ECONOMICS OF LENTIL PRODUCTION UNDER RELAY AND CONVENTIONAL TILLAGE PRACTICE

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ABSTRACT

The study was intended to find out the most profitable method between the relay and tillage growing method of lentil production. For primary data collection, a simple random sampling method was followed. Household survey was conducted in two districts Bardiya and Kailali in 2021 AD. A total of 107 lentil farmers (43 farmers following relay and 64 farmers following tillage practices) were randomly selected from two pockets area (relay and tillage method adopters) of each district. Benefit-Cost (BC) ratio analysis was done to find out the most profitable method of lentil cultivation. Multiple regression model was applied to estimate the factors determining the lentil production. The average BC ratio is 2.18 which indicates that lentil cultivation is profitable with average productivity of 0.64 mt/ha. The total cost incurred per ha in relay and tillage method was NRs. 24345 and NRs. 33549 respectively. Similarly, gross income from relay and tillage method was found NRs. 56160 and NRs 69870, per ha respectively. In between the two popular methods (relay and tillage) of lentil cultivation, the BC ratio was found 2.31 in the relay method compared to 2.08 in the tillage method. Among the several socio-economic independent variables used in the model, the age of the household head and fertilizer application significantly influenced the lentil production. However, lentil production is negatively affected by the practice of intermixed cropping. Hence the result indicates that relay cropping with mono-cropping and appropriate management of fertilizer could play a crucial role to boost the profitability of lentil farming

Keywords: Benefit-cost ratio, Lentil, Relay, Multiple regression model, Tillage.

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INTRODUCTION

Lentil is the leading pulse crop in terms of area (63 %) and production (64 %), (Upadhyay et al., 2019) which is widely cultivated in Nepal as a winter pulse crop under rice-based cropping system. It is primarily grown from October to April just after the harvest of monsoon-based rice crop. Lentil is almost produced in all districts however commercial production is concentrated in the Terai regions of Nepal. The total amount of lentils produced in 2019 AD was 262835 mt in 212878 ha area with the productivity of 1.23mt/ha (MoALD, 2020). High protein content in lentils ensures the nutritional security of subsistence and marginal farmers along with soil fertility maintenance (Matny, 2015). It has the potential of fixing free nitrogen up to 107 kg per ha soil. Besides having nutritional and conservative values, lentil is also known as a commodity having high export potential and socio-economics impact in Nepal (Darai et al., 2020).

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Lentil is generally cultivated before/after rice harvesting by relay method or from tillage practices. Relay cropping is perceived as a conservation technology that ensures timely sowing, best use of soil residue moisture, and cost reduction by 45% (Oli and Sarker, 2017). Similarly, relay cropping is taken as one of the productive ways to increase profitability, as relay cropping has the capacity of optimum utilization of residue moisture and fertilizer residual (Kundu, 2017). Whereas tillage practice reduces weed infestation by 71% compare to the no-till system (Jonas et al., 2017). However, excessive tillage leads to the adverse effect on soil distribution and aggregates and reduce soil carbon stocks in the long term (Shrinivasarao, 2012). The conventional tillage method requires more resources and inputs which are increasingly becoming scarce and expensive too. Conservational agriculture could be an appropriate way for sustainable cost reduction.

Approximately 84% of the farmers reside in the rural areas (SINA, 2020). More than half population (60.4%) is dependent on agriculture for their basic requirements and subsistence form of agriculture is common for the farmers in Nepal (MoALD, 2020). Yield from farming is the major source of their income. Small parcels of land, higher competition, agri-business challenges reduce the return to farmers (Dhital, 2017). Proper cost estimation analysis helps farmers and development stakeholders to make the proper decisions required for further improvement. In this light, BC ratio analysis will help to recognize the strength of revenue from each method.

Lentil is generally grown by almost farmers either from tillage or relay method based on the availability of irrigation facility, soil moisture, labour, time, intention of intermixed cropping etc, basically to meet their consumption demand. However, the profitability of the sowing method of lentil cultivation has not been widely evaluated. Most lentil-related studies were based on the adoption, production aspect of lentils and less attention was paid towards the profitable methods of cultivation. So the objective of this study is to find out the most beneficial method in between relay and tillage of lentil cultivation. This study will help farmers and development stakeholders to imply the effective method and policies respectively, to increase the farmer's income from lentil production in Nepal.

