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Economic Analysis of Potato Basic Seed Production Under Contract Farming in Kavrepalanchok, Nepal

Kumar Bolakhe[1, *], Krishna Hari Dhakal[2], Sabin Nepal[1], Rachana Dahal[1]

[1]Faculty of Agriculture, Agriculture and Forestry University, Rampur, Nepal

[2]Department of Genetics and Plant Breeding, Faculty of Agriculture, Agriculture and Forestry University, Rampur, Nepal

Email address:

kumarbolakhe99@gmail.com (K. Bolakhe)

[*]Corresponding author

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Abstract: In Nepal, potato basic seed production under contract farming is at the initial phase. However, pre-basic seed potatoes were produced in Nepal since 1989/90, production of the basic seed has been relatively low, despite the government's lucrative subsidy on the price of pre-basic seed. There have been very limited studies on the production and economics of potato-basic seed under contract farming. This study examines the cost of production, resources use efficiency, return to scale, and various problem associated with the production of basic seed under contract farming in Kavrepalanchok, Nepal. The authors used the Cobb Douglas production function to explore the technological relationship between inputs and outputs. As well as to estimate and analyze the return to scale. They used a scaling technique to construct an index for prioritizing the problems of potato seed production under contract farming as per farmers' perception. The authors found the cost of basic-potato seed production per 500m² areas under contract farming as Rs. 99129.0064. The high cost of production is due to the higher cost of pre-basic seed. They found the gross return from seed production as Rs. 171547.2 per 500m² areas and the Benefit-cost ratio as 1.72. Similarly, they found positive regression coefficients for seed cost and organic manure which is significant at 1% level and negative regression coefficients for human labor which is significant at 5% level. They observed the overutilization of inputs in potato seed production under contracting farming, which was primarily due to the restrictions impeached by the contract agencies on the contract farmers. The authors found that unavailability of pre-basic seed in required quantity as the major problem faced by the farmers of the study area. A comparative study of the seed production with contract and without a contract, may illustrate the better scenario of the study area. Only a few studies have examined the economics of seed production under contract farming in developing countries. The authors' findings suggest that productivity and profitability can be maximized if a proper allocation of the resources and existing problems of irrigation, insect.

Keywords: Cost, Economics, Potato, Production, Production Function

1. Introduction

The main concern in Nepalese potato farming is the scarcity of high-quality seed tubers. As a result, quality seed tuber production and improved cultivation techniques are significant factors in increasing productivity. The availability of superior seeds is critical to the productivity of any crop. Most farmers recycle their tuber or obtain them from informal sources, resulting in seed degeneration and the accumulation of various tuber-borne diseases, which ultimately affect yields [1]. Such a seed system is the main reason behind the lack of good quality potato seed. Different fungal and bacterial seed-borne diseases spread swiftly, and cannot be checked using chemicals. Seed-borne disease can be reduced by using superior seeds that are healthy and disease-free, as well as proper crop rotation and field inspection.. Seed tubers of high quality are free of seed-borne disease and pests, are not mixed with other varieties, have high sprouting vigor, and weigh 30-50 gm [2]. The tuber should be rigorous, wrinkle-free, and free of disease signs and symptoms. More production is provided

by high-quality seed tubers. Different strategies to rapidly multiply the seed tubers as tissue culture are practiced in various research stations of Nepal to mitigate the shortage of quality seeds. These technologies should be considered and promoted in different parts of the country to increase potato yields. Pathogen-free in vitro potato plantlets are transplanted into an aphid-proof glasshouse and/or screen house under protected conditions to produce disease-free potato mini-tubers [3]. These tubers are the first generation seed which is called pre-basic seeds. The next generation of pre-basic seed is basic one seed. PBS has been produced for 19 different recommended and released potato cultivars so far. Similarly, 3,465,799 PBS have been produced and 3,217,666 pre-basic seeds have been distributed to various seed potato growers groups, Agriculture Knowledge Centre, government farms/research stations and NGOs/INGOs for basic seed potato production [3]. Due to land constraints, increasing potato production by expanding cultivation area is difficult. There is an opportunity to increase potato production by improving existing production technology and allocating available resources more efficiently. Contract farming is a type of forwarding agreement in which farmers and processing and/or marketing firms agree to produce and supply a variety of agricultural products at predetermined prices that are typically higher than market prices. The agreement also requires the purchaser to provide some level of production support, such as the supply of various inputs and the provision of technical advice. The foundation of such arrangements is the farmer's commitment to provide specific farm produce at quality and quantity standards determined by the company, as well as the company's commitment to support the farmer's production and purchase the commodity as per the contract [4]. This system helps to solve the problem of marketing if regulated properly by the authorities.

