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Mob: +92 300 3008585, Fax: +92 41 8815544
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Research Article
Analysis of Resource-use Efficiency in Monsoon and Spring Rice Production in Nepal

[1]Rajani Osti, [1]Muhammad Rizwan, [1]Abede Kidane Assefa, [1]Deyi Zhou and [2]Dinesh Bhattarai

[1]College of Economics and Management, Huazhong Agricultural University, 430070 Wuhan, People's Republic of China
[2]College of Animal Science and Technology, Huazhong Agricultural University, 430070 Wuhan, People's Republic of China

Abstract
Objective: This study was carried out to assess the profitability and resource-use efficiency of rice production during monsoon and spring season in Chitwan district of Nepal in view to increase the rice production and food security. **Methodology:** Multistage sampling technique was followed to select a sample of 287 rice growing farmers selected randomly comprising 132 monsoon and 155 spring rice growers from the study area. The primary data collected through direct interviewing the sample farmers. The data was analyzed by using Microsoft Excel and SPSS software. Gross margin and cobb-douglas production function analysis were used to calculate the profitability and resource use efficiency, respectively in producing rice during two seasons. **Results:** The finding of this study revealed that rice production was more profitable during monsoon season. Cobb-douglas production function analysis showed that land, organic manure, potassium fertilizer and human labor, contributed significantly to the output of monsoon rice. Similarly, spring rice production was contributed significantly by land, seed, potassium fertilizer, human labor and irrigation. Rice growers of both seasons were in the second stage of the production function and were found inefficient in using the available resources. Organic manures, potassium fertilizer and human labor were over utilized and land was under-utilized in monsoon rice production. For spring rice, land and seed were under-utilized and potassium fertilizer, human labor and irrigation were over utilized. **Conclusion:** This study verified that appropriate adjustment is required for optimum allocation of resources that maximizes the revenue from the monsoon and spring rice production and also secures the domestic food supply.

Key words: Profitability, resource-use efficiency, cobb-douglas production function, monsoon rice, spring rice

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Corresponding Author: Rajani Osti, Huazhong Agricultural University, College of Economics and Management, No. 1 Shizishan Street, Hongshan, Wuhan, 430070 Hubei, People's Republic of China Tel: +8613294162472

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Rice is the most consumed food grain of Nepal. In terms of area under cultivation, rice comes first among the cereals contributing about 43% of the total area under food crops of 1.48 million hectares[1]. It is the widely produced crop with 53% of total edible cereal production and about 18% to Agricultural Gross Domestic Product (AGDP) in the country[2]. Cereals provide 65% of the total Dietary Energy Supplies (DES) to Nepalese people and out of which, 30% is contributed by rice alone[3]. The byproducts of rice including straw and rice husk also serve as the important fodder, feed and materials for flooring and roofing to the livestock housing.

Ecologically, the Terai region covering 23% of the total land area has only the fertile soil to produce an overall grain surplus. Terai region contributes about 56% of the annual cereal production where rice is grown dominantly (62%) and is followed by hills (34%) and mountains (4%). Nearly two third of the total rice production comes from only the granary region, Terai; hills and mountains contributed 32.52 and 2.7% of total rice production in the country[1]. Albeit, this granary region of Nepal is the most densely populated area[4,5]. The average size of agricultural land holding in Nepal is 0.68 ha where half of the holdings are less than 0.5 ha, 28% are in between 0.5-1 ha, that challenges the potential for supporting and producing surplus to feed the families in hills and Tarai[6-8]. A study on national level in Nepal shows that the area (1486951 ha), production (5047047 Mt) and productivity (3394 kg ha^{-1}) of rice in 2013 decreased by 8.34% (1362908 ha), 14.81% (4299078 Mt) and 7.07% (3154 kg ha^{-1}), respectively in the year 2015[9].

Chitwan district, Nepal's inner Terai valley between the Mahabharat and Siwalikranges is one of the potential rice growing districts of Nepal where rice is intensively grown during monsoon (June/July-October/November) and spring season (February/March-June/July) contributing around 73% of the total cultivable area with the production of 119455 Mt and 3.5 Mt ha^{-1} yield[10]. However, the yield of rice in Chitwan is much lower than its neighboring districts with similar geographical features. Farmers in Chitwan are facing huge instability in yields due to the improper functioning of irrigation systems, inadequate extension service and the lack of technical knowledge regarding the proper use of modern agricultural inputs. Rising population and alluring urbanization decaying the loss of farmland has been a major issue in the sustainability of rice production system in Nepal[11,12]. The domestic commercial land acquisition is another recent phenomenon in Nepal which is rapidly expanding towards the most productive arable land in the country for real estate and other non-agricultural commercial purposes causing food insecurity at the national level[13].

Fallen yields and production of cereal crops have shifted farmers to grow cash crops, to meet the demands of the increasing urban population which decrease the food supply thereby[14]. The data obtained from Government department about food availability and requirement shows that there is the food shortage in 33 districts of Nepal and regarding Chitwan district, it has food deficit of 55.33 Mt[15]. Loss of rice output is mainly due to the increase in unplanted paddy land and the decrease in crop yield[4]. Harvesting in Nepal is usually performed manually by using locally made serrated sickles[16]. The inefficiency in such sickles and other local tools also increase the number of human labor that reduces the profit margin. The potential for further increase in the country or the larger region's food security remains high when there is self-sufficiency in rice production for domestic food security. Therefore, emphasis should be given for increasing the production of rice which is decelerating amid the upsurge of modern economic sectors[17]. The increase in production is possible mainly through improvement in crop productivity which could be achieved by efficient utilization of available resources. Optimum use of resources could also increase the profit margin if the farmers are using inputs like agrochemicals indiscriminately. The additional rice to supply food for deficit areas and hunger people could be produced from the uncultivated potential rice areas and also from the potential rice areas which are diversified for other purposes. In this scenario, spring rice could be a viable option to provide extra staple food.

Government efforts to increase the food sufficiency are primarily focused for main season rice (monsoon rice) only during last few decades. But the expectation to meet the supply gap is not achieved yet. The economics of spring rice has not been yet explored. Yadav and Sinha[18] found higher profitability in Boro rice production than in any other crops produced during the season which also provided employment opportunity for farmers in Bihar state of India. Hence, the inception of study on profitability and efficiency may help the producing farmers and expected stakeholders in realizing the existing level of inputs use and profit margin in spring and monsoon rice production in Nepal. Farmers could be motivated to produce spring rice in potential areas if found profitable and hence the agrarian society will be benefited by increased farm income and food supply. This study was designed and conducted with the objective to study the profitability and resource use efficiency of monsoon and spring rice production in Chitwan district of Nepal.

MATERIALS AND METHODS

Study area: The present study was conducted in Chitwan district of Nepal (Fig. 1) which is located between 27°21' to 27°52' North latitude and 83°54' to 84°48' East longitude with a total land area of 218000 ha, located at an altitude of 141-1943 m. The annual rainfall: 1950.7 Mm, mean temperature: 32.2-18°C and average relative humidity: 83%[19]. Chitwan district was purposively selected for the present study as the district is known as the food basket of the country and is one of the potential rice growing districts. Further, this district well represents among the granary regions with increasing population density that increases the risk of food insecurity.

Sampling and data collection: Multistage sampling technique was followed to select the four municipalities from Eastern and Western part of the district in the first stage, wards from the selected municipalities were chosen in the second stage and ultimately the sample farmers from each selected wards in the third stage. Municipalities and wards were chosen on the basis of the concentration of monsoon and spring rice growers in the area. In total, a sample of 287 rice growing farmers was selected randomly comprising 132 monsoon and 155 spring rice growers from the study area.

The data pertaining to the crop season 2014-15 were collected with the help of pre-tested, semi-structured interview schedule. Hence, primary data related to farm inputs like land size, seed, organic manures, different chemical fertilizers, labor (human and machine), irrigation, agrochemicals and output of rice along with byproduct; their quantity and associated prices were obtained from personal interviews, group discussion, field observations and empirical observations.

Analytical framework: Gross margin and net farm income analyses (budgeting techniques) were employed to estimate cost and returns (over variable costs) per Kattha (1,361 ft^2) and to assess the profitability of rice production in monsoon and spring season on an average in the study area. Rice being a short duration crop, only the variable cost was considered to calculate the cost of production and profitability further[20,21]. All costs and returns were computed in Nepalese currency (NRs) value and given as Eq. 1:

$$GM = TR - TVC \quad (1)$$

Where:

GM = Gross margin
TR = Total returns from rice production (including the return from straw)
TVC = Total variable cost incurred in rice production

Choice of production function: Cobb-Douglas (CD) production functions as described by Acharya *et al.*[22] was used to measure the resource-use efficiency of the inputs employed by the monsoon and spring rice growers in Chitwan district. The general form of Cobb-Douglas (CD) production function is given as Eq. 2:

Fig. 1: Map of Nepal showing the study area. The country is landlocked and surrounded by India in East, West and South, China in the North. The study area is located in Central Southern part of Nepal which shares its borders with India

$$Y = aX_1b_1\ X_2b_2\ X_3b_3\ X_4b_4\ X_5b_5\ X_6b_6\ X_7b_7\ X_8b_8\ X_9b_9Ut \quad (2)$$

Where:

Y = Rice output (Quintal)
X_1 = Farm size (Kattha)
X_2 = Quantity of seeds (kg)
X_3 = Quantity of organic manures (OM) (kg)
X_4 = Quantity of nitrogen fertilizer (N) (kg)
X_5 = Quantity of phosphorous fertilizer (P) (kg)
X_6 = Quantity of potassium fertilizer (K) (kg)
X_7 = Human labor (Man-days)
X_8 = Machine labor (h)
X_9 = Irrigation (Days)
a = Constant
b_i = Elasticities of the various inputs X_i
u = Error term

Resource-use efficiency: The estimated coefficients of the relevant independent variables were used to compute the Marginal Value Products (MVP) and their corresponding Marginal Factor Costs (MFC). The ratio of the MVP to MFC was used to determine the resource use efficiency[23] as shown in the following Eq. 3:

$$r = MVP/MFC \quad (3)$$

Where:

r = Efficiency ratio (ratio of the MVP of an input and unit price of the input)
MVP = Marginal value product of a variable input
MFC = Marginal factor cost (price per unit input)

The Marginal Physical Product (MPP) was given by Eq. 4:

$$MPP_i = b_i \times APP_i \quad (4)$$

Where:

b_i = Elasticities of the various inputs
APP = Geometric mean of output Y/Geometric mean of input X_i

Using the above specifications and the output and input prices, the Marginal Value Products (MVPs) and Allocative Efficiency Index (AEI) were computed as following Eq. 5 and 6:

$$MVP_i = MPPi \times P_y \quad (5)$$

$$AEI_i = MVPi/MFC_i \quad (6)$$

where, P_y and MFC_i are the unit prices of output and factor input respectively. The decision of whether a resource is used efficiently or not, thus allocative efficiency is based on the value of AEI_i. If AEI_i is equal to one ($AEI_i = 1$), then the factor input is efficiently utilized, hence the farmer is considered allocative efficient. The factor input is over-utilized if AEI_i is less than 1 ($AEI_i<1$) and under-utilized if AEI_i is greater than unity ($AEI_i>1$).

Statistical analysis: The data were analyzed statistically with one way ANOVA, with the significance of each explanatory variable using the t-test. The overall significance was determined by the F-ratio at 1% level of significance.

RESULTS AND DISCUSSION

The perusal of Table 1 depicts the major physical inputs per farm for rice production during monsoon and spring along with their productivity. It includes land, seed, fertilizers (organic manure, nitrogen, phosphorous and potassium), irrigation, labor (human and machine) and chemicals. Most of the inputs used in spring rice were lower (land, seed, organic manure, nitrogen, phosphorous, irrigation and machine labor) than in monsoon rice but the productivity was found 1.13 times higher in spring rice (26.00 Quintal/farm). It was observed that the use of organic manure, phosphorous and water was higher in monsoon rice.

The average cost of various major inputs, average gross return, average gross margin and benefit cost ratio of monsoon and spring rice production are depicted in Table 2. It can be observed that rice production during monsoon and spring season was profitable in the study area. The average profitability of monsoon rice (NRs 11285.347 per farm) was higher than that of spring rice (NRs 7637.1650 per farm). The items that greatly reduced the profit of spring rice in the study area were lower average gross return (1.073 times) even having greater productivity and higher cost per farm on items like seed (NRs 2418.5419), potassium fertilizer (NRs 258.8065), irrigation charges (NRs 5605.2419) and miscellaneous cost (NRs 4418.8323) including cost of chemicals. Yadav and Sinha also revealed the higher cost of production and productivity in Boro rice than Kharif rice in their study[18]. Among the cost items, labor alone incurred around 46% of the total variable cost in the production of rice during both seasons. This result is inconsistent with the findings of previous studies[20,24,21]. Similarly, the study of MOAD also found the human labor wage rate for paddy was increased by 1019% from the base year 1993/94 to 2013/14 in Nepal and the profit from cereals including rice was very low because of high input price growth rate and relatively smaller growth rate of output price rate[25]. So, replacing the human labor by mechanization will be a suitable option to reap higher profit from rice production. The

Table 1: Input used in production of monsoon and spring rice

Items	Monsoon rice	Spring rice
Land (Kattha/farm)	15.5188	14.9516
Seed (kg/farm)	37.4511	35.6774
Organic Manure (OM) (kg/farm)	3067.2930	1980.4194
Nitrogen fertilizer (N) (kg/farm)	36.87218	32.6645
Phosphorous fertilizer (P) (kg/farm)	34.50376	23.7161
Potassium fertilizer (K) (kg/farm)	3.06015	6.1290
Irrigation (Days/farm)	32.96992	21.6903
Human labor (Man-days/farm)	38.88722	41.8000
Machine labor (h/farm)	7.019098	5.8377
Productivity (Quintal/farm)	22.9112	26.0065

Source: Computed from field survey data

Table 2: Average gross margin of monsoon and spring rice production

Items	Monsoon rice	Spring rice
Seed cost (NRs/farm)	1851.068	2418.5419
Organic manure cost (NRs/farm)	6846.21212	3672.2065
Nitrogen fertilizer cost (NRs/farm)	903.2273	896.4065
Phosphorous fertilizer cost (NRs/farm)	1749.583	1114.206
Potassium fertilizer cost (NRs/farm)	131.0606061	258.8065
Irrigation cost (NRs/farm)	1935.4924	5605.2419
Human labor cost (NRs/farm)	21264.53788	21183.4194
Machine labor cost (NRs/farm)	10300.52273	6152.4968
Agrochemicals and other cost (NRs/farm)	1003.782	4418.8323
Average variable cost (NRs/farm)	45985.49	45720.1600
Average gross return from rice (NRs/farm)	57270.8333	53357.3226
Average gross margin or net return from rice (NRs/farm)	11285.347	7637.1650
Benefit/cost ratio	1.245	1.167

Source: Computed from field survey data

production of rice in the study area could be more profitable if the inputs were efficiently combined and costs were reduced.

The cobb-douglas production function was used for empirical analysis of elasticity of various inputs used in the production of rice during monsoon and spring seasons. Results of the estimated values of the coefficients of each input employed show that monsoon rice was positively and significantly correlated with the land, organic manure and human labor but was negatively and significantly correlated with the use of potassium fertilizer (Table 3). This implies that the output of monsoon rice increased with the increased quantity of land, organic manure and human labor and the decreased quantity of potassium fertilizer. Nimoh *et al.*[21] also reported a positive and significant relation of land and labor to the production of rice in Western Ghana[21]. Similarly, Adhikari[20] also revealed the significant positive results of labor and some organic manure like poultry manure and oil cakes in producing organic rice[20]. Inputs like seed, nitrogen, phosphorous, machine use and irrigation were not significantly correlated with the output of monsoon rice.

The allocative efficiency of land (3.1479), organic manure (0.0470) and human labor (0.2935) shows that land was underutilized and organic manure, potassium, as well as human labor were over utilized (Table 4). The cost of land was smaller as compared to the value marginal product of monsoon rice. Hence, there is further room for increasing the use of land. The cost of organic manure, potassium and human labor was higher as compared to the value of their respective marginal products. Therefore, farmers can incur more cost on land and reduce cost on organic manure, potassium and human labor so as to produce monsoon rice efficiently. Akighir and Shabu[26] in their study found all the inputs for rice production including land were underutilized. Human labor, organic manure and fertilizers were found over utilized in the production of monsoon rice under irrigated condition in Chitwan district of Nepal[24].

For spring rice production, inputs like land, seed, potassium fertilizer, human labor and irrigation were found significantly increasing the output of spring rice. The estimated coefficient values of these significant inputs revealed that land (0.692), seed (0.095), human labor (0.154) and irrigation (0.063) were positively correlated but potassium (-0.044) was negatively correlated with the output. This implies that output of spring rice increased with the increase in land, seed, human labor, irrigation and decrease in potassium fertilizer. Akighir and Shabu[26] found all the inputs like land, fertilizer, herbicides, seed and labor were positively

Table 3: Estimated values of coefficients and probabilities of the production function

Variables	Monsoon rice coefficient	p-value	Spring rice coefficient	p-value
Intercept	0.153**	0.018	0.115^{NS}	0.250
Land	0.816*	0.000	0.692*	0.000
Seed	-0.034^{NS}	0.569	0.095***	0.100
Organic manure	0.009***	0.051	-0.001^{NS}	0.917
Nitrogen	-0.006^{NS}	0.899	0.001^{NS}	0.961
Phosphorous	0.014^{NS}	0.644	0.012^{NS}	0.590
Potassium	-0.019***	0.096	-0.044**	0.050
Human labor	0.155***	0.100	0.154**	0.050
Machine	0.026^{NS}	0.525	-0.007^{NS}	0.866
Irrigation	-0.006^{NS}	0.875	0.063***	0.045
R2	0.806		0.790	
Adjusted R2	0.795		0.777	
F-value	73.414*		60.763*	
Durbin Watson stat	1.617		1.759	

Source: Computed from field survey data, *,**,***Statistically significant at 1, 5 and 10% level, respectively

Table 4: Coefficient Marginal Physical Product (MPP), Marginal Value Product (MVP), Marginal Factor Cost (MFC) and Allocative Efficiency Index (AEI)

Variable	Coefficients	MPP	MVP	MFC	AEI
Monsoon rice					
Land	0.8160	1.1773	2392.4600	760.0000	3.1479
Organic manure	0.0090	0.0001	0.1074	2.2880	0.0470
Potassium	-0.0190	-0.4186	-850.6164	42.4300	-20.0475
Human labor	0.1550	0.0780	158.6076	540.4638	0.2935
Spring rice					
Land	0.7550	1.2939	2253.4308	416.0000	5.4169
Seed	0.0950	0.0684	119.1419	71.7200	1.6612
Potassium	-0.0440	-0.2915	-507.6626	41.9700	-12.0958
Human labor	0.1540	0.0855	148.8877	506.7804	0.2938
Irrigation	0.0630	0.0660	114.8692	267.6700	0.4291

Source: Computed from field survey data

and significantly associated with rice production in Nigeria. The allocative efficiency of land (5.4169) and seed (1.6612) showed that these two inputs were underutilized indicating that there is a sufficient room to increase the use of land and seed further. The result is also consistent with the findings of Akighir and Shabu[26]. Potassium (-12.0958), human labor (0.2938) and irrigation (0.4291) were over utilized depicting that their costs were more as compared to their respective marginal value products.

The sum of estimated coefficients of production function inferred that rice growers were in the second stage of production zone with decreasing returns to scale during monsoon (RTS = 0.955) and spring (RTS = 0.965) production season. Coelli *et al.*[27] had a similar result of decreasing returns to scale for rice production in two different seasons (dry and monsoon) in Bangladesh. The Bore well irrigated and rainfed monsoon rice farms also revealed to have decreasing returns to scale while producing rice in Chitwan district[24].

CONCLUSION AND FUTURE RECOMMENDATIONS

It is concluded that monsoon rice was more profitable though having less productivity than spring rice. Higher uses of agrochemicals and irrigation along with their associated higher prices have increased the cost of production of spring rice. Allocative inefficiencies were seen in rice production during both seasons. The return from monsoon rice was likely to increase if more land was allocated and fewer inputs such as organic manure, potassium fertilizer and human labor were used. Similarly, spring rice could also be efficiently produced by increasing the use of land and seed and reducing the use of potassium fertilizer, human labor and irrigation.

The government should devise plans and policies for the proper distribution of irrigation facility that will check the haphazard use of water. The introduction of Mechanization could be encouraged in plains of Nepal to replace the excess human labor, especially for transplanting and harvesting. Further studies on the efficiency of locally made hand tools might enhance the sustainability of labor-intensive rice production system of Nepal. Government subsidies could also help to reduce the marginal factor cost and hence improve efficiency level. Despite only providing the promising inputs, proper technical knowledge and farm management skills to allocate the resources were found to have paramount importance in increasing the production and productivity of rice that could promote national food security through gaining self-sufficiency in rice production. In context of increasing demand of rice and decreasing the potential rice areas, there remains an opportunity to expand the domestic rice production by improving the resource use efficiency of existing rice farms. Efficient production of rice during the spring, other than the principle rice producing season will not only create scope for staple food surplus meanwhile it will also create the income generating opportunities for farm families. A similar study should be conducted on hilly areas of Nepal where farmers could not fetch more profits from monsoon rice because of landslides and water floods and where rice is also produced during the spring for its demandable water availability and higher crop demand.

SIGNIFICANCE STATEMENTS

This study discovers the production efficiency of rice production (monsoon and spring) in Nepal that can be beneficial for overall growth of agricultural GDP and reduce the deficits of rice production in Nepal. This study will help the researchers and government bodies to uncover the critical areas of agricultural production efficiency of similar agronomical crops and agricultural planning program in the long run that still remain unexplored. Thus a new theory on agronomical crop production efficiency analysis may be arrived at.

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