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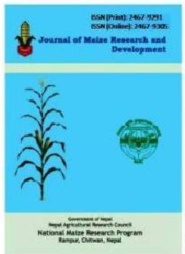
Productivity and profitability of maize-pumpkin mix cropping in Chitwan, Nepal



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ABSTRACT

The study was conducted to determine the productivity, profitability and resource use efficiency of maize-pumpkin mix crop production in Chitwan. The study used 53 maize-pumpkin mix crop adopting farmers from among 300 farmers adopting different pollinator friendly practices. Descriptive and statistical tools including Cobb-Douglas production function were used to analyze data, collected from structured interview schedule. The benefit cost ratio (1.58) indicates that maize-pumpkin mix cropping was profitable with productivity of 2.83 ton per ha on maize main product equivalent basis. The magnitude of regression coefficients of maize-pumpkin mix cropping implied that expenditure on seed and fertilizer and irrigation had significant positive effect on gross return with estimated decreasing return to scale (0.85). According to estimated allocative efficiency indices, it is suggested to increase expenditure on seed and fertilizer cum irrigation by about 90% and 55% respectively. Extension of modern technologies with adjustment on resource use is to be encouraged for increase in productivity and profitability of maize-pumpkin mix crop production which indirectly promotes and ensure forage for pollinators

INTRODUCTION

Maize (*Zea mays* L.) is second most important cereal crop of Nepal and is popularly known as *Makai* in Nepal. It occupied 8,49,635 ha of land area, with the production of 19,99,010 t and productivity of 2.35 t/ha (MoAD, 2013). This crop is cultivated mainly for food, feed and fodder purpose on both irrigated as well as non-irrigated land across the different agroclimatic condition of the country (Paudyal & Poudel, 2001). Specifically, it is subsistence staple food crop in hill area of the country and mostly used as feed in terai and inner terai of the country which is growing it as important cash crop in the area. It is general practice of growing pumpkin (*Cucurbita moschata*) as mix crop with maize in Nepal as important vegetable component in summer and rainy season. This type of mix-cropping system makes the cropping system pollinator friendly as compared to mono-cropping of maize. It is imperative to recognize the factors that hinder farmer's resource use efficiency in

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maize-pumpkin mix cropping production and further quantify the extent to which the resources are to be adjusted for optimum economic advantage. Area under maize in Chitwan in 2013 was 29400 ha and productivity was 3.4 t/ha (DADO, 2014). Honeybees and other natural pollinators visit on very attractive flowers of pumpkin and ultimately results into cross pollination. If maize only is grown in monocropping system, then it avoids visit of honey bees. Growing pumpkin mixed with maize provides foraging space for bees which is not possible in monocrop of maize. Honeybees are natural pollinators of plants throughout their natural range. The main significance of honey bee keeping is pollination with honey and wax as products of secondary value (Verma, 1990). Pollination is a critical link in the functioning of ecosystems and it is essential for the production of a wide range of crops. Several studies have shown that pollination makes a very significant contribution to the agricultural production of a broad range of crops, in particulars fruits, vegetables, fiber crops and nuts (Gordon & Davis, 2003). Crop pollination services are being hampered by a decline in the number and diversity of pollinator populations throughout the Hindu Kush Himalayan region (Partap *et al*., 2001). Pollinator loss in Chitwan has been attributed to habitat loss resulting from misuse of fertilizers and pesticides, reluctant in beekeeping, deforestation, loss of natural vegetation, increased commercial agriculture, use of high yielding varieties, monocropping and; many other abiotic and biotic factors (Devkota, 2013). Pollinator friendly practices are those which increase forage for pollinators through mixed crop types over a growing season, planting crop with long flowering period, growing crop with mass flowering, mixed crop types with at least one pollinator attractant crop, greater crop genetic diversity, patches of non crop vegetation, shade tree cultivation, strip cropping, conservation of grass lands etc. Secondly, practices for reducing use of chemicals like selective weeding to conserve weed for pollinators, organic farming, use of less toxic chemicals and less use of inorganic fertilizers are also pollinator friendly practices. The third category of pollinator friendly practices is managing for bee nest sites through no till agriculture, hand tillage, leaving dead trees and fallen branches undisturbed, avoidance of flood irrigation etc. The fourth category of pollinator friendly practices is use of managed pollinators through beekeeping and introducing nesting sites for bee pollinators (FAO, 2008). The present maize-pumpkin mix crop production practice under study could be treated as one of the important pollinator friendly practices as it has incorporated pollinator friendly cucurbit crop with extended flowering period and good forage for bees and other natural pollinators. Maize-pumpkin growing in mix crop pattern is traditional practice and the district is popular for maize production in all three crop production seasons. Maize-pumpkin mix crop production used in the study is for summer season maize production. The supply of maize is maintained through import at the huge cost of foreign exchange to meet the growing demand of maize in domestic market. While making production decision, farmers consider costs of production and yield which ultimately affect rate of adoption and sustainability of any crop. So, profitability study on maize-pumpkin mix crop production is expected to reveal valuable information relating to farms and farmers practicing this system of mix crop production. Resources used in any production activity are regarded as the inputs that drive the production process. A resource is said to be efficiently utilized when it is put to the best use possible and at minimum cost allowable. For this better and improved technologies could be helpful but, it is very essential to analyze whether farmers are making rational use of available resources. Farmers might use the resources rationally but not at the economic optimum level, which is mainly due to inadequate knowledge on resource optimization. As the aim of every agribusiness firm is to maximize profit whiles minimizing cost, it is pertinent to determine the efficiency of resource use. Furthermore, future of maize production in general and maize-pumpkin mix crop production in particular in the study area depends very much on the awareness of its profitability and resources use efficiency in the context of growing competitive crops in summer season, specially with vegetable crops. Keeping this in view the study was undertaken to determine profitability and resource use efficiency of maize-pumpkin mix crop production for the promotion of livelihood of growers and forages for pollinators.

METHODOLOGY

The study was conducted at Chitