUW 234

The impact of wheat cultivar, HUW 234, has been assessed in terms of costs and returns, yield, input demand and chapati making quality. The comparison of HUW 234 is made on several counts against PBW 343 which was identified as the most popular wheat variety not only in the study area but also in the entire region of eastern Uttar Pradesh.

Impact on costs and returns

The summary of costs and returns is presented in Table 6. Data show that cost items of irrigation, seed, human labour and fertilizers and manures were the major inputs to lower the cost of cultivation for HUW 234 as compared to PBW 343. The savings in these items of cost accounted for about 6 per cent of total cultivation cost incurred for HUW 234. This extent of reduction in cost was equivalent to value of 1 quintal of wheat or capable of bridging the yield gap by 1 quintal (or by 50 per cent). Data shows that cost on irrigation was about 20 per cent lower than that of PBW 343. This further implies that in view of changing climate and increasing frequency of heat stress and water scare regime, planting of HUW 243 is advantageous and less risky. The expected yield reduction of HUW 234 over PBW 343 is 5 per cent, while the net return received from HUW 234 was 4.79 per cent less than PBW 343. Moreover, the net return per rupee of expenditure from HUW 234 was higher than popular variety PBW 343.

Impact on input demand

The impact of HUW 234 was also studied with the help of demand function generated from profit function approach. The coefficients of estimated parameters are presented in Table 7. Out of 15 estimates, 10 estimates are statistically significant having expected signs. The value of R square of three share equations given in Table with homogeneity imposed in the data is not very high. The R square of irrigation, fertilizer and labour share equations were 0.35, 0.57 and 0.66, respectively.

The demand equations of irrigation, fertilizer and labour showed negative relationship with their respective prices. This implies that increase in the prices of an input would reduce the demand of the particular input. This is an expected observation. Nevertheless, in this analysis we wish to exercise the impact of HUW 234 on input demand so our major focus lies on the coefficient of dummy variable used for variety.

All the coefficients of varietal dummies were found negative and significant. The result reveals that at equal factor price, the share of factors would not be equal among the wheat varieties. The coefficient of varietal dummy in irrigation share equation is negative and significant at 1 per cent which implies the wheat variety, HUW 234, is less water requiring and suitable for growing in water constraint region. Similarly, in case of fertilizer and labour demand, the coefficients are negative and significant which implies HUW 234 requires less fertilizer and labour. In other words, the resource poor farmers who generally apply less resource in cultivating HUW 234 can get almost similar returns in comparison to other varieties.

This analysis conclusively indicates that wheat variety HUW 234 is well adapted to low resource environment. The similar finding was also reported by Arun *et al*. (2003) for eastern India. Broad adaptation was reported in low resource environment prevalent in eastern India. This was attributed to HUW 234's ability to perform well under abiotic stress such as heat, limited irrigation and variable fertilizer doses.

Impact on crop productivity

The impact of any new agricultural technology from inputs demand perspectives is important, but the technology will not be popular and accepted among farmers unless it gives higher yield (Lin, 1994). The yield of HUW 234 was compared with popular and dominant variety, PBW 343. The results show that the average yield of HUW 234 was lower by 1.7 q/ha (*i.e*. 4%) as compared to PBW 343 and almost equal to other wheat varieties grown by the farm households (Table 8). However, as noted earlier, the requirement of irrigation and fertilizer was lower in cultivation of HUW 234 over PBW 343. To separate out the yield disadvantage owing to varietal attribute of HUW 234 requiring low level of irrigation and fertilizers, regression analysis was used to estimate the impact of HUW 234 on crop productivity and the results are described in following section.

Table 9: Estimates of regression analysis.

