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Adoption intensity and efficiency of improved technologies in Lower Shivalik Hills

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ABSTRACT

Agricultural technologies are seen as an important means for alleviating poverty in most of the developing countries. However, the rate of adoption of farm technologies has remained at low level. Present study conducted during 2016-19 in lower Shivalik hills of Uttarakhand which aims at shedding some light on the driving forces that influence the intensity of technology adoption using econometric models like quantile regression (QR) model since it produces different effects along the distribution (quantile) of the dependent variable. Improved varieties of two major crops (Rice and Wheat) of lower Shivalik hills of Uttarakhand have been enlisted. Kendall Tau estimation has been used to measure the extent of association of explanatory variables with the adoption level. To estimate sustaining productivity (economic efficiency) of selected technologies (varieties) and to identify best suited available technology, Seeming Unrelated Regression (SUR) model was used as it estimates the parameters of all equations simultaneously. The estimates of quantile model show that operational land holding, extension contact, family type, house type and farm assets had significant influence on intensity of adoption. Besides, findings of SUR model identified PB-1121 of rice and HD-2967 of wheat the best suitable varieties. The paper also suggested some farm policy-related issues for the welfare of the farmers under study.

Key words: Adoption intensity, Economic Efficiency Measure, Quantile Regression, SUR Model

Agriculture continues to be the mainstay of the Indian economy because of its greater share in employment and livelihood (NITI Aayog 2015). Although its relative contribution to the nation's gross domestic product (GDP) has been declining over the years where it accounts for about 14% of the nation's GDP, about 11% of its exports, and provides livelihood to about half of the population. India's overall demand for food grains is expected to increase from 236.2 million tonnes in 2010 to 303-318 million tonnes in 2030 (Anonymous 2017). Accelerating the growth of agriculture production is therefore, necessary not only to achieve an overall GDP target of 8% during the 12th Plan and meet the rising demand for food, but also to increase incomes of those dependent on agriculture to ensure inclusiveness (FAO 2017). But Indian agriculture is presently challenged by a number of constraints like, depleting natural resources, land fragmentation, deceleration in productivity growth etc. The Shivalik hills in Uttarakhand is an area of agriculture base but progress in agricultural sector still remains unresolved and is continuously haunting agriculture. The new agricultural technologies are considered to be the prime mover to the process of agricultural development in India (Diagne *et al*. 2009). A good number of improved technologies like crop varieties have been adopted by the farmers in lower Shivalik hills. But adoption of yield and income generating technologies for the farmers has not yet been established (Dorosh and Rashid 2013). Therefore, the present study has exercised econometric models to estimate the adoption intensity of the farmer as well as the factors responsible for system efficiency. With increasing pressure of population, demand for food supply is always increasing in a geometric rate. Increasing agricultural productivity and, hence, output of farm sector using improved technologies (varieties) is a necessary step for achieving food security. Thus, the study has also tried to explore farm level eco efficiency of the available technologies that will guide the farmers for application of the best suited technologies for sustaining productivity of selected technologies as well as augmenting the production of agriculture in general.

MATERIALS AND METHODS

Shivalik region is sandwiched between Himalayan ecosystem and Indo-Gangetic plains in North-Western India. The delineated map shows, i.e. Jammu region of J&K and Malwa region of Punjab, parts of Haridwar, Udham Singh Nagar and southern plains of Nainital districts of Uttarakhand comes under lower Shivalik hills (Yadav *et al.* 2015). Instead of adequate natural resources for successful

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crop growth like fertile soil, 87% irrigation water, the productivity was found not to reach a competitive level for various crops as compared to other parts of the lower Shivalik Hills (i.e. Jammu region of J&K and Malwa region of Punjab) (Sati and Wei 2018) because of unavailability of improved planting materials (seed), poor access to modern technologies, poor productivity level leading to abysmally low marketable surplus in plains (Roy *et al*. 2016). Thus, the study was purposively conducted during 2016-19 in the lower Shivalik hills of Uttarakhand (Haridwar, Udham Singh Nagar and Nainital) with 360 farmers to explore the possibilities to upgrade the existing subsistence level of agriculture to competitive agriculture with the prevailing natural resources and probing a suitable strategy for select best suited technologies (varieties) in that region. From review of available literatures and secondary sources of information, it was found that wheat and paddy are most important crops in the lower Shivalik hills (Anonymous 2019). Among the listed varieties, three varieties have been selected randomly without replacement method with help of Fisher random number table. Pusa Basmati1121 (PB-1121), Pusa Sugandh 5 (PS-5) and Pant Sugandh Dhan 21 of rice were finally enlisted for the study. Similarly, HD-2967, HD-3086 and HD-3059 of wheat have been selected with a view to measure adoption intensity and farm level efficiency.

QR model has been adopted to estimate intensity of adoption (Bekkerman *et al*. 2011). Uniqueness of using this model is that instead of estimating the model with average effects using OLS linear model, it produces different effects along the distribution (quantile) of the dependent variable (Roy *et al*. 2020). To measure farm level economic efficiency of selected varieties, Seeming Unrelated Regression (SUR) has been adopted (Afolayan and Adeleke 2018). The SUR method estimates the parameter of all equations simultaneously, so that the parameters of each single equation also take the information provided by the other equations into account.

RESULTS AND DISCUSSION

The Table 1 illustrates the results from the QR estimation for each quantile. The regression provides a more complete picture of how factors influence adoption level at different degrees (Levin 2001). This model explains about 50% effect of independent variable in adoption level of farm community.Table 1 shows that extension contact (X_5), rented house (X_{16}) and farm assets (X_{18}) possess significant positive factor leads lower adoption. The positive value of coefficient of extension contact (0.047) indicated that increase in the extension contacts among farmers can significantly enhance the adoption level. Similarly, positive values of coefficients of rented house (0.612) and farmassets (0.385) implied that these coefficients have influenced the adoption positively.The operational land holding and farm assets have positive influence on medium and high adoption level. Positive coefficients of operational land holding (0.12 and 0.20) in both cases lead to more adoption compared to the first quartile.This indicates that adoption level increases with operational holding size and farm assets. Low level of extension contact causes lack of awareness about improved varieties of crops. Thus, they go for traditional varieties which results in lower production and low income. Majority of farmers depends on solely agriculture for their livelihood security. They had lower income from farm sector force them to live in rented house. Henceforth, they were not able to purchase all necessary farm assets which consequently lead lower adoption. Those farmers, who had more operational land, take more risk for adoption of improved varieties leads to higher production. When improved varieties has been grown it enhance yield as well as income helped them purchasing farm assets for crop production. Besides, family type (joint family) has also played a positive driving role for higher adoption which is justified with the positive coefficients value (0.591) of family type indicated that farmers belonged to joint family had higher adoption level. The family members engaged themselves directly in the farming activities. Moreover, economic constraints and lack of opportunities were much pronounced and therefore they can't opt for higher education which compels the younger members of the family to join hands with their elders in farm activities. As family members were involved in farming activities, farmers get leisure time to attain different agricultural programme. As

Table 1 Estimates of adoption intensity by Quartile Regression Model

QR Model	1st quartile (25 percentile)		2nd quartile (Median)		3rd quartile (75 percentile)	
Variables	Coefficient	P>t	Coefficient	P>t	Coefficient	P>t
Operational land holding (acre) (X_1)	0.079 (2.77)	0.006**	0.121 (3.89)	0.00**	0.200 (5.07)	0.00**
Family type (if joint=1, 0 otherwise) (X_4)	0.172 (1.53)	0.127	0.328 (2.44)	0.015*	0.591 (3.62)	0.00**
Extension contact (ordinally measured) (X_5)	0.047 (2.820)	0.01*	0.041 (2.220)	0.027*	0.035 (1.420)	0.155
Marital status (if single=1, 0 otherwise) (X_8)	-0.246 (-2.050)	0.041*	-0.240 (-1.700)	0.091	-0.201 (-1.150)	0.250
Mass media exposure (ordinally measured) (X_9)	0.038 (1.240)	0.216	0.050 (1.520)	0.129	0.089 (2.370)	0.018*
Rented (X_{16})	0.612 (3.760)	0.00**	0.269 (1.510)	0.133	-0.233 (-1.100)	0.271
Fram asset (nos.) (X_{18})	0.385 (5.800)	0.00**	0.276 (3.830)	0.00**	0.254 (2.940)	0.00**
Possesion of vehicle (if yes=1, 0 otherwise) (X_{20})	-0.156 (-2.240)	0.026*	-0.053 (-0.440)	0.662	-0.090 (-0.86)	0.39

Note:Value in parenthesis indicate t-value, ** significance at 1%, * Significance 5%

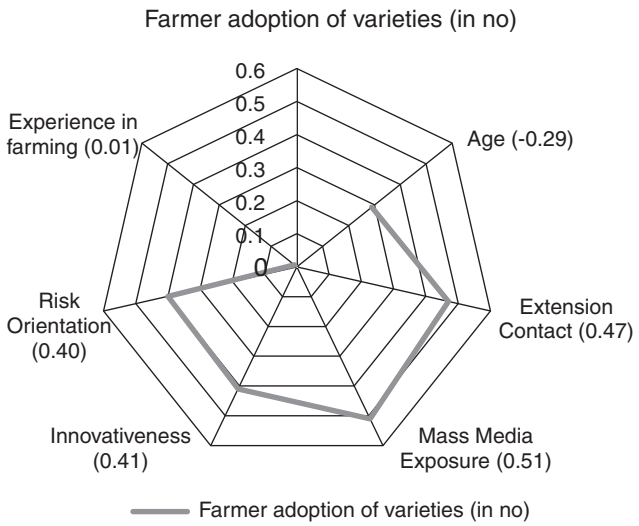

Fig 1 Kendall tau estimation for extent of association of the explanatory variables with adoption level.

a consequence, the awareness level of those farmers had been enhanced which helps in higher level of adoption of technologies. It was found that variables like Age (X_2), Education (X_3), Extension activity (X_6), Availability of information (X_7), Frequency in use of mass media (X_{10}), Risk Orientation (X_{11}), Distance from input market (X_{13}), Distance from output market (X_{14}), Pucca house (X_{17}), no of livestock (X_{19}), possession of vehicle (X_{20}) have no influence in quarter wise adoption intensity.

