Estimation of Production Function of Hiunde (Boro) Rice

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ABSTRACT

Hiunde (Boro) rice has not been popularized due to least attention given to this crop in Nepal. In order to estimate the production function of this crop, a field survey in Morang district during 2002/2003 was carried out using a semi-structured questionnaire. The primary information was collected through face to face interview. The result of the empirical model of Cobb-Douglas production function revealed the model significant at 1% level and defined 95% variation in Hiunde rice production due to variation in independent variables included in the model. The coefficient of area, nitrogen, phosphorous, and tractor hour were found significant at 1% level while the dummy for more than 10 times of irrigation was significant at 5% level and up to 10 times of irrigation and potash was significant at 10% level. The effect of human and bullock labor was found non-significant. Among the sampled farmers the average cropping intensity was 194% and average yield of Hiunde rice was 4802.50 kg/ha. On an average 131 kg of nitrogen, phosphorous and potash was applied for one ha and 15 irrigations in average. The net benefit from Hiunde rice was found to be Rs. 14507.41/ha with 1.73 benefit cost ratio. About 31% cost was incurred in land preparation and transplanting which was highest among the operations. It was followed by the costs incurred in fertilizers and agrochemicals which counted 23%.

Key words: Estimate, Hiunde rice, production function

INTRODUCTION

Agriculture is the mainstay of Nepalese economy which is continued to be dependent upon monsoon rainfall due to lack of sufficient irrigation facilities. The average annual economic growth rate of agriculture sector was estimated to be 3.3% as against the target of 4% during the period of Ninth Plan while this target is 4.1% per annum during Tenth Plan (MoF 2003). The average annual growth rate of paddy production during Ninth Plan was 2.34% while for yield it was 2.26% (ABPSD 2003). Rice is a major staple food crop which contributes more than 50% to total edible cereal production and about 20% to agriculture domestic product (AGDP) in the country. During 2003/2004, the preliminary estimation has predicted 50.15% contribution of rice to total edible cereal grain requirement (ABPSD 2004). The surplus production was in eastern and western region while other three regions were in food deficit status.

Paddy during 2003/2004 was grown in 1559436 ha which produced 4455722 mt with an average yield of 2857 kg/ha (ABPSD 2004). The improved varieties covered about 83% area which was about 46% under irrigated and about 37% under unirrigated environment. The net profit from one ha of rice cultivation during 2002/2003 under improved and irrigated condition in Tarai belt was Rs 9524.00/ha while it was Rs 10500.00 for hills (DoEAS 2004).

Rice in Nepal is mostly grown in two distinct seasons; main/summer season (June/July-October/November) and early/Chaite/Autumn rice (March/April-May/June). Except these two season crops, farmers are also growing rice as *Hiunde Dhan* (Boro) on winter in certain parts of the country. They had started rice cultivation in winter (November/December-May/June) season in Kawasoti Village Development Committee (VDC) of Nawalparasi district since 1968 (Joshi 2004). Other VDCs growing Hiunde rice in Nawalparasi district are Angeli and Pithauli. The winter rice cultivation has been introduced in Benauli and Sira Ineruwa VDC of Bara district; Biruwaguthi, Madhuwan (Auraha) VDC of Parsa district (Personal communication with KP Bhurer, RARS, Parwanipur, Bara); Parwaha, Nikal (Sapahi), and Sakhuwa Mahendranagar (Pakadia) VDC of Dhanusa district (Personal communication with Dr N Adhikari and RB Yadav, NRRP, Hardinath, Dhanusha). Despite theses areas, Morang is a leading district in winter rice cultivation where Rangeli, Aampgachhi, Takuwa and neighboring VDCs are major pocket areas. It is also grown in Mahabhara VDC of Jhapa district. Though the official statistics on area of winter rice is not available, the area covered by this crop is estimated to be more than 400 ha in Nepal (Bhujel 2004).

