Research Article

Adoption of improved wheat varieties in eastern and western Terai of Nepal

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ABSTRACT

The research was conducted from March to May 2019 for assessment on adoption of improved wheat varieties in two major wheat growing districts of Nepal, Sunsari, and Kailali; one representing eastern and another western Terai. A pre-tested interview schedule was used to collect the primary information; in addition, two Key Informant Surveys were performed. Furthermore, relevant literatures were reviewed for secondary information. The simple random method of sampling was used within the selected areas that were identified in consultation with Agriculture Knowledge Centre and agricultural officials of the local government. Altogether, 194 samples were taken for the purpose of the study, omitting the outliers and incomplete responses. Descriptive statistics, probit regression, and indexing were used for data analysis. Probit econometric model revealed that membership dummy (1% level), age (1% level) number of family members involved in agriculture (1% level), subsidy dummy (10% level), number of schooling years (10%) and loan dummy (10% level) significantly determined the adoption of improved wheat varieties developed after NARC establishment. Furthermore, indexing identified- lack of availability of quality improved seeds (I= 0.80) as the major problem associated with the wheat production followed by poor availability of fertilizers (0.77), labour shortage (0.57), lack of proper irrigation (0.46) and lack of agricultural machines (0.39). The government agricultural institutions should assure access to quality seeds and fertilizers to the farmers; in addition, subsidy on irrigation and agricultural machines allied with agricultural loan to the educated youths could be the point of attraction for wheat cultivation which leads to increased wheat productivity.

Key words: Adoption, indexing, probit regression, wheat productivity

INTRODUCTION

Agriculture is a major component of the Nepalese economy which has a significant role in Gross Domestic Product (GDP) with the share of 27.6%. Wheat (735850 hectare) is the third most important crop in Nepalese agriculture after rice (1552469 hectare) and maize (900288 hectare) in terms of area. The total production and yield of wheat in Nepal have been reported 1879191metric ton (t) and 2554 kg/ha respectively (MOAD, 2018). It is a major winter cereal crop in Nepal and more than 80% of wheat is grown in rice-wheat cropping pattern (Kandel et al., 2018).

NARC has released and recommended 43 improved varieties of wheat which has been recommended for different ecological zones (26 for Terai and 17 for hills). However, 13 wheat varieties have been denotifed and only 30 varieties are under cultivation (Timsina et. al., 2018). National Wheat Research Program (NWRP) is the national commodity research program of NARC which is located in Bhairahawa, Rupandehi, Nepal which had developed high yielding and disease resistant varieties such as: Gautam,Vijay, Bhrikuti, NL 971, Tilottama, Aditya, WK1204, BL 1473, Dhaulagiri, Danphe etc. However, NL 297, UP262 and RR21 which were developed before establishment of Nepal Agricultural Research Council (NARC) are yet common varieties among the farmers despite being disease susceptible and in less prioritization for seed production by the government. The Terai region is the major ecological region for wheat production in Nepal; eastern and western terai region contributes significantly higher to wheat production. More than 60% of wheat is produced in the Terai (plain) region. Sunsari and Kailali districts are the districts in the eastern and western terai having the highest wheat area coverage. The total area, production and yield of wheat in Sunsari and Kailali are: 14500 hectare (ha), 43800 t, 3021 kg/ha and 34530 ha, 101863 t, 2950 kg/ha, respectively (MOAD, 2018).

The difference between actual yields in a region and agro-climatically achievable yields in the same region is termed the 'yield gap' (Shrestha and Subedi, 2019). Timsina et.al. (2019) reported that there is a huge gap between yield potential and average national productivity. To achieve greater impact of wheat research in Nepal, it is necessary to bridge the gap by making the availability of improved seed with an improved package of practices. Furthermore, Thakur et al. (2007) revealed that the adoption of much improved technologies by the farmers have significant effect in rate of change in wheat productivity. Nepal Agricultural Research Council (NARC) was established in 1991 as an autonomous organization under "Nepal Agricultural Research Council Act - 1991" to conduct agricultural research in the country to uplift the economic level of the people. Very few studies have been carried out to assess the adoption of improved wheat varieties released and recommended by NARC. In this context, this research is designed to determine the status of adoption of improved wheat varieties and the factors affecting the decision to adopt improved varieties developed after NARC establishment. Also, this research explores the major problems associated with the wheat production in Terai region of Nepal.