In the contrast, kendall's tau coefficient was used to measure the ordinal association between two measured quantities. Age has significantly negative (-0.29) relation with adoption level (Fig 1). This indicated that adoption level decreases with increase of age. Other selected variables i.e. extension contact (0.47), mass media exposure (0.51), innovativeness (0.41), risk orientation (0.40) and experience in farming (0.01) have significantly positive role for adoption of improved technologies. It implied that the old farmers have low level of awareness and consciousness about new technologies which could have impacted negatively on productivity and income in general. This also shows lack of attachment with State Agricultural Universities (SAU), Krishi Vigyan Kendra (KVKs) and State Department of Agriculture.

Therefore, they used to grow mainly traditional old varieties which were available in the market at lower price. On the contrary, adoption level increases with the extension contact. During discussion it was revealed that farmers had strong linkage with extension personnel, who involve them in various agricultural activities conducted by State Agricultural Universities (SAU), Krishi Vigyan Kendra (KVKs) and State Department of Agriculture. It gives them opportunities to learn about different new technologies as well as create awareness among them. It was also observed that majority farm families had T.V. and electric power supply at their places. Moreover, farmers belong to joint families, are involved themselves in all the agricultural operations so the work load has been reduced. Hence, they get ample time to expose to mass media. Adoption of new practices will occur when farmers had more risk bearing capacity. Farmers can take up calculated risk by practising new technologies in a small-scale area. The observed results of trial ability have shown higher level of adoption. These characteristics can lead to more innovativeness and, therefore, they will show interest to adopt new technologies for enhancing farm productivity and income.

Estimation of farm level economic efficiency for improved varieties: Effort has been made to identify the various factors influencing the yield variation among improved varieties and tries to quantify the impact of input use and socio-economic factors on overall yield. As the independent variables were identical for the four regression models the correlation matrices of error terms was computed and usage of a SURE regression model was found to be appropriate from the results of the Bresusch-Pagan test of independence (Zellner and Israilevich 2005). Breusch Pagan test gave a value of 6.852 ($P<0.1$) suggesting that the residuals of the estimated equations were correlated, thus using the seemingly unrelated regression technique was appropriate.The coefficient value 0.219 of Pusa Sugandh 5 (PS-5) implied that it has 0.219q more yield than PB 1121. Similarly, coefficient value (-2.586) for Pant Sugandh Dhan 21 indicated that this variety yield 2.586 q less than the base variety (PB-1121) which is significant (P value -0.001) both at 1% and 5% level. Thus, from the results of SUR model it can be said that PB-1121 is the best suited variety in the region in terms of yield. In case of others explanatory variables, it has been found that N use (kg/ha) and educational status have significant positive impact on overall yield. Coefficient value (0.035) of N use indicated that use of additional 1 kg of N, yield has been increased by 0.035 q/ha which is significant at 1% and 5% level. So, judicious application of fertilizer for better return assume much importance. Similarly, educational status (0.048) has also positive and significant impact on overall production level.With increase of education level; farmers understand better management practice and judicial use of inputs to reduced cost of cultivation and enhanced the efficient use of input for sustaining overall yield. Since a higher level of education implies better technical know-how on management and farming skills, it is desirable to have educated farmers with better understanding of the yield increasing management practices. Similar results have been found in case of the yields of the by-products (q/ha). The yield of by-product of PS 5 is less by 6.62 q/ha compared to PB 1121. On the other hand, Pant Sugandh Dhan 21 produced 2.048 q/ha less yield compared to PB 1121. It can thus, be seen that PB 1121 is the best suited rice variety in that region in terms of both yield of main product and by-product. The results also suggested that 1 kg increase of nitrogen and potassium application, by product yield will be enhanced by 0.012 and 0.172 kg/ha which are found to be significant at 5% level. Similarly for wheat varieties, yield of HD-3059 and HD-3086 were found to be less by 4.595

q and 26.57 q respectively per ha compared to HD-2967. So, HD-2967 is most profitable variety among the all wheat varieties. Farmers exposed to different organizations have obtained more opportunities for dissemination of improved technologies which resulted in increased adoption of improved technologies and augmenting yield of the produce.

In the study, the result of quantile regression model revealed that operational land holding, extension contact, family type, house type and farm assets had significant influence on intensity of adoption. Economic efficiency of farm level estimation (SUR model) to identify best suited available technology (variety) showed that that PB-1121 of rice, HD-2967 of wheat were the best suited varieties in the area under study. This suggests that adoption of improved varieties significantly enhance the production, productivity and income of the selected respondent-farmers. However, lack of awareness and effective extension mechanism were also recorded. It can, thus, be suggested that programs, strategies and policies may be framed in such a way that could lead to higher level of adoption of improved technologies to achieve maximum attainable farm production and also generate more income for improvement of welfare of rural households in Lower Shivalik hills of Uttarakhand.

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