Winter rice in Nepal is generally called as Hiunde *Dhan* while in India and Bangladesh it is popularly known as 'Boro Rice'. Boro - a Bengali term originated from the Sanskrit word 'BOROB'. It refers to a special cultivation of rice in low land pockets during November-May; taking advantage of the residual water in the field after harvest of *Kharif* season paddy, longer moisture retentivity of the soil and surface water stored in the near by ditches (Singh et al 2003a). Thakur et al (2003) reported Boro in Shivapuran as one of the offerings to the God. In Bangladesh rice is grown in three distinct seasons; *boro* (January to June), *aus* (April to August), and *amon* (August to December). Modern rice varieties were introduced for the *boro* and *aus* seasons in 1967 and for the *amon* seasons in 1970 (Hossain et al 1994). In Bangladesh *boro* rice occupied nearly 35% of the 10.80 million ha of rice harvested area, and contributed 50% of the 38.7 million tons of rice produced in 2001/2002. The yield in 2001/2002 was 4.9 ton/ha (Singh et al 2003b).

In India it is commonly grown in the deeply flooded areas of North East Bihar, West Bengal, Assam and Eastern Uttar Pradesh. Pusa 2-21, IR 8, Jaya etc. became popular varieties (Thakur et al 2003). In Madhubani District, substantial increase in farm income was observed due to *boro* farming which made the distribution more equitable particularly on small farm households. *Boro* rice production helped in increasing employment, particularly in slack agricultural season. It has brought about a change in socio-economic status of rural households (Nilanjali and Singh 2003). The net return to the farmers from the cultivation of *boro* in Bangladesh during 2000 was about US $ 433/ha, almost eight times higher than that from *aus* and about three times compared to the return from wheat (Hossain 2003).

The estimation of production function of winter rice in eastern region of the country has not been found sufficiently studied and its socio-economics study is also lacking. Considering these facts a primary level study on winter rice was carried out during 2059/2060 (2002/2003). The main objective of this study was to estimate production function.

METHODOLOGY

Morang being a leading district in winter rice cultivation was selected for the study. The popular VDCs for winter rice cultivation in Morang district like Rangeli, Aampgachhi and Takuwa were purposively selected as these are the major pocket areas of this crop. A sampling frame of winter rice growers was prepared and 35 farmers were selected randomly without replacement. The primary information was collected from sample farmers through face to face interview schedule. A standardized semi-structured questionnaire was finalized after pre-testing and interview carried out. The secondary data were collected from published documents and personal communication with related agencies.

Empirical model

The empirical model used in this study was the Cobb-Douglas production function and other simple statistical tools like mean, total count and percent. This model was selected because; among the production functions, the power production function is a new linear production function which is also known as Cobb-Douglas production function after the name of the persons who first applied it in empirical works (Debertin 1986, Sankhayan 1988). This function has been widely used in agricultural studies because of its simplicity. Furthermore, this function allows either constant, increasing or decreasing marginal productivity, or not all the three and even any two at the same time.

The model specified was:

$$Y = AX_1^{b1}X_2^{b2}X_3^{b3}X_4^{b4}X_5^{b5}X_6^{b6}X_7^{b7}D_1^{b8}D_2^{b9}\ \mu$$

Where,
Y = Production of winter rice (kg), A = Intercept, X_1 = Area of winter rice (ha), X_2 = Human labor (Man days), X_3 = Bullock labor (Labor days), X_4 = Nitrogen (kg), X_5 = Phosphorous (kg), X_6 = Potash (kg), X_7 = Tractor hour, D_1 = Dummy for number of irrigation (1 for up to 10 irrigations, and 0 for otherwise), D_2 = Dummy for number of irrigation (1 for more than 10 irrigations, and 0 for otherwise), b_1 to b_9 = Elasticities coefficients, μ = Error term

Above model can be estimated by using Ordinary Least Square (OLS) method. The Cobb-Douglas Production Function was transferred into log-linear form as:

$$\ln Y = \ln A + b_1\ln X_1 + b_2\ln X_2 + b_3\ln X_3 + b_4\ln X_4 + b_5\ln X_5 + b_6\ln X_6 + b_7\ln X_7 + b_8D_1 + b_9D_2 + \mu$$

The values of the input coefficients imply their contribution to the production of winter rice or the coefficients are the level of determination to winter rice production.

RESULTS AND DISCUSSION

The primary information was collected from 35 farmers and only 33 were valid for final analysis due to outlier nature of certain information. The calculation was done for farm size, cropping intensity, yield, labor (human and bullock), quantity of inputs and cost incurred in different operations for the cultivation of winter rice. Similarly, the share of inputs for different operations was also calculated.