Variable	Description	Coefficient	Standard error	t-value	Prob.
Seed	Logarithm of seed rate	0.304	0.133	2.281	0.024
Fertilizer	Logarithm of fertilizer amount (per ha)	0.396	0.099	4.018	0.000
Manure	Logarithm of manure amount (per ha)	0.257	0.111	2.309	0.002
Irrigation	Logarithm of number of irrigation	0.151	0.082	1.844	0.067
Labour	Logarithm of labour days (per ha)	0.128	0.063	2.040	0.043
Machine labour	Logarithm of value of machine labour (Rs. per ha)	0.043	0.078	0.549	0.584
Chemicals	Logarithm of value of chemicals amount (Rs. per ha)	0.020	0.006	3.158	0.002
Wheat Variety	Varietal Dummy (1 for HUW 234; 0 otherwise)	-0.109	0.049	-2.221	0.028
Region	District Dummy (1 for Azamgarh; 0 otherwise)	-0.001	0.028	-0.052	0.958
Age	Age of farmer (years)	3.27 E-05	0.001	0.027	0.978
Land	Logarithm of land holding	0.057	0.014	4.035	0.000
Education	Dummy (1 for high school or more; 0 otherwise)	-0.034	0.028	-1.216	0.226
Constant		5.217	1.095	4.766	0.000
Regression statistics		R^2 0.396			

Source: Authors' estimation.

The impact of HUW 234 on crop yield was estimated using Cobb-Douglas production function. The main reason to adopt this functional form is the ease in estimation and interpretation. The dummy variable for variety is incorporated in the model to study the impact. The productivity of each farm was regressed against a set of exogenous variables. The coefficients of 8 variables (out of 13) are statistically significant and having expected sign. The value of R square is 39.6 per cent, which imply that 39.6 per cent of variability in the model is explained by exogenous variables (Table 9). The low value of R square could be attributed to the low variability in the response of sample households.

The coefficient of seed estimated to be 0.304 at was significant at 5 per cent level, which implies that 10 per cent increase in seed rate would increase the crop yield by 3.04 per cent. The other input like irrigation, fertilizer, manure, labour and plant protection chemicals also showed positive and significant impacts on increase of wheat yield and implies that these resources are being underutilized and there is a further scope to increase the efficiency of resources being used to improve the yield. The personal attributes of farm households namely, age and education were found insignificant. Among the variables, fertilizer was found to be predominant factor in increasing wheat yield and coefficient infers that 10 per cent rise in fertilizer use, holding other factors constant, will lead to surge in wheat yield by 3.96 per cent.

The coefficient for HUW 234 wheat is negative and significant, indicating that the variety reduces wheat yields when controlling for other factors. The net yield disadvantage of HUW 234 over other wheat varieties evaluated at sample means was around 11.52 per cent. In other words, total factor productivity of HUW 234 was estimated to be 11.52 per cent lower than other popular varieties grown by the sampled farmers.

Impact on quality of chapati

About one-third of sample households reported that the variety is very good for chapati making because of the dough quality and sweet tastes. The adopter farmers with marginal holdings were cultivating HUW 234 only. Whereas, the large farmers were cultivating it in small portion to meet their home consumption demand. As acknowledged by the farming fraternity, the taste of HUW 234 is superior over other varieties, thus there is a need to quantify the taste preference of farmer in monetary terms. This can be done by evaluating the foregone value that farmer would have got if cultivating other varieties.

The significant yield difference of HUW 234 from other wheat varieties was found to be 1.7 q/ha, implies that the farmers who cultivate HUW 234 forego 1.7 q/ha of wheat grain. Thus, the monetary value of likeliness of farmers consumer towards taste of HUW 234 is equal to or even higher, the value of wheat grain foregone (*i.e.* Rs. 2592/ha). This preference for taste is an emerging opportunity to sell the wheat at premium price. The premium price mechanism would help to increase farmers' income.

CONCLUSION

The HUW 234 is a wheat variety still popular in eastern region of Uttar Pradesh even after 30 years of its release. The area covered at sample farms under the variety is about 10 per cent of total wheat area. The variety is popular among old farmers due to its chapatti making quality and good taste. The results suggest that the variety is mainly grown for home consumption. Farmers do not prefer this cultivar for commercial purpose due to the presence of other high yielding varieties. Although, the impact of HUW 234 on crop yield was slightly lower over popular variety of PBW 343, but the net return per rupee of investment was higher for HUW 234. The input demand for HUW 234 was also found to be low indicating its suitability to perform well in resource poor environment. Thus, the variety is known for its good taste, good chapati quality and better performance in late sown and poor resource condition. However, farmers need a variety with characteristics like higher yield, late sown and good chapatti quality. Thus, there is need of making focused

breeding efforts to develop a wheat variety which could be meeting the farmers' preferences.

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