METHODOLOGY

STUDY SITE AND SAMPLING

Primary data was collected in 2021 AD (FY: 2077/78) from Kailai and Bardiya districts. Two districts (Kailali and Bardiya) were selected based on the highest area of lentil cultivation in Far West Province and Lumbini Province respectively. Based on consultation with Agriculture Knowledge Center (AKC), Nepal Agricultural Research Council (NARC), Integrated Agricultural and Livestock Development Office (IALDO)'s officers, and local leader farmers, pocket area of relay and conventional tillage practice of lentil cultivation were selected in each district. In Bardiya district, Madhuban municipality was selected as a pocket area where relay cropping is a widely adopted method of lentil cultivation while Thakurbaba municipality was selected as the other pocket area where the tillage method is mostly adopted for lentil cultivation. Similarly in the

Kailali district, two pocket areas viz. Godavari municipality and Bhajani municipality were selected as a pocket areas of relay and tillage practices respectively. A random sampling method was applied for the survey. Farmers were selected randomly from the pocket area. In total 107 farmers were surveyed, among which farmers following relay practices were 43 and that of tillage practices were 64. Direct interview was approached with key informants and lentil growers for data collection. The data was collected with the help of a pre-tested open as well as close-ended set of questionnaires. The cost was calculated as a function of inputs such as seed, fertilizer, irrigation, labour cost whereas income is calculated as the market value of economic yield. Further, the collected information were validated with secondary data gathering through the literature review of articles and books.

DATA ANALYSIS

Data entry, cleaning, transformation were primarily carried out in excel sheets. Descriptive analysis was done in excel, and for the inferential analysis, STATA 12 was used.

MULTIPLE REGRESSION MODEL

To estimate the socioeconomic factors influencing the lentil production, multiple regression model was used. Adhikari et al. (2018) have used the multiple regression model to estimate the factors determining hybrid maize production. Multiple linear regression analysis is an extension of simple linear regression analysis, used to assess the association between two or more independent variables and a single continuous dependent variable. The multiple linear regression equation is as follows:

$$Y=c+b0\ X0+ b1\ X1+ b2\ X2+ b3\ X3+b4\ X4\ +\ldots\ldots..+ bi\ Xi +ei$$

Where

c =Constant
b= Coefficient
X=Explanatory variables (input cost)
ei = Error term

BENEFIT COST RATIO ANALYSIS

BC ratio was calculated after calculating the total cost and total revenue from the lentil production. It was calculated by dividing the total revenue by total cost.

$$\text{Benefit Cost Ratio} = \frac{\text{Total revenue}}{\text{Total cost}}$$

Lamichhane et al. (2017) and Adhikari et al. (2018) also used a similar formula to assess the profitability of tomato cultivation under plastic house and maize farming respectively.

RESULTS AND DISCUSSION

SOCIOECONOMIC AND DEMOGRAPHIC CHARACTERISTICS OF RESPONDENT IN STUDY AREA

Average age of the household head was found 46.42 years in the study area. The age of farmers practicing the relay method (47) was found higher than the age of the farmers following the tillage method (46). On an average, years of schooling of household head was 7 years in the study site. The average household size was found six with an average of four members involved in agricultural activities. Average cultivated land was found 15 kattha among the respondents. Land allocated for relay and tillage method is statistically significant at a 5% level of significance. Farmers practicing the relay method have average cultivated land of 12.41 kattha which was lower than the farmers practicing the tillage method (16.74 kattha). Similarly, an average of 7 kattha land was found allocated for lentil cultivation, farmers practicing the tillage method are found to allocate higher land area (nearly 8 kattha) for lentil cultivation than the farmers practicing the relay method (6 kattha) which is statistically significant at a 5% level of significance. Lentil farmers were found to have an average of 32 years of farming experience. The farming experience was found significantly higher (significant at 1% level of significance) in the case of farmers who adopted the relay method (36.67years) than the farmers following the tillage method for lentil cultivation (29.45years).