Therefore, the main objective of the study is to figure out the efficient use of available resources in potato basic seed production under contract farming in Kavrepalanchok, Nepal.

2. Materials and Methods

The survey was carried out in Kavrepalanchok, a typical mid-hill district of Bagmati province, Nepal, exhibits immense climatic potentialities to produce different types of crops, especially suited for potato production. The district lies within coordinates of 27.5259° N latitude, 85.5612° E longitude, and an altitude of 1007 to 3018 masl. The potato seed producer of the selected area was the target population for the study. The leading farmers and potato seed growers were included in the sampling frame. The potato profile prepared by the Super zone was consulted. A household survey was conducted at the major potato seed-producing wards. The farmers were selected after consulting the previous data of potato seed production in Kavrepalanchok published by Super zone and Agriculture Knowledge Center. Similarly, Key Informant Interview and Group discussions were carried out were conducted to validate information obtained from respondents. Data analysis and comparisons were made to obtain results. The data were entered in Microsoft Excel, SPSS, and STATA. Analysis was done by using SPSS and STATA.

2.1. Definition of Terms and Concepts Used

2.1.1. Input and Costs

Different inputs used in the production of basic seed are discussed below:

(i). Pre-basic Seed (PBS)

The contract company gave PBS seed for the farmers at Rs 8 per seed after, in the collaboration with PMAMP, PIU, Sindhupalchok/Kavrepalanchok. The actual market price of PBS per seed is Rs 16 but 50 percent of the cost of PBS is defrayed by PMAMP, PIU, Sindhupalchok/Kavrepalanchok. The firm provides PBS of different varieties such as Janakdev, Desiree, Khumal rato.

(ii). Human Labor

Human labor was estimated based on eight working hours per day, and the current wage rate is Rs 1000 for men and Rs 600 for women. Human labor is used for FYM and chemical fertilizer application, Land preparation, Earthling-Up, plant protection chemical application, harvesting, and packaging.

(iii). Tractor Labor

Tillage for land preparation before sowing was done using a power tiller. The average hiring charges of power tiller were Rs 800 per hour.

(iv). Manure and Fertilizers

The average price of FYM was Rs 60 per doko in the study area while the cost of urea per kg was Rs 22, DAP per kg was Rs 48 and potash was Rs 36 per Kg during the study time.

(v). Irrigation Costs

In the case of electric pump and tube well users, the irrigation charges were calculated based on the actual amount of electricity bill and pump maintenance cost paid by the farmers while in the case of canal users, it is calculated based on the amount they pay for the maintenance of the cannel.

(vi). Land Rental Value

The actual rental value of land as it exists in the study area at the time was used. The rental value of the land ranged between Rs 5000 to Rs 15000 per 500 m² per annum in the study area.

(vii). Interest on Working Capital

Working capital interest was calculated at a rate of 12% per year on the total variable cost.

(viii). Management Charges

Management fees were calculated at a rate of 10% of total variable costs.

(ix). Risk Factors

Risk factors were calculated at the rate of 10 percent of total variable cost.

2.1.2. Contractor / Agency

The contract farmers sold basic one seed of the potato to the contractors at predetermined prices.

2.1.3. Cost and Returns in Potato Seed Production

The average expenditure on various inputs such as human labor, seed, fertilizers, plant protection chemicals, irrigation expenses, and machine power were worked per 500 m^2 area to estimate the costs of producing basic one seed from pre-basic seed. The total variable cost of production was made up of these costs plus interest on working capital at a rate of 9% per year. Additional management expenses and risk factors were estimated at 10% of the variable cost. To calculate the total cost of cultivation per 500 m^2 area, the total variable cost was multiplied by the land rental value, management fees, risk factors, and transportation costs. The opportunity cost of owned resources and the actual prices paid by farmers for purchasing the input were used to calculate the actual costs. The returns were also calculated based on the actual prices received by the farmers. The return over variable cost and over total cost was calculated by deducting the respective costs from the gross return.

2.1.4. To Examine the Resource Use Efficiency of Important Inputs and Their Impact on Yield

(i). Analysis of the Contribution of Different Factors to the Gross Income of Potato

The following form of Cobb-Douglas production function was used to evaluate the resource use efficiency in the production of potato seed.

The general form of the production function fitted as follows;

$$Y= aX_1^{b1}.X_2^{b2}. X_3^{b3}. X_4^{b4}. X_5^{b5}. X_6^{b6}.U$$

Where Y= gross income (Rs/500m²area)
a= Constant
X_1= Human labor (Rs/500 area)
X_2= Machine labor (Rs/500m²area)
X_3= Seed (Rs/500m²area)
X_4= Chemical Fertilizers and organic manure (Rs/500m²area)
X_5= Plant protection expenditure (Rs/500m²area)
X_6= Organic manure (Rs/500m²area)
U= Random disturbances term
b_i= (i=1 to 6) indicate the regression coefficient of factor inputs.

The above expressed Cob-Douglas production function was linearized into a logarithmic function in order to get a practically amenable form and was expressed as below;

$$\ln Y= \log a + b_1.\ln X_1 + b_2.\ln X_2 + b_3. \ln X_3 + b_4. \ln X_4 + b_5. X_5 + b_6. \ln X_6 + U$$

Where ln = Natural logarithm, a = Constant, U = Error term
Source; [5].

For the calculation of return of scale from potato, Cob-Douglas production function was used and calculated using form ula:

$$RTS = \sum b_i$$

Where, b_i = regression coefficient of i^{th} variable. The sum of b_i from the Cob-Douglas production function indicates the nature of return to scale. Return to scale division rules are:

If RTS < 1: It indicates decreasing return to scale that means over-utilization of resources;

If RTS = 1: It indicates constant return to scale that means efficient-utilization of resources;

If RTS >1: It indicates increasing return to scale that means under-utilization of resources.

The result of the analysis were subjected to test by the coefficient of multiple determination and relevant 't' test.

Source: [7, 6].

Level of Significance

The regression coefficient (b_i) was tested for their significance using' test at the chosen level of significance.

$$t = \frac{b_i}{\text{Standard error of } b_i}$$

(ii). Resources Use Efficiency

The efficiency of resources used in the production of potato basic seeds was determined by the ratio of Marginal Value Product (MVP) to Marginal Factor Cost (MFC) of variable inputs based on the estimated regression coefficients. It is an indication of increment in the gross return by using an additional unit of a given input while keeping the level of other units constant. The coefficients from the Cob-Douglas production function were used in the resource use efficiency measurement. The resources use efficiency was calculated by using the formula as given below:

$$r = MVP / MFC$$

Where, r = Efficiency ratio
MVP = Marginal value product of a variable input,
MFC = Marginal factor cost (Price per unit input),

The value of MVP was estimated using the regression coefficient of each input and the price of the output. The marginal value product (MVP) of the i^{th} inputs was measured by using the formula:

$$MVP = b_i * MPPx_i * Py \text{ (The unit price of output)}$$

$$\text{But, } MPPx_i = (\overline{y}/\overline{x_i})$$

$$MVP = b_i*(\overline{y}/\overline{x_i})*P_y$$

Where: $\overline{y}$ = Geometric mean of value of potato yield per 500 m² area (Rs.)
$\overline{x_i}$= Geometric mean of the i^{th} input (Rs.)
b_i = Regression coefficients of each inputs

If the ratio of MVP to factor cost was found to be greater than one, then the use of resources could be increased till MVP is equal to one.

The decision rule for the efficiency analysis was as:

When,

r = 1; Efficient utilization of a resources;

r < 1; Over-utilization of a resources;

r > 1; Under-utilization of a resources.

Again the relative percentage change in MVP of each resource required so as to obtain optional resources allocation i.e. r = 1 or MVP = MFC was estimated using the equation below;

$$D = (1\text{-}MFC/MVP)*100 \text{ OR } D = (1\text{-}1/r)*100$$

Where, D = absolute value of percentage change in MVP of each resource.

Source: [7].

2.2. Problems/Constraints of Potato Seed Production Under Contract Farming

According to farmers' perceptions, an indexing or scaling technique was used to create an index for prioritizing the problems of potato seed production under contract farming. Scaling techniques provide the respondents' direction and extreme attitude toward the proposition. Weighted indexes were calculated and ranked using five-point scales based on response frequencies. The following formula is used to calculate the intensity index for various problems:

$$Iprob = \sum Si\ fi / N,$$

Where, Iprob = index value for intensity of problem

∑= summation

Si = scale value at ith intensity/severity

fi= frequency of the ith severity

N= total no. of the respondents = ∑fi where, Iprob = index, $0 < I < 1$

Source: [6].

2.3. Fixation of Procurement Price

The cost of potato seed production and the average yield from the previous year were taken into account when determining the procurement price. Aside from that, the profitability and market price of the previous year's potato crop were compared to other crops of the same season, such as cauliflower, wheat, and mustard.

3. Result and Discussion

3.1. Economics of Potato Basic Seed Production Under Contract Farming

Cost and Return

A comprehensive view on the economics of the potato seed production under contract farming is presented in Table 1. The per 500 m² total cost were found to be Rs 99129.0064, whereas per 500 m² variable cost is estimated to be RS. 78440.8464, which is the 79.19 percent of the total cost. The gross returns were observed to be Rs. 171547.2. The returns over variable cost were worked out to be, whereas net returns were observed and the Benefit Cost ratio was found to be 1.71, implied with investment of one rupee in seed production, farmers of Nepal got profit of 72 paisa. The maximum share in the cost of production was observed in seed cost i.e. 43.17 percent of total cost, followed by total labor cost which was 12.18 percent of total cost. The average production of Basic one seed was 714.78 kg per 500 m².

Table 1. *Economics of potato basic one seed production under contract farming (Rs.\ 500 m²), Field Survey 2021, Kavrepalanchok.*

S.N	Inputs	Average value Rs per 500 m²	Percentage
	Cost of production		
1	Seed (PBS)	43371.56	43.76
2	Organic Manure	2843.7	2.87
3	Chemical Fertilizer		0
i.	Urea	298.67	0.31
ii.	DAP	822.61	0.83
iii.	Potash	582.66	0.59
iv.	Micronutrient	376.74	0.39
	Total	2080.68	2.1
4	Plant protection Chemical	827.33	0.84
5	Tillage	1374.48	1.39
6	Irrigation	595.08	0.61
7	Labor Cost	0	0
i.	Ridging	1668.52	1.69
ii.	Sowing	1315.77	1.33
iii.	Irrigation	1096.48	1.11
iv.	Earthing up	2510.61	2.54
v.	FYM application	1242.52	1.26
vi.	Chemical fertilizer application	6500	0.66
vii.	Pesticide Application cost	2223.96	2.25
viii.	Harvesting cost	1496.13	1.51
	Total labor cost	12198.99	12.31
8	Grading	576.92	0.59
9	Packaging	1153.83	1.17
10	Transportation	948.58	0.96

S.N	Inputs	Average value Rs per 500 m²	Percentage
11	Storage	4065.32	4.11
	Total	70036.47	70.66
12	Interest on working capital @ 12	8404.3764	8.48
	Total variable cost	78440.8464	79.14
13	Management charge @10%	7844.08	7.92
14	Risk Factor @ 10%	7844.08	7.92
15	Rental value of land	5000	5.05
	Total cost	99129.0064	100
16	Production (kg)	714.78	
17	Price per Kg (Rs.)	240	
18	Gross Return (Rs.)	171547.2	
19	Net Return (RS.)	72418.19	
20	B:C Ratio	1.73	

3.2. Input Utilization Pattern

The input utilization pattern has been estimated in term of money Rs. per 500 m². The seed utilization pattern was found highest among the all inputs i.e. Rs 43367.91 per 500 m², which is 70 percent of total input cost. On an overall basis Rs. 12198.99 per 500 m² for human labor and Rs. 1374.48 per 500 m² for tillage were utilized by the farmers. Rs3836.66, 2080.68, 827.38, and 595.08 per 500 m² was utilized for organic manure, chemical fertilizer, plant protection and tillage respectively.

Table 2. *Production function analysis of potato basic production under contract farming, Field Survey 2021, Kavrepalanchok.*

Explanatory variables	Coefficient	Standard error	t value	P value
Constant	3.123***	0.705	4.427	0.000
Ln _plant protection cost	0.001	0.019	0.069	0.9500
Ln _Fertilizer cost	-0.006	0.031	-0.206	0.838
Ln _FYM cost	0.079***	0.019	4.275	0.000
Ln _tillage cost	-0.008	0.064	-0.120	0.905
Ln _Human labor cost	-0.124**	0.052	-2.401	0.020
Ln_Seed cost	0.186***	0.048	3.873	0.000
R^2	.699			
Adjusted R^2	.667			
F value	22.070***			
Returns to scale (∑bi)	0.128			

*** Significance at 1% level
** Significance at 5% level.

3.3. Production Function Analysis of Basic One Seed Production

The total function of certain inputs such as land, labor, and capital can be considered in agricultural production. Variations in these input factors have a direct impact on gross agricultural production. Because a simple tabular analysis based on means, percentages, and the like cannot accurately measure the contribution of a specific resource to output when combined with other resources that cause changes in output levels, the Cobb-Douglas production function was used. Table 2 shows the Cobb-Douglas production function estimates for contract farmers in detail.

At the 1% level, the F value (22.070) was statistically significant, indicating that the model has good explanatory power. The value of R^2 indicated that the explanatory variables in the model adequately explained about 67 percent of the variations in the dependent variable (Table 2). Keeping all other factors constant, a 1% increase in plant protection costs would increase the income from basic one seed production by 0.001%; however, the increase was found to be statistically non significant. The results showed that a 1% increase in chemical fertilizer costs would result in a 0.006% decrease in income from basic one seed production, which was statistically insignificant. The FYM regression coefficient indicated that a 1% increase in FYM spending would result in a 1% increase in total spending. Similar result is found by [8]. Similarly, 1% increase in cost of tillage would decrease the total income by 0.008% which was not statistically significant. The regression coefficient of human labor cost indicates that 1% increase in the expenditure on the human labor would decrease the total income from potato seed production by 0.124% which was statistically significant at 1% level. The finding was in line with [9]. Finally, 1% increases in the expenditure of seed increase the total income from potato seed production by 0.186% which was statistically significant at 1% level.

3.4. Return to Scale Analysis

The Cobb-Douglas Production Function yielded a sum of regression coefficients of 0.128, indicating a decreasing return to scale in potato basic one seed production.

Resources Use Efficiency

Table 3 shows the MVC and MFC of the respective inputs.

For human labor, seed cost, tillage hour, chemical fertilizer, and plant protection chemical, the ratio of Marginal value product to Marginal-fixed cost was less than unity and greater than unity for FYM. Inputs such as labor and fertilizer were also discovered to be over-utilized resources in the potato production process [10]. Furthermore, the percent adjustment of FYM was 78.31, implying that cost should be increased by 78.31 percent for efficient allocation of FYM.

Table 3. *Resource Use efficiency.*

Inputs	Geometric mean	Coefficient	MVP	MFC	R	Efficiency	D
Revenue	156769.6						
Seed	42975.67	0.185	0.68	1	0.68	Over utilized	-47.0588
Chemical Fertilizer	2051.107	-0.006	-0.49	1	-0.49	Over utilized	304.0816
FYM	2698.273	0.079	4.61	1	4.61	Under utilized	78.30803
Human labor	12125.37	-0.124	-1.61	1	-1.61	Over utilized	162.1118
Plant protection chemical	797.7778	0.001	0.26	1	0.26	Over utilized	-284.615
Tillage	1370.243	-0.008	-0.92	1	-0.92	Over utilized	208.6957

Problems Associated with the Potato Basic One Seed Production Under Contract Farming

Under contract farming, there are a number of issues with potato seed production. The major issues in potato production must be identified and prioritized, with appropriate solutions provided. Scaling technique (indexing) was used to rank the problems based on the farmers' perceptions. The study found that the most significant production issue was the lack of PBS in required quantities (I= 0.83), followed by low produce prices (0.71), high disease and insect/pest sensitivity (I= 0.65), lack of proper irrigation facilities (I= 0.46), and a reduction in produce weight (I=0.33) (Table 4). These are the problems associated with the potato basic one seed production under contract farming which are hindering the profit and farmer's interest on seed production. The lack of high-quality seed was also identified as a major issue in potato production in Nepal's Terai region by [11]. Minimizing or mitigating these issues could increase profit and farmer interest in seed production. It has been reported that pre-basic seed tuber quality, disease, and pest infestation have a significant impact on productivity [12].

Table 4. *Problems associated with the potato basic one seed production under contract farming.*

S.N	Problems	Index value	Rank
1	Unavailability of PBS in required quantity	0.83	I
2	Low price of the produce	0.71	II
3	High sensitive to the disease and insect/pest	0.65	III
4	Lack of proper irrigation facilities	0.46	IV
5	Cut in weight of produce	0.33	V

4. Conclusion

Under contracting farming, there was an overuse of inputs in potato seed production. This was primarily due to the contract companies' restrictions on contract farmers. Seed cost and organic manure both had positively significant regression coefficients, while human labor had significant negative regression coefficients. In the study area, contract farmers have a lot of opportunities to increase potato seed productivity. Farmers switched to contract farming because of the higher income and higher quality of inputs provided by the contracting agency. Furthermore, the main reasons for contract farming's non-adoption were primarily due to a communication gap regarding delivery systems and contract farming's benefits..

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