METHODOLOGY

Study area, sample size, and data collection

Sunsari and Kailali districts were purposely selected for the study as these were the districts in the eastern and western terai having the highest wheat area coverage (MOAD, 2018). A pre-tested interview schedule was used to collect the primary information; in addition, two Key Informant Surveys were performed. Furthermore, relevant literatures were reviewed for secondary information. The simple random method of sampling was used within the selected areas that were identified in consultation with Agriculture Knowledge Centre and agricultural officials of the local government. Altogether, 194 samples were taken for the purpose of the study, omitting the outliers and incomplete responses.

Determination of factors affecting the decision to adopt improved wheat varieties

A probit regression model was used to analyze the effect of different variables on decision to adopt improved wheat varieties developed after NARC establishment. To determine the factors affecting the adoption of improved technology, the probit model has been found to be used used in many studies (Hattam, 2006). Kafle (2010) also used probit model to analyze the factors affecting the decision to adopt improved maize varieties in developing countries. The probit model is often used when a choice is to be made between two alternatives; in this study, decision to either adopt (or not adopt) improved wheat varieties released after NARC establishment. From the perspective of an economist, an individual i makes a decision to adopt if the utility associated with that adoption choice (V_{Ij}) is higher than the utility associated with decision not to adopt (alternative choice), (V_{0j}). Koop (2003) stated that the difference in utilities of the two alternative choices is stated as $Y_j^* = V_{Ij} - V_{0j}$ and the econometric specification of the model is given in its latent as:

$$Y_j^* = X_j\beta + e_j$$

Where Y_j^* is an unobserved (latent) random variable that defines farmer's binary (adoption) choices, X_j is sets of explanatory variables associated with individual j. β is a vector of coefficients associated with the explanatory variables while e_j represents the random error terms defined as: $e \sim N(0, 1)$. The relationship between the unobserved variable Yj^* and the observed outcome (Yj) can be specified as:

$Yj = 1$, if $Yj^* \geq 0$

$Yj = 0$, if $Yj^* < 0$

Probit model has the characteristic feature; the effect of independent variables on dependent variables is non-linear. It is a statistical model which aims to form a relation between probability values and explanatory variables ensuring that the probability value remains between 0 and 1. For the statistical analysis of the model, STATA software package was used.

In this study, adoption of improved wheat varieties developed after NARC establishment was based on an assumed underlying utility function. According to this theory, improved wheat varieties developed after NARC establishment has been adopted by the farmer, if the utility obtained from it exceeds that non-adoption. The farmer's behaviour towards improved wheat varieties developed after NARC establishment. is described by the following equations;

$Prob(Y_i^*) = \sigma_0 + \Sigma \delta_n X_i + \varepsilon_i$ ………………….. Equation 1

$Prob(Adopt=1) = \Upsilon^{'} K + \varepsilon_i$ ……………………………... Equation 2

Where,

Y^{*}_i = A latent variable representing the propensity of a farm household i to adopt improved wheat varieties developed after NARC establishment (1 if adopt and 0 otherwise).

X_i = K= the vector of households' socio-economic and farm characteristics and variables that influence the adoption decision

σ_0, δ_n = parameters to be estimated

ε_i = error term of the ith farm households

i = 1, 2, 3, … n farm households

Table 1. The statistical description of the variables used in the probit regression model.

Variables	Description	Value	Expected sign
Membership	Membership of any organization	If had membership = 1, otherwise = 0 (Dummy)	+
Subsidy	Subsidy in inputs given by the government	If subsidy provided = 1, otherwise = 0 (Dummy)	+
Gender	Gender of the household head	Male=1, otherwise = 0	+/-
Ag_inv	Number of family members involved in agriculture	Persons (in number)	+
F_size	Number of family members	Persons (in number)	+/-
education	Number of schooling years	Years (in number)	+ /-
Age	Age of the household head	Years (in number)	+/-
Loan	Availability of loan for agriculture	Yes=1, otherwise = 0	+

The probit model specified in this study to analyze the factors affecting farmers' decisions to adopt improved wheat varieties developed after NARC establishment.

Pr (adopting improved varieties developed after NARC establishment =1) = f (b_0+ b_1 X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9)

where, Pr = Probability score of adopting improved varieties developed after NARC establishment

X_1= membership (Dummy)

X_2= subsidy (Dummy)

X_3= Gender of the household head (decision maker) (Dummy)

X_4= Number of family members involved in agriculture

X_5= Number of family members

X_6= number of schooling years of the household head

X_7= Age of the household head

X_8= Availability of loan for agriculture (dummy)

$b_1, b_2.... b_9$ = Probit coefficient, b_0 = Regression coefficient

Problems/constraints of wheat production

Indexing/Scaling technique was applied to construct an index for prioritizing the problems as per farmers' perception. Miah (1993) stated that the scaling techniques provide the direction and extremity attitude of the respondents towards any proposition. On the basis of responded frequencies, weighted indexes were calculated and were ranked by using five-point scales. The formula used to determine the index for intensity of various problems is:
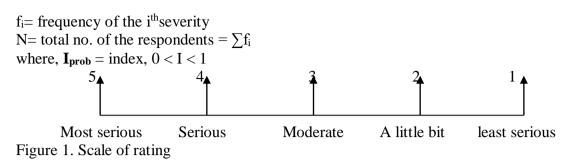
$$I_{prob} = \sum \frac{Sifi}{N}$$

where, I_{prob} = index value for intensity of problem

$\sum$ = summation

S_i = scale value at i^{th} intensity/severity

f_i= frequency of the ith severity

N= total no. of the respondents = $\sum f_i$

where, $\mathbf{I_{prob}}$ = index, 0 < I < 1

5	4	3	2	1
Most serious	Serious	Moderate	A little bit	least serious

Figure 1. Scale of rating

RESULTS AND DISCUSSION

Varietal distribution

This study revealed that, of the surveyed farmers in Sunsari, 100% were cultivating the improved wheat varieties; unlike this, in Kailali, 95.4% were found to be cultivating improved varieties, 2.1% the local and 2.5% the Indian. The improved varieties found to be cultivated in the study area are Gautam, Vijay, NL 297, UP 262, BL 1022, NL 971, Aditya, Dhaulagiri etc. Within the improved varieties' coverage, NL 297 was found to have the highest area coverage of 48.3 % followed by Vijay (24%), Gautam (15.7%) and Aditya(10.3%). This study showed the wide adoption of improved varieties in Terai region of Nepal which is better illustrated in figure 2 and figure 3.
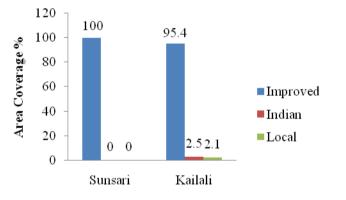

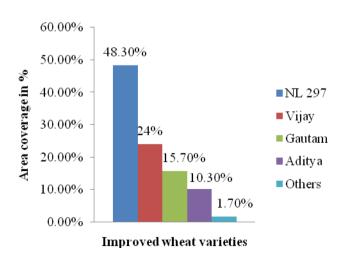Figure 2. Area coverage of different wheat varieties in Sunsari and Kailali

Figure 3. Area coverage of improved wheat varieties in Sunsari and Kailali

Determination of factors affecting the decision to adopt improved wheat varieties

To identify the factors affecting the decision to adopt improved wheat varieties developed after NARC establishment, a probit model of regression was used. The binary response of the 194 respondents was coded as; adopters =1 and 0 otherwise. The Wald test (LR chi^2) for the model indicated that the model has good explanatory power at the 1% level.

This means that all the explanatory variables included in the model jointly influence farmer's probability of adoption of improved wheat varieties developed after NARC establishment. The probit model estimation gave a pseudo R^2 of 0.17 which implies that the variables included in the model are able to explain about 17% of the probability of farm household's decisions to adopt or not to adopt wheat varieties developed after NARC establishment. The area under ROC curve for the regression is 0.77 which reveals that the model presents adequate discrimination. Also, probit regression analysis showed that the six variables were statistically significant for the decision to adopt; membership, subsidy, number of family members involved in agriculture, number of schooling years of the household head, age of the household head and availability of loan for agriculture (Table 2). For the interpretation of the model, marginal effects were driven from the regression coefficients, calculated from the partial derivatives as a marginal probability. The interpretation is shown in Table 2.

Table 2. Factors affecting the decision to adopt improved wheat varieties developed after NARC establishment.

Variables	Coefficients	P>|z|	Standard error	dy/dx[b]	S.E[b]
membership (yes =1)	.7489***	0.000	.211	.288	.0780
subsidy (yes=1)	1.264*	0.067	0.690	0.357	0.105
Gender (male =1)	-.426	0.200	0.332	-.157	.114
Ag_inv	0.270***	0.002	.0884	.105	.034
F_size	-.063	0.289	.059	-.024	.023
Education	-.044*	0.079	.025	-.017	.009
Age	-.032***	0.001	.009	-.012	.004
Loan	-.640*	0.052	.329	-.251	.124
Constant	1.436	0.016	.596	-	-

*** *Significant at 1% level ;** Significant at 5% level ; * Significant at 10% level*
[b]*Marginal change in probability evaluated at the sample means*

Summary Statistics	
Number of observation(N)	194
Log likelihood	-110.70589
LR chi^2 (8)	44.03*** (Prob> chi^2 =0.0000)
Pseudo R^2	0.17
Predicted probability (adoption)	0.59
Goodness of fit test	Pearson chi^2 (185) = 194.56 .Prob> chi^2 = 0.3004
Area under ROC curve	0.77

Source: Field survey, 2019

Age of the household head was found to be highly significant at 1% level of significance and negatively related to the adoption of improved varieties released after NARC establishment. With the increase in age of the household head by one year, the probability of adoption of improved varieties released after NARC establishment decreases by 1.2% (Table 2). In contrast to this, Subedi and Dhakal (2014) revealed that the age of the household head is positively related to the adoption of new agricultural technology. This study revealed that the younger are the early adopters of new agricultural technology. Al-Karablieh (2009) also

revealed that the adoption of seed drill technology was negatively associated with the farmers' age.

For farmers as a member of any organization, the probability of adoption of improved varieties released after NARC establishment increases by 29% as compared to farmers having no membership (at 1% level of significance) (Table 2). In line of this finding, Subedi and Dhakal (2014) also stated that there is positive relationship between the adoption of poultry manure technology in agriculture and membership in any organization or cooperatives. Moreover, Mignouna et al. (2011) also reported that belongingness to a social group enhances idea and information exchange where farmers learn the benefits of usage of a new technology.

The probability of adoption of improved varieties released after NARC establishment decreases by 25% for the farmers which had taken a loan as compared to farmers which hadn't(10% level of significance) (Table 2). Perhaps, the loan taker farmers prefer to invest in non-agricultural high return giving enterprises. In contrast to the findings of this study, Yirga (2007) and Pattanayak et al. (2003) reported that availability of credit was found to be positively related to the adoption of agricultural technology; this might be due to the provision of agricultural loan with low-interest rate.

The probability of adoption of improved varieties released after NARC establishment increases by 36% for the farmers which had got subsidy for wheat production from the government as compared to farmers which hadn't got a subsidy (at 10% level of significance) (Table 2). The subsidy supports the production cost and monitoring, as well as technical assistance of government agricultural officials, might be there to support the adoption of new technology. In line with this finding, Mason and Smale (2013) also reported that the government subsidy can allow farmers to experiment with the technology.