Sowing and harvesting time

The response of sample farmers revealed the popular sowing time for winter rice as *Kartik-Mangsir* (November-December) for seeding, *Magh* (January/February) and latest by first week of *Falgun* was the suitable time for transplanting, while *Jestha* (May/June) and latest by the first week of *Ashadh* was the period when most of the farmers harvested the crop. The most popular variety grown by the farmers was *Jaya* which was supposed to be introduced from neighboring part of Bihar, India. The variety was not replaced and continued to be used from generation to generation.

Farm size

Among the sample farmers the average operational holding was 5.08 ha and the distribution of more than 0.67 ha to 3 ha holding was high showing the 40% farmers within this status (Table 1).

Table 1. Average farm size of winter rice growers in Morang District

SN	Operational hectare	Number of farmers	Percent
1	Up to 0.67	1	3
2	> 0.67-3	13	40
3	> 3-5	9	27
4	> 5-7	6	18
5	> 7	4	12

Cropping intensity

Farmers were not much interested to grow wheat or early rice during this season and very few were found growing wheat and *Chaite* rice along with winter rice during a period of one year. However, the cropping intensity was found to be 194% in average. More than 48% farmers were found to have more than 150 to 200% cropping intensity (Table 2).

Table 2. Average cropping intensity of winter rice growers in Morang District

SN	Cropping intensity, %	Number of farmers	Percent
1	Up to 150	5	15
2	> 150-200	16	48.5
3	> 200-250	7	21
4	> 250	5	15.5

Yield

The farmers were very much enthusiastic to achieve high yield from winter rice, however, the average yield recorded from sample farmers was 4802.5 kg/ha. The majorities of the sample farmers (21.21%) produced 3700-4200 kg/ha, while more than 18% farmers were found producing more than 5700 kg/ha average yield (Table 3). Only 3% farmers produced up to 2700 kg/ha.

Table 3. Average yield of winter rice among the sample farmers in Morang District

SN	Average yield, kg/ha	Number of farmers	Percent
1	Up to 2700	1	3.03
2	> 2700 - 3700	3	9.09
3	> 3700 - 4200	7	21.21
4	> 4200 - 4700	1	3.03
5	> 4700 - 5200	5	15.15
6	> 5700	6	18.18

Seed rate

Among the sample farmers 85 kg/ha seed rate was adopted which varied from 72 to more than 157 kg/ha (Table 4). The seed rate being high in winter rice is due to high chances of seedling mortality and injury due to cold and slow growth as it has to tolerate natural cold during seeding to seedling stage. Therefore farmers use high seed rate to compensate the anticipated damage of seedlings. Majority of sample farmers were found applying more than 72 to 115 kg seed/ha and very few were found to sowing more than 157 kg seed for one ha (Table 4).

Table 4. Average seed rate of winter rice applied by the sample farmers in Morang District

SN	Seed rate, kg/ha	Number of farmers	Percent
1	Up to 72	10	30.30
2	> 72 - 115	18	54.54
3	> 115 - 157	4	12.12
4	> 157	1	3.04

Use of nitrogen

Dia-Ammonium Phosphate (DAP) and urea were found as major sources of nitrogen. The average rate of nitrogen used by sample farmers in survey area was 74.52 kg/ha. Some of the farmers were also using even more than 100 kg nitrogen/ha. However, the range between more than 70-90 kg/ha application of nitrogen was dominant among the sample households (Table 5). The range of more than 90 to 100 kg nitrogen/ha was lowest among the sample farmers which was only 6%.

Use of phosphorous

Dia-ammonium phosphate (DAP) was the main source of phosphorous which provides 46% nutrient phosphorous. The average quantity of phosphorous applied by the farmers was 38 kg/ha while the range of its application from more than 30-50 kg/ha was applied by 61% of the sample farmers (Table 6). Quantity ranging from more than 30-40 kg P_2O_5/ha was applied by 42% of the sample farmers.

Table 5. Average dose of nitrogen applied by the sample farmers for winter rice in Morang District

SN	Nitrogen, kg/ha	Number of farmers	Percent
1	Up to 50 kg	6	18.18
2	> 50-70	9	27.27
3	> 70-90	12	36.36
4	> 90-100	2	6.06
5	> 100	4	12.12

Table 6. Average dose of phosphorous applied by the sample farmers for winter rice in Morang District

SN	Phosphorous, kg/ha	Number of farmers	Percent
1	Up to 30	8	24.24
2	> 30-40	14	42.42
3	> 40-50	6	18.18
4	> 50-60	1	3.03
5	> 60	4	12.12

Use of potash

Farmers were applying Muriate of Potash as a main source of potash. The average nutrient potash used by the sample farmers was found 18.58 kg/ha and the majority of the farmers applied up to 30 kg of potash/ha (Table 7). Only 3 per cent farmers applied more than 40 kg potash/ha.

Table 7. Average dose of potash (K_2O) applied by the sample farmers for winter rice in Morang District

SN	Potash, kg/ha	Number of farmers	Percent
1	Up to 30	30	90.90
2	> 30-40	2	6.06
3	> 40	1	3.03

The above figure of nitrogen (N), phosphorous (P) and potash (K) made the ratio of 74:38:19 kg NPK/ha counting whole NPK as 131 kg/ha on an average. However, the dose of more than 100-130 kg/ha was applied by the majority of the farmers counting more than 30% followed by 27.28% who were found applying more than 145 kg NPK/ha (Table 8).

Table 8. Average dose of NPK applied by the sample farmers for winter rice in Morang District

SN	NPK, kg/ha	Number of farmers	Percent
1	Up to 100	5	15.16
2	> 100-130	10	30.31
3	> 130-145	7	21.22
4	> 145	9	27.28

Irrigation

The winter rice is irrigation intensive crop as it needs whole winter season to medium summer season for its life cycle. Without assured irrigation, the production cannot be expected high for this crop. Therefore, the number of irrigation for this crop was found very high in comparison with other winter crops. The average number of irrigation supplied by sample farmers was 15 times while the majority of the farmers were found irrigating winter rice more than 16 to 20 times for whole crop season (Table 9). The high number of irrigation is due to its long period that crosses whole winter season and also the spring season where the crop has to be faced moisture stress condition. To overcome this situation, the irrigation needs to be frequent and regular. More than 9% of farmers were found irrigating more than 20 times.

Table 9. Average number of irrigation applied by the sample farmers for winter rice in Morang District

SN	Irrigation number	Number of farmers	Percent
1	Up to 4	2	6.06
2	> 4-8	5	15.15
3	> 8-12	5	15.15
4	> 12-16	6	18.18
5	> 16-20	12	36.36
6	> 20	3	9.10

Human and bullock labor

The human and bullock labor in average used by sample farmers of winter rice growers was found 84 man days and 16 bullock pairs/ha, respectively. More than 35 to 70 human labor/ha was used by more than 33% of sample farmers while more than 14-20 pairs of bullock was used by more than 51% of sample farmers at survey site (Table 10). The number of human and bullock labor was also determined by the use of tractors by the farmers. Farmers also used/hired tractor for land preparation which determined the number of labors (human and bullock).

Table 10. Average number of human and bullock labor/ha used by sample farmers for winter rice cultivation in Morang district

SN	Number of human labor/ha	Number of farmers	Percent	Number of bullock pair/ha	Number of farmers	Percent
1	Up to 35	6	18.18	Up to 8	7	21.21
2	> 35-70	11	33.33	> 8-14	6	18.18
3	> 70-105	9	27.27	> 14-20	17	51.51
4	> 105	7	21.22	> 20	3	9.10

Use of tractor

The sample farmers were also using tractor for land preparation of winter rice which was 1.69 hour/ha on an average. Majority of them used at least for one hour (Table 11). Farmers also used tractor for more than 5 hours/ha. Tractor is generally used by most of the farmers at least for first plowing after which they used bullocks.

