Journal of Agriculture and Natural Resources (2020) 3(1): 12-19
ISSN: 2661-6270 (Print), ISSN: 2661-6289 (Online)
DOI: https://doi.org/10.3126/janr.v3i1.26999

Research Article

Decision to use herbicide in wheat production by the farm households in Nepal: A probit regression analysis

Surya P. Adhikari*, Yuga N. Ghimire, Sanjiv Subedi and Hema K. Poudel

Socioeconomics and Agricultural Research Policy Division, Khumaltar Lalitpur, Nepal
*Corresponding author:adhikarisurya56@gmail.com;ORCID:https://orcid.org/0000-0002-2712-9387
Received: August 27, 2019; Accepted: November 22, 2019; Published: January 7, 2020

ABSTRACT

The use of herbicides in wheat production is increasing in Nepal mainly due to labor shortage and higher wage rates, even if available. However, little information is available on what factors determine the use of herbicides. This study explored the major factors that affect the decision to use herbicide by the wheat farmers. The semi-structured interview schedule was administered to 343 farmers from four major wheat-growing districts. The study employed a probit regression model to identify the factors that influenced the decision to use herbicides. Educations, membership, migration, wheat cultivated area, amount of urea use were identified as the significant factors influencing the decision of farmers to use herbicides. Herbicides user farmers produced 220 kg more wheat grain yield from one hectare of land compared to non-users. This study suggests that the wheat yield of Nepal could be increased through adopting better weed management techniques.

Keywords: herbicide, labor, probit regression, wheat yield

Correct citation: Adhikari, S.P.,Ghimire, Y.N, Subedi, S., & Poudel, H.K. (2020). Decision to use herbicide in wheat production by the farm households in Nepal: A probit regression analysis. *Journal of Agriculture and Natural Resource, 3*(1), 12-19. DOI: https://doi.org/10.3126/janr.v3i1.26999.

ISSN: 2661-6270 (Print), ISSN: 2661-6289 (Online)
DOI: https://doi.org/10.3126/janr.v3i1.26999

INTRODUCTION

Wheat is the third important crop of Nepal after rice and maize both in area and production. The present wheat area is 7, 06,842 ha with average productivity is 2757 kg/ha. Wheat is grown on 25% of the cultivated land in the country. Wheat productivity has steadily increased from 2.2 to 2.75 t/ha in the last ten years (MoALD, 2018). Rice-wheat is the most common and important cropping pattern in the Terai region. However, the average productivity of wheat is low as compared to neighboring countries India and China 3.37 ton/ha and 5.48 ton/ha respectively. There are several factors responsible for low wheat productivity in Nepal. Weed is one of the major factors that contribute to a lower yield. Losses caused by weeds in wheat depend on the infesting weed type, its intensity, and agronomic practices adopted in wheat cultivation (Singh, 2007). Losses caused by weeds in wheat vary from 20-50 percent, but there could be complete crop failure in extreme cases (Malik & Singh, 1995). Losses are not only caused by direct nutrient competition between weeds and the crop but also because the presence of weeds may attract other biotic yields – reducing factors, such as diseases and grain-feeding birds (Demont & Rodenburg, 2016).

The use of herbicides is the increasing rate in the world for crop production. Herbicides are being rapidly adopted in developing countries that shortage of hand weeding labor and the need to an increase in crop production. Increased herbicide use promotes efficient fertilizer use, which leads to an increase in production. Herbicide application is usually the most effective and least labor-intensive weed control method with the highest yield return (Rodenburg et al., 2015). In Nepal, many farmers depend on herbicides to control weeds in wheat fields. Manual weeding is a traditional practice used to control weed competition with crops, but their cost is rising due to increased labor cost. Nepal imported about 1.05 t herbicides in 2016/17 (CBS, 2019). No herbicides are produced in Nepal. Annual herbicide use in Nepal is increasing. Farmers mostly use herbicide to control weed in cereal production. Most of the herbicides are imported from India and China. Despite the increase in herbicide use in Nepal, no empirical examines the determinants of herbicides used. In this paper, we examine factors affecting herbicide use in Nepal.

Mbazima (1997) studied herbicide adoption rates among small and medium-scale farmers in Zambia. The study by Pingali (2001) found that higher labor costs, decreasing herbicide price and the wide adoption of herbicide-resistant GM crops could be potential factors driving the expansion in herbicide use. A study on factors that affect the use of herbicides in Philippine rice farming system found that the age of the farmer, household size, irrigation, farm size, land ownership, price of herbicides, income and credit were the significant factors determining the adoption of herbicide (Beltran et al., 2013). Research on rising herbicide use and its driving forces in China showed that migration, irrigation, farmers' education were significant factors in herbicide use (Huang et al., 2017). A study on factors affecting the joint adoption of herbicides and conservation technologies in Zambia found that male-headed household, members to a cooperative, farm size, having knapsack sprayer and receiving advice on CA technologies were critical in positively influencing the joint- adoption of herbicides and CA technologies (Mutale et al., 2017). A study by Tamru et al. (2017) in Ethiopia found that positive labor productivity effects of herbicide use of between 9 and 18 percent. They also identified the adoption of herbicide is strongly related to proximity to urban centres, access to all weather roads, and wage rate. Research in India found that as the

Journal of Agriculture and Natural Resources (2020) 3(1): 12-19
ISSN: 2661-6270 (Print), ISSN: 2661-6289 (Online)
DOI: https://doi.org/10.3126/janr.v3i1.26999

rural nonfarm employment increases, the probability of adoption of herbicides increases (Gupta et al., 2017).

The overall objective of this study is to determine farm-level factors that determine herbicide use in a wheat-based farming system in the Terai region of Nepal. An empirical analysis that identifies the impact of various factors on the adoption of weed management strategies can help to provide valuable input into the formulation of policies related to the herbicide.

METHODOLOGY

The farm-level data were collected through face to face interviews with 343 wheat farmers in the Terai region of Nepal, which covered four districts: Sunsari district from eastern Terai, Bara from central Terai, Rupandehi from western Terai and Kailai from far western Terai. The households' survey was conducted using a semi-structured interview schedule during January-April 2019. Multistage sampling was used in the study. At first, four Terai districts were selected based on the highest wheat-growing district in that region of Nepal. In the second stage, three pockets in each district were selected based on wheat area, production and productivity with the consultation of the Agriculture Knowledge Centre and the households were selected randomly from the pockets. One focus group discussion was conducted in each pocket. The survey collected information on household demographics, the quantity of inputs use, wheat production technologies and outputs obtained. The collected information from four districts was entered in Excel and data analysis was conducted by using software Stata (version 15.1). Both descriptive and inferential statistics were used to analyze the data. In this study, the treatment group includes farm households who used herbicides in wheat farming. The control group represented farmers who didn't use herbicides in the wheat field. Among the sample households, 176 households used herbicides whereas, 167 households didn't use herbicides in their wheat field.

Factors Influencing Herbicide use

A probit model was used to determine the factors influencing herbicide use in the wheat field. A probit model is appropriate for modelling dichotomous dependent variable which takes value 1 for adopter and 0 for non-adopters. The Logit model is also used in the discrete model which produces the same results as the probit model (Gujarati, 2004). The difference between logit and probit model is only in the distribution of the errors. The logit model has a standard logistic distribution of errors where the probit model has a standard normal distribution of errors (Gujarati, 2004). The estimated parameters in the probit model are between 50% and 60% smaller value than the corresponding parameter estimates in the logit results.