The number of family members involved in agriculture was found to be highly significant at 1% level of significance and positively related to the adoption of improved varieties released after NARC establishment. With the increase in number of family members involved in agriculture by one, the probability of adoption of improved varieties released after NARC establishment increases by 11% (Table 2). Of course the increase in agricultural labour morally encourages in adoption of new technology and supports agricultural production. In a synonymous manner, it has been revealed that a larger household agricultural labour have the capacity to relax the labor constraints required during introduction of new technology (Mignouna et al., 2011; Bonabana-Wabbi, 2002).

Similarly, the number of schooling years was found to be significant at 10% level of significance and negatively related to the adoption of improved varieties released after NARC establishment. With the increase in number of schooling years by one, the probability of adoption of improved varieties released after NARC establishment decreases by 1.7% (Table 2). The educated person could be well aware of the risk associated with the adoption of new technology and so not willing to do so. Also, with the increase in their education status, they might be interested in service rather than agriculture. In a like manner, studying the effect of education on technology adoption, Uematsu and Mishra (2010) reported a negative influence of formal education towards adopting genetically modified crops.

Assessment of problems/constraints of wheat production

From the survey conducted among the wheat growers, lack of availability of quality improved seeds was ranked as the major problem followed by poor availability of fertilizers when questioned about the problems associated with the wheat production. Similarly, labour shortage, lack of proper irrigation and lack of agricultural machines were the third, fourth and

fifth problems respectively as per farmer's ranking (Table 3). Paudyal (2001); Shrestha and Timsina (2011) also stated that the yield is significantly affected by seed quality, an infestation of disease and pest and availability of irrigation. Similarly, Hailu (1992) stated that the lack of availability of quality seeds including other inputs (fertilizers, farm machinery) are the main bottlenecks in increasing maize production and productivity. In addition, Hintze *et al.* (2003) reported that the adoption of maize seed production, increment in maize production and income are assisted by the availability of technical assistance and adequate irrigation facilities.

Table 3. Problems associated with the wheat production

S. N	Problems	Index value	Rank
1	Lack of quality improved seeds	0.80	I
2	Poor availability of fertilizers	0.77	II
3	Labour shortage	0.57	III
4	Lack of proper irrigation	0.46	IV
5	Lack of agricultural machines	0.39	V

CONCLUSIONS

Adoption of the improved wheat varieties in the Sunsari district was found to be 100 % which showed very good co-ordination between research and extension. However, the majority of the variety- NL 297(not recommended by the government for seed production and multiplication) in area coverage among the improved wheat varieties revealed that appropriate extension strategies should be adopted for wide adoption of newly released disease resistant high yielding varieties developed by NARC. The involvement of farmer in any organization should be promoted as it has been found to be significant in the adoption of technology. Moreover, the agriculture policy should be formulated intending to create the environment for involvement of youths in agriculture. Giving aggressive subsidies, providing the agricultural credit at low interest rate could promote the adoption of recently released high yielding varieties of NARC. The formal education may not be enough to grave the interest of even an educated people in adoption of new agricultural technology, some agriculture-related courses at the high school and certificate levels and even informal agricultural knowledge extension programs could be needed for better understanding of agricultural technologies. Lacking proper access to quality improved seeds and fertilizers, unavailability of labour in time, lack of proper irrigation facility and agricultural machines has been explored as the major problems associated with the wheat production from this study. Appropriate solutions should be adopted to address these problems taking consideration of the determinants of the adoption to increase the wheat productivity in Nepal.

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Author contributions

S Subedi was the main investigator and the initiator of this research. SP Adhikari, D Devkota, HK Poudel, and BK Sapkota were responsible for literature search, data generation and

drafting of the manuscript. S Subedi and YNG were responsible for overall study design and finalization of the manuscript. All authors read and approved the final manuscript.

Conflict of interest

The authors declare no conflicts of interest regarding publication of this manuscript

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