Table 11. Average tractor hour used by the sample farmers for winter rice in Morang district

SN	Tractor hour/ha	Number of farmers	Percent
1	Up to 1	19	57.57
2	> 1-3	8	24.23
3	> 3-5	3	9.10
4	> 5	3	9.10

Estimation of production function

The share of input variables to winter rice production was estimated by using OLS technique. The value of F test in OLS estimation indicated that the model is significant at 1%. The value of adjusted R^2 is 0.95 which reveals that the model has explained 95% of total variation in winter rice production due to the variation in area, human and bullock labor, nitrogen, phosphorous, potash, use of tractor and number of irrigations (Table 12). According to Gujrati (1995), the coefficient of determination (adjusted R^2) is a summary measure that tells how well the sample regression line fits the data. The fit of the model is said to be better the closer is R^2 to 1. Therefore, in this model 95% variation in winter rice production has been defined by independent variables included in the model. The intercept is significant at 1% level which implies the level of output when the value of all independent variables is zero. The coefficient of winter rice area is positive and significant at 1% level which implies that, other factors keeping constant, one per cent increase in area would result in 0.91% increase in winter rice production. Similarly, *ceteris paribus*, one per cent increase in phosphorous, potash, tractor use would result into 0.33, 0.02 and 0.02% increase in production from the use of respective variables. Similarly, irrigation for up to 10 and more than 10 are significant at 10 and 5% level, which reveals that other factors keeping constant, when one per cent irrigation for 10 is increased, the production would be increased by 0.36% and when it is applied to more than 10 number of irrigation it would result in increasing 0.42% winter rice production.

The nitrogen effect on production is significant at 1% level and has negative value which indicates the excess application and the variety which is not much responsive to higher dose of nitrogen, however the dose of phosphorous and potash can be increased. Similarly, the human and bullock labor has not any significant effect in production, but the tractor hour can be increased which can further reduce these labors and make the cultivation cost effective.

Table 12. Estimates of ordinary least square (OLS) technique

Explanatory variables	Elasticities	Standard errors	t statistics
Intercept	8.09***	0.47	17.24
Area, ha	0.91***	0.11	8.14
Human labor, days	0.05	0.05	0.97
Bullock labor, days	0.01	0.03	0.48
Nitrogen, kg	-0.33***	0.12	-2.64
Phosphorous, kg	0.33***	0.10	3.13
Potash, kg	0.02*	0.01	1.93
Tractor use, hour	0.02***	0.009	2.68
Dummy for number of irrigation up to 10†	0.36*	0.19	1.84
Dummy for number of irrigation > 10‡	0.42**	0.18	2.26
Adjusted R^2	0.95		
F value (9, 23)	75.63***		
Observations	33		

****, **, * Significant at 1, 5, and 10% respectively. † 1 for up to 10 irrigations and 0 for otherwise. ‡ 1 for more than 10 irrigations and 0 for otherwise.*

Analysis of gross margin

Application of different inputs was taken as variables and their cost as variable costs. The total variable cost incurred in winter rice cultivation was found Rs 19878.49/ha in average while the gross income from the grain production was found Rs 34385.90, which counted 1.73 as benefit cost ratio. It provided Rs 14507.41 as net benefit from one hectare of winter rice cultivation (Table 13). The scenario of gross margin was as follows:

Average production of winter rice, kg/ha	:	4802.50
Average price of winter rice, Rs/kg	:	7.16
Gross revenue from grain production, Rs	:	34385.90
Total variable cost, Rs	:	19878.49
Benefit cost ratio	:	1.73

Table 13. Gross margin of winter rice cultivation in Morang District

SN	Operations and items	Expenditure, Rs/ha	Percent of total expenditure
	Input costs		
1.	Seed	919.47	4.62
2.	Chemical fertilizers and agrochemicals	4613.29	23.20
3.	Land preparation and transplanting	6095.41	30.66
4.	Weeding and harvesting	4261.641	21.44
5.	Irrigation	3856.69	19.41
6.	Land tax and interest	132.53	0.66
	Total variable costs	19878.49	100
	Gross revenue from grain production	34385.90	
	Net profit	14507.41	

The highest cost incurred was found by land preparation and transplanting which was more than 30% followed by the costs for chemical fertilizers and agrochemicals (Figure 1) which counted more than 23%.

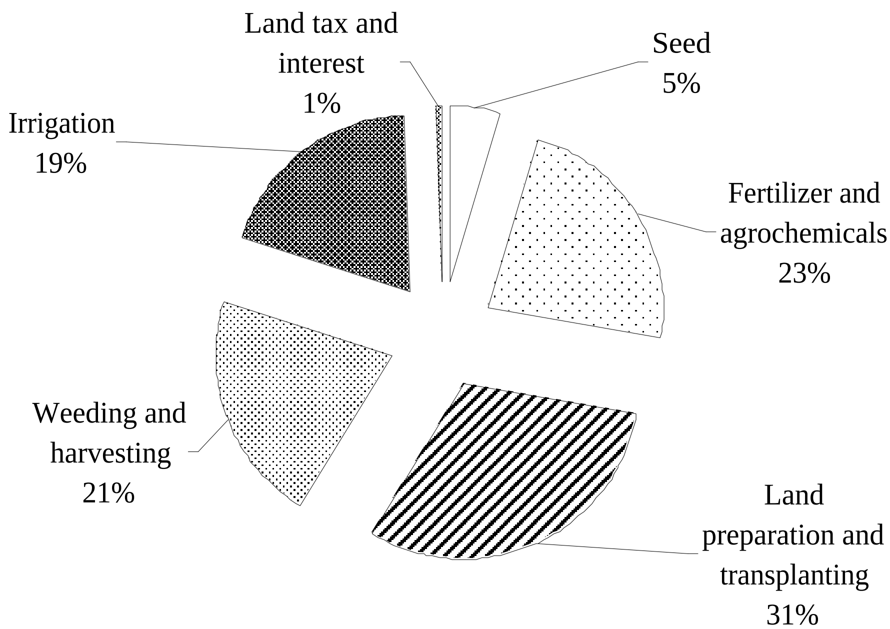

Figure 1. Cost incurred in winter rice cultivation in Morang.

The hypothesis tested was found true that the farmers received more net profit from winter rice in the survey area as benefit cost ratio for this crop was found 1.73. The net profit of Rs 14507.41 is far higher than normal/early rice or wheat crop in the district. It was only Rs 10500.00 and Rs 9524.00/ha from normal rice under irrigated and improved variety in hills and Tarai in 2002/2003.

Why farmers grow winter rice

On the basis of farmer responses followings are the reasons:

- The production of winter rice is higher than chaite rice and wheat.
- It is harvested before monsoon rainfall and thus it makes the farmer easy to thresh and get rid of disturbance from rainfall as it happens with C*haite* rice.
- Due to early harvest, summer rice can be planted in time.
- Majority of the farmers let the straws into the field which adds humus to soil and improve soil health.
- To the date the market problem has not been experienced seriously as the product is sold immediately after threshing (even from the threshing flour) and the fresh grains weigh more due to high moisture content and fetch more money through satisfactory market price. The rice mill owners also get fresh product which is generally used for flat/beaten rice so called *Chyura*.
- The essence of this crop is that it provides hard cash at the period of *Jestha*/*Ashadh* which is/are month/s of crisis for both cash and kind in rural farm households. They are in dire need of resources at this period as there is no any crop to harvest and fetch money. They get relief by earning cash money from winter rice which substantially helps cultivate summer crops, pay school/admission fee of their children and run household activities. Thus winter rice is not only a cereal crop but is **'**A hard Cash in Crisis' too (*Hiunde Dhan Aapatma Bardan* = Winter Rice - Boon in Crisis).

Problems

Since the market is available and product is sold out, farmers are satisfied but are in need of high yielding variety that can produce more than presently cultivated *Jaya* variety. Some of the farmers raised problems on availability and quality of chemical fertilizers and fuels, irregular supply of electricity, and sometimes electric poles/pillars were damaged by storm and were not timely corrected by concerning agencies. They expect encouragement in installing irrigation facilities by government through some subsidy program. Because it is an irrigation-intensive crop and needs more irrigations than any other crop. Quality of inputs was found as a matter of more concerns of the farmers in the survey site.

The cash income earned by the farmers improves their socio-economic status and grows rural economy which can substantially help reduce poverty. The water logged area and the area where excess moisture is exerted in winter season causing unfit for other winter crop can be well utilized by growing winter rice for which a campaign needs to be organized to its extension with package of practices. Migration of rural youth, unemployment and food deficit can be minimized by encouraging winter rice production in the area where it is still not practiced but has its scope and potentiality. Since this was a primary survey, it needs to be carried out in more detail in other rice growing area of the country so as to formulate a proper policy of winter rice in the future.

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