In this study, farmers' use of herbicide was based on an assumed underlying utility function. The difference between the utility from using herbicides (UiA) and the utility from not using herbicide (UiN) may be denoted as Ui*, such that a utility-maximizing farm household i will choose to adopt new technology if the utility gained from adopting is greater than the utility from not adopting (Ui* = UiA –UiN> 0). Since, these utilities are unobservable, they can be expressed as a function of observable elements in the latent variable model as shown in the below equation. FelekeandZegeye (2006), Janvry et.al.(2010), Asfaw et al. (2012), and Kohansal and Firoozzare (2013) used the adoption decision modeled in a random utility framework as follows:

$\text{Prob}\,(U^*_i) = \sigma_0 + \Sigma\, \delta_n X_i + \varepsilon_i$ ……………………. Equation 1

Journal of Agriculture and Natural Resources (2020) 3(1): 12-19
ISSN: 2661-6270 (Print), ISSN: 2661-6289 (Online)
DOI: https://doi.org/10.3126/janr.v3i1.26999

$$\text{Prob(Adopt=1)} = U^{'}K + \varepsilon_i \quad \text{......................................} \quad \text{Equation 2}$$

Where,

U^{*}_{i} = A latent variable representing the propensity of a farm household i to use herbicides (1 if farmer using herbicide and 0 otherwise)

X_i = K= the vector of farm households' asset endowments, household characteristics and location variable that influence the herbicide using decision

$\sigma_{0,}\ \delta_n$ = parameters to be estimated

ε_i =error term of the i^{th} farm households

i = 1, 2, 3, … n farm households

RESULTS AND DISCUSSIONS

Socio-Demographic Characteristics

Table 1 presents the descriptions and summary statistics of the entire variable that are used in the probit model. It also shows the expected influences (positive and negative signs) of the explanatory variables on herbicide use decisions. In the probit model, a discrete latent variable of herbicide use (adopt) is generated, taking on a value of 1 if the farmer used herbicides in the wheat field and 0 if the farmers didn't use herbicide in their wheat field. About 51% of the sample households used herbicide in the wheat field. Most of the farmers used postemergence herbicide 2,4-D for weed control. They applied 2,4-D herbicides after 20-35 days after sowing. The average age of the household head was about 50 and the average household head formal schooling was 6 years. The mean wheat area is 0.76 ha. On average wheat farmers used 124 kg urea per hectare for wheat production.

Table 1: Description, summary statistics, and expected signs for variables in the model

Variable	Description	Mean	SD	Expected sign
Dependent variable				
Adoption of herbicide	=1 if the farmers use herbicides, 0 otherwise	0.51	0.50	
Independent variable				
Age	Age of the household head (years)	49.91	12.64	+, -
Education	Number of schooling of household head (years)	6.12	4.51	+
Farm size	Farm size of wheat farming (ha)	0.76	0.88	+
Urea	Amount of nitrogenous fertilizer applied (kg/ha)	124	52	+
Migration	Value 1 if household membersmigrated, 0 otherwise	0.19	0.39	+
Membership	Value 1 if member of an Agricultural organization, 0 otherwise	0.56	0.49	+
Training	Value 1 if attended a wheat training, 0 otherwise	0.17	0.38	+
Region dummy	Value 1 if farm located in eastern and Central region, 0 if farm located in western and far western	0.55	0.49	+,-

About 20% of household members migrated to foreign countries. About 56% of farmers were members of Agriculture related organizations, whereas about only 17% of farmers received training on wheat farming. About 55% of farmers were surveyed from the eastern and central part of the country, whereas about 45% of farmers were from the western and far western regions.

Table 2 presents the results of differences between means of characteristics describing herbicides users and non-users. The education of the household head was significant different between herbicide users and non-users. The total wheat area was higher for adopters compared to non-adopter, but it is not significant. The amount of urea application was

Journal of Agriculture and Natural Resources (2020) 3(1): 12-19
ISSN: 2661-6270 (Print), ISSN: 2661-6289 (Online)
DOI: https://doi.org/10.3126/janr.v3i1.26999

significantly higher for adopter farmers. The wheat productivity was significantly higher for herbicide user farmers as compared to non-users. Herbicide user farmers produced 220 kg more wheat in one hectare of land than non-user farmers.

Table 2: Characteristics of herbicide users and non-users

Variables	Herbicide users	Herbicide non users	Difference	t-value
Age (Years)	50.11	49.71	0.40	0.769
Education (Years)	6.83	5.37	1.46	0.002**
Family Size (no.)	7.130	7.635	-0.504	0.215
Farm size (ha)	0.838	0.683	0.155	0.104
Urea quantity (kg/ha)	133.92	113.48	20.45	0.000***
Wheat productivity (kg/ha)	2881	2661	220	0.006**
Migration	0.22	0.16	0.066	0.126
Membership	0.71	0.41	0.30	0.000***
Training	0.19	0.16	0.032	0.437
Region dummy	0.64	0.46	0.18	0.001***

Source: Field survey; 2019

Table 3 presents the estimated parameters for the adoption of herbicide use. The result for the probit regression shows that the model is significant at 1% level based on LR chi-square value of 59.55 with 8 degrees of freedom. The value of pseudo R^2 of the model is 0.125, with 68.51% of the responses predicted correctly. The area under the ROC curve for the probit regression is 0.72 which reveals that the model presents adequate discrimination. In table 3 the marginal effect (dy/dx), which represents the percentage change in herbicide use per percentage change in each of the independent variables. Among the explanatory variables year of schooling, total wheat area, amount of urea use, membership, migration, and region were statistically significant.

To assess the effect of farm size on the probability of adoption of herbicides, the wheat area was included in the model. The positive and significant sign-on farm size indicated that as farm size increased, the likelihood of application of herbicides increased. As shown by the marginal effect, increasing a farm size by 1 percent the probability of taking the decision to use herbicide increases by 0.07 %. Beltran et al. (2013) in the Philippines also found that farmers who have large farm areas tend to adopt herbicides.

The education of household head was found to have a significant impact on herbicide use in wheat production. The positive coefficient of education suggests that educated farmers apply herbicides than farmers with less education. This is because educated members have more knowledge of herbicides than less educated members. The marginal effect of variable education is 0.012. This implies that holding other factors constant, one year increase in schooling year of the household head will increase the probability of herbicide used by 1.2 %. This is consistent with the literature that education creates a favourable mental attitude for the acceptance of new agricultural technology (Waller et al., 1998; Caswell et al., 2001). However, This result is contradicted with Huang et.al, 2017 in China.

Moreover, the model revealed that increasing the urea usage by 1%, the probability of taking the decision to use herbicide increases by 0.14% (at 1% level of significance). This implies that farmers who applied more urea applied in the wheat field have a higher probability of herbicide application. This may be because a higher nitrogen application helps to grow more weed in the wheat field. This may be because weeds establish and grow more easily in

ISSN: 2661-6270 (Print), ISSN: 2661-6289 (Online)
DOI: https://doi.org/10.3126/janr.v3i1.26999

nitrogen-rich soil (Ampong-Nyarko & De Datta, 1991). This finding is consistent with the amount of nitrogen fertilizer applied is a positive significant factor in herbicide expenditure (Beltran et al., 2013).

Migration has a positive association with herbicide applications. The finding indicates that the probability of herbicide application is 10% more for households with foreign migrants as compared to non-migrant households. Households with foreign migrants who send remittances are able to buy herbicides and apply in their field. This is in line with the findings of the study conducted in Bangladesh (Mendola, 2008) which showed that foreign migration has a positive effect on adopting superior agricultural technologies.

Table 3: Probit model estimation of herbicide use

Variables	Coefficient	SE	z-value	p>| z |	dy/dx
Log Age (Years)	0.050	0.104	0.26	0.869	0.017
Education (Years)	0.034**	0.006	1.94	0.053	0.012
Log farm size (ha)	0.194**	0.029	2.27	0.023	0.067
Log Urea kg	0.407***	0.056	2.52	0.012	0.141
Migration	0.312*	0.062	1.73	0.084	0.101
Membership	0.734***	0.046	5.55	0.000	0.253
Training	-0.068	0.067	-0.35	0.726	-0.023
Region dummy	0.345**	0.049	2.43	0.015	0.119
Number of observation (N)	343				
LR chi2 (8)	59.55				
Prob> chi2	0.000				
Pseudo R2	0.125				
Log likelihood	-207.86				
Goodness of fit test	Pearson chi2 (331) = 341.6 prob>chi2 = 0.332				
Correctly predicted percent	68.51				