Table 1. Socio demographic characteristics of lentil growers by land preparation method

Variables name	Total (N=107)	Relay practice(N=43)	Tillage practice(N=67)	t-value
Age of HH (years)	46.42	47.18	45.90	0.62
Education of HH (years)	6.41	6.97	6.03	1.55
Total household size (No.)	5.70	5.25	6	-1.51
Members involved in agriculture (No.)	3.61	3.51	3.70	-0.55
Total cultivated land (kattha)	15.00	12.41	16.74	-2.02**
Lentil cultivated land (kattha)	6.87	5.51	7.79	-2.19**
Farming experience (years)	32.35	36.67	29.45	3.63***

****,** and * indicate significance at 1% 5% and 10% levels, respectively. 30 kattha = 1 hectare. Source: Field survey,2021*

In total, about 54 % of households had received training on lentil cultivation. Numbers of farmers acquired the training related to lentil cultivation was significantly higher at a 5% level of significance for the tillage method adopters than the farmers follow relay method. Similarly, total cultivated land (5% level), and farming experience (1% level) had significantly higher value for the farmers following tillage methods. Likewise, training received on lentil cultivation, subsidy,

and involvement in agricultural organizations were found higher for the farmers following tillage practice than the farmers following relay practice.

Table 2. Categorical socio-demographic characteristics of lentil farmers in study area

Variables name	Total	Relay practice	Tillage practice	chi^2 value
Training on lentil cultivation (1=yes, 0=otherwise)	54.2	16.82	37.38	3.49**
Gender of HH Head(male=1, female=0)	83	32.71	50.46	0.16
Ethnicity(Brahmin/chettri=1,0= otherwise)	28.03	20.56	0.07	20.74***
Membership in an agricultural cooperatives (1=yes, 0=otherwise)	16.82	37.38	54.20	3.4*
Migration (1=Yes, 0= otherwise)	25.23	0.07	17.75	1.35
Subsidy received (1=yes, 0=otherwise)	30.84	0.05	25.22	9.61***

****,** and * indicate significance at 1% 5% and 10% levels, respectively. Source: Field survey,2021*

AREA AND PRODUCTIVITY OF LENTIL FARMERS

The average area under the lentil cultivation was found about 7 kattha with an average productivity of 21.46 kg per kattha. Productivity was found higher in case of the tillage method (23.29kg/kattha) of lentil cultivation compared to the relay method (17.68kg/kattha). The average productivity of lentil was found 0.64mt/ha which is lower than the national average yield of lentil (1.2mt/ha) which might be due to no use of micronutrients and insufficient use of fertilizer. Darai et al. (2020) also observed lower productivity of lentil because of poor access to quality seeds, inputs and technology delivery services. Byproduct yield (straw, husk) was not taken into account as farmers do not keep any record and buying and selling of lentil byproduct is not in practice in the study area.

Table 3. Area and productivity of lentil in study area by land preparation method

Variables name	Total (N)	Relay practice	Tillage practice	t-value
Area (kattha)	6.87(0.22)	5.51 (0.18)	7.79(0.26)	-2.19**
Productivity (kg/kattha)	21.46	18.72	23.29	-1.35
Productivity (mt/ha)	0.64	0.56	0.69	-1.35

*Note: Figure in parenthesis represents the land unit in ha. ** indicates significance at 5% level, respectively. Source: Field survey,2021*

COST AND RETURN ANALYSIS

The average total cost of lentil production per ha for one year considering farmer's practices was estimated as NRs.29603. Average total cost for lentil cultivation by the tillage method was NRs 33549 which is higher than the cost of lentil cultivation by relay method NRs 24345. In case of revenue, average revenue from lentil cultivation was calculated as NRs 64386 per ha. Revenue was higher for the farmers who cultivated lentil by the tillage method (NRs 69870) than the farmers who adopted the relay method (NRs 56160) for lentil cultivation. Average benefit-cost ratio calculated for lentil cultivation was 2.18, BC ratio is found higher for the relay method (2.31)

than the tillage method (2.08). Benefit cost ratio higher than 1.5 (in agricultural crop and cropping system) is regarded as economically viable for farmers (Dhital, 2017). Lentil cultivation is considered a profitable crop for marginal and smallholder farmers.

Table 4. Benefit cost ratio (per ha) of lentil cultivation by land preparation in study site

Variables name	Total	Relay practice	Tillage practice
Total cost (NRs)	29602.5	24345.47	33549.07
Revenue (NRs)	64386	56160	69870
BC ratio	2.18	2.31	2.08

Source: Field survey,2021

Seed rate was found higher in case of the relay method. Farmer's practice relay method applied higher seed (1.43 kg per kattha) in comparison of seed rate of farmers practice tillage method (1.29kg per kattha). Parveen and Bhuiya (2010) have proven from a field experiment that higher seed rate is better than lower seed rate as it gave the higher yield. A study conducted by using the Iowa max program participant's survey data set, have found that in case of soybean, conventional tillage resulted in lower profit than the conservational tillage like no-till, relay method.

The present result is similar to a research done in Bangladesh by Islam et al. (2017). Study has presented that seed yield is higher in furrow method of sowing (tillage method) but benefit-cost ratio is high in the relay method. Muhammad et al. (2017) also stated that conventional tillage lowers wheat productivity and profitability as it increases the cost production, soil compaction, and weed infestation. Similarly, another study done by Magar et al. (2014) in Nepal has also observed the similar kind of result in which the BC ratio of lentil cultivation was found higher in the relay method (1.26) than the tillage method (1.15). Likewise, a study conducted by CRS-Nepal (2020) has discussed that BC ratio can go up to 9 for lentil cultivation where farmers invest less and use family members as labour with the general BC ratio of 1.7 for lentil cultivation.

Table 5. Cost estimation of lentil production by land preparation in study site

Variable cost (NRS per ha)	Tillage practice	Relay practice
Seed rate (kg)	38.7	42.9
Seed cost	3990 (11.89)	4456.5 (18.31)
Land preparation cost	8187.6 (24.40)	0
Seed sowing cost	184.8 (0.55)	270.9 (1.11)
Urea cost	214.2 (0.64)	20.4 (0.08)
DAP Cost	991.872 (2.96)	41.328 (0.17)
Potash Cost	51 (0.15)	17.34 (0.07)
Irrigation cost	510 (1.52)	0
Weeding cost	5203.5 (15.51)	6624 (27.21)
Harvesting cost	8792.1 (26.21)	8863.2 (36.41)
Threshing cost	5424 (16.17)	4051.8 (16.64)
Total cost	33549.07	24345.47
Production	698.7	561.6
Lentil price (Rs/kg)	100	100
Total revenue	69870	56160
BC ratio	2.08	2.31

Figures in parenthesis are in percentage; Source: Field survey,2021

FACTORS AFFECTING LENTIL PRODUCTION

To determine the socioeconomic factors influencing the lentil production, multiple regression model was used, statistical description of the variables used in the multiple regression model are presented in Table no 6 and the estimated results are shown in Table 7. The dependent variable used in the regression model is lentil production in kg per kattha.
The value of the coefficient of determination (R2), 0.47 shows that 47% of the variation in lentil production kg per kattha is explained by the selected independent variables. Table 7 shows that the F- statistic (7.69) confirms the stability of the overall regression equation and joint significant at 1 percent level (P=0.000) in explaining lentil production and confirms the coefficients to changes in specifications. Variance Inflation Factors (VIF) is 1.49 means there was no multicollinearity between the independent variables used in the model.

Independent variable like the practice of mixed cropping has the significantly negative effect on the lentil production. Commercialization aspect was found lacking in the farmers. They produce for home consumption, only surplus production is sold. Lentil is generally grown as an intermixed crop with rapeseed, chickpea to minimize the risk of complete crop failure of lentil as it is perceived to be sensitive to high rainfall. However, the result depicts that lentil production is decreased by 8 kg per kattha if lentil is cultivated as intermixed crop. Discussion with the farmers revealed that even though the relay practice is found beneficial, farmers are reluctant to continue relay farming as they perceive mono-cropping is risky. One light rain is required to enhance the lentil production, however; heavy rainfall during the bloom season can destroy the whole production. In reverse, if the farmers follow the tillage and intermixed practice, production from alternate crops can ensure their production and saves them from severe loss. Past experience of complete crop failure caused by heavy rainfall, leads a significant number of commercial farmers being unwilling to continue the commercial lentil production. Lentil farmers switched to wheat to minimize the loss. Crop insurance can be the solution to demoralize the decreasing pattern of lentil areas.