Note: * significant at 10% level, ** significant at 5% and *** significant at 1%

The participation of the membership in an agriculture-related organization has a positive relation with herbicide application. Thus, those farmers who are involved in farm organizations have more probability of herbicide application. A positive relation between membership and herbicide application could arise because the farm organization gives the knowledge and information about herbicides application to the farmers. The coefficient of membership is positive and statistically significant. Holding other factors constant, farmers who are members of an agriculture-related organizations; the probability use of herbicide is increased by 25%. Farmers who were members of agricultural organization; the probability of adoption of new agricultural technology was increased (Adhikari et al., 2018; Subedi et al., 2019; Mutale et al., 2017).

The location variable (region) showed a statistically significant and positive relationship with wheat farmers’ decision to use herbicide in the wheat field. This means that farmers in the eastern and central regions have 12% more probability to use herbicides as compared to western and far western region farmers. This may be due to eastern and central region farmers are more aware of using herbicides than western and far western region farmers.

CONCLUSION

The results of this study revealed that different socioeconomic factors such as the education of household head, membership, migration and farm size significantly affect in a decision to use herbicides; taking account of their relation, the use of herbicides could be promoted. In

ISSN: 2661-6270 (Print), ISSN: 2661-6289 (Online)
DOI: https://doi.org/10.3126/janr.v3i1.26999

addition, the study explored that the farmers applying a high dose of nitrogenous fertilizers were using the herbicides while the vice versa was also true. This study also found that the use of herbicides increases the productivity of wheat; the wheat productivity of the farmers using the herbicide was higher as compared to non user farmers. Furthermore, the study disclosed that there is a significantly higher probability of using herbicide in wheat production among the farmers of the eastern and central regions than western and far western regions. This study highlighted that appropriate weed management strategies could contribute to increase the wheat productivity of Nepal.

ACKNOWLEDGEMENT

Authors want to thank Nepal Agricultural Research Council (NARC) for providing the fund to conduct this research. The authors extend sincere gratitude to the respondent farmers for their valuable help and cooperation.

Authors Contribution

SPA designed and drafted the paper. YNG, SS and HKP were responsible for edition and revision of the paper.

Conflicts of Interest

The authors declare that there are no conflicts of interest in this paper.

REFERENCES

Adhikari, S.P., Timsina K.P., & Lamichhane, J. (2018). Adoption and impact of rain water harvesting technology on rural livelihoods: The case of Makwanpur district, Nepal. *Rural Extension & Innovation System Journal*, *14* (1), 34-40.

Ampong-Nyarko, K., & De Datta, S.K. (1991). A handbook for weed control in Paddy plant. Paddy Research Institute, Manila, Phillippines.

Asfaw, S., Shiferaw, B., Simtowe, F., & Lipper, L.(2012). Impact of modern agricultural technologies on smallholder welfare: Evidence from Tanzania and Ethiopia, *Food Policy*, *37*(3), 283– 295.

Beltran, J., White, B., Burton, M., Doole, G., & Pannell, D. (2013). Determinants of herbicide use in rice production in the Philippines, *Agricultural Economics*, *44*(1), 45-55.https://doi.org/10.1111/j.1574-0862. 2012.00631.

Caswell, M., Fuglie, K., Ingram, C., Jans S., & Kascak C. (2001). Adoption of Agricultural production practices: Lessons learned from the US. Department of Agriculture Area Studies Project. US Department of Agriculture, Resource Economics Division, Economic Research Service, Agriculture Economic Repor no. 792. Washington DC

CBS. (2019). Environmental Statistics of Nepal.CentralBureau of Statistics, Kathmandu Nepal.

Demont, M., & Rodenburg, J. (2016). On the interaction between weedand bird damage in rice. *Weed Research*, *56*, 193–197. https://doi.org/10.1111/wre.12206.

Feleke, S., & Zegeye, T. (2006). Adoption of improved maize varieties in Southern Ethiopia: Factors and strategy options. *Food Policy*, *31*(5), 442–457.

Gujarati, D.N. (2004). Essentials of Econometrics. 4rd ed. Singapore: The McGraw−Hill/Irwin Companies

Gupta, S.D., Minten, B., Rao, N.C., & Reardon, T. (2017). The Rapid Diffusion of Herbicides in Farming in India: Patterns, Determinants, and Effects on Labor Productivity. *European Journal of Development Research,* DOI: 10.1057/s41287-017-0091-6

Huang, J., Wang, S., & Xiao, Z. (2017). Rising herbicides use ad its driving forces in China. *The European Journal of Development Research*, *29*, 614-627. doi:10.1057/s41287-017-0081-8

Janvry, D.A., Dustan, A., & Sadoulet, E. (2010). Recent advances in impact analysis methods for ex-post impact assessments of agricultural technology: Options for the CGIAR. *In: Proceeding of University of California at Berkeley.*http://impact cigar org/meetings-and-events.

Kohansal, M.R, & Firoozzare, A. (2013). Applying multinomial logit model for determining socio-economic factors affecting major choice of consumers in food purchasing: The case of Mashhad.*Journal of Agricultural Science Technology*, *15*, 1307–1317.

Malik, R.K., & Singh, S. (1995). Littleseedcanarygrass (Phalaris minor) resistance to isoproturon in India, *Weed Technology*, *9*, 419–425.

Mbazima, K.M. (1997). Factors Affecting the Use of Herbicides in Small and Medium Maize Production.The Case of Copperbelt and Central Provinces of Zambia.M.B.A. Dissertation, TheCopperbelt University.

Mendola, M. (2008). Migration and TechnologicalChange in Rural Households: Complements orSubstitutes? *Journal of Development Economics*, *85*(91), 150-175.

MoALD. (2018). Statistical Information on Nepalese Agriculture.Ministry of Agricultural and Livestock Development. Monitoring, evaluation and statistics division, Singhdurbar, Kathmandu.

Mutale, G., Kalinda, T., & Kuntashula, E. (2017). Factors Affecting the Joint Adoption of Herbicides and Conservation Tillage Technologies among Smallholder Farmers in Zambia, *Journal of Agricultural Science*, *9* (12).

Pingali, P. (2001). Environmental consequences of agricultural commercialization in Asia, *Environment and Development Economics*, 6, 483–502.

Rodenburg, J., Saito, K., Irakiza, R., Makokha, D.W., Onyuka, E.A., & Senthilkumar, K. (2015). Labor-saving weed technologies for lowlandrice farmers in sub-Saharan Africa. *Weed Technology*, *29*(4),751–757. https://doi.org/10.1614/WT-D-15-00016.1.

Singh, S. (2007). Role of management practices on control of isoproturon-resistant littleseedcanarygrass (Phalaris minor) in India, *Weed Technology*, *21*, 339-346.

Subedi, S., Ghimire, Y.N., Adhikari, S.P., Devkota, D., Shrestha, J., Poudel, H.K., & Sapkota, B.K. (2019). Adoption of certain improved varieties of wheat (*Triticum aestivum* L.) in seven different provinces of Nepal. Archives of Agriculture and Environmental Science, 4(4) 404-409, https://dx.doi.org/10.26832/24566632.2019.040406

Tamru, S., Minten, B., Alemu, D., & Bachewe, F. (2017). The rapid expansion of herbicide use in smallholder agriculture in Ethiopia: patterns, drivers, and implications. *The European Journal of Development Research*, *29*(3), 628–647. https://doi.org/10.1057/s41287-017-0076-5.

Waller, B.E., Hoy., C.W., Henderson., J.L, Stinner B., & Welty C. (1998). Matching innovations with potential users: A case study of potato IPM practices. *Agriculture, Ecosystems and Environment*, *70*, 203-215.