Independent variables *viz.* age of the household head and application of fertilizer have a positive and significant effect on the lentil production. Regression coefficient of age (0.25) is statistically significant at a 10% level. This implies that the age of the household head is significantly related to the lentil production, i.e. yield will be increased by 0.25 kg with one year increment in farmer's age, holding other variables constant. It might be because older farmers have more experience of farming, knowledge of minimize the weather shocks.

Similar result was found in a research conducted by Tiwari et al. (2021) at Sindhupalchowk where the maize production has positively correlated with the age of the farmers. Positive coefficient of fertilizer application (22.85) suggests that households used fertilizer have 22 kg more production than the households where fertilizer was not applied, ceteris paribus, and the finding is statistically significant at a 1 percent significance level. Result is in corresponds with the Poudel et al. (2020). Study has discussed that purchased fertilizer is positively correlated with yield of lentil. The

recommended fertilizer dose for lentil is 20:40:20 NPK per hectare (Krishi diary, 2020). However, the fertilizer application was found very low i.e. 12.6 kg of urea, 21.6 kg of DAP, and 0.15 kg of MoP per ha in the study site. Though not significant, lentil production is found to increase by 2 kg per kattha if single hand weeding is done in comparison to the production of field with no weeding.

Table 6. Statistical description of the variables used in the multiple regression model

Variables	Description	Value	Expected sign
Tillage	Land preparation practice for lentil cultivation	If followed tillage =1 relay=0	+/-
Mixed cropping	Practice of lentil cultivation with mixed crop	If intermixed=1 sole cropping=0	+/-
Seed Rate	Applied seed rate	in kilogram/kattha	+/-
Seed source	Seed used from formal or informal source	If formal=1 informal=0	+
Age of household head	Age of the household head	Years (in number)	+/-
Gender of household head	Gender of the household head	Male=1, otherwise = 0	+/-
Economic active members in family	Total number of economic active members in HH	in number	+
Training related to lentil cultivation	If family member/HHH has received lentil farming related training	If received=1 otherwise=0	+
Total cultivable land	Total land cultivated by the HH	In kattha	+
Fertilizer application	Application of inorganic fertilizer	If applied =1 otherwise=0	+
Weed management	Practice of weed management	If weeding/herbicide applied =1 otherwise=0	+

Table 7. Parameter estimates of regression model for lentil production with different explanatory variables in study area

Variables	Coefficients	Standard error	T value	p value
Tillage	-0.59	3.83	-0.15	0.877
Mixed cropping	-8.40	3.46	-2.44	0.017
Age of household head	0.24	0.14	1.77	0.080
Gender of household head	0.81	3.55	0.23	0.820
Economic active members in family	0.02	0.70	0.03	0.972
Seed rate	-0.15	2.50	0.06	0.950
Seed source	-1.81	3.22	-0.56	0.575
Training	2.25	4.50	0.50	0.618
Total cultivable land	0.08	0.14	0.59	0.552
Fertilizer application	22.80	3.80	5.99	0.000
Weed management	1.65	3.45	0.48	0.633
Constant	4.51	8.61	0.52	0.601

Variables	Coefficients	Standard error	T value	p value
Summary Statistics				
Number of observation (N)	107			
LR $chi^2(11)$	7.69*** (Prob> chi^2 =0.0000)			
Pseudo R^2	0.47			
VIF	1.49			

CONCLUSION

Since the lentil is one of the important exportable agricultural commodities, research and development efforts should be primarily focused on the promotion of commercial and profitable lentil production. BC ratio of 2.30 indicates that relay cropping is highly profitable for lentil production. All categories of farmers can be benefitted from the relay cropping. Less use of input, resources and reduction in operational cost ensures the higher benefit from lentil in a relay than the tillage practice. To minimize the risk of crop failure during mono-cropping, development stakeholders must prioritize the insurance of lentil crops. Therefore, mono and relay cropping with the use of inorganic/organic fertilizer and an efficient weed management strategy would be a sustainable way to increase lentil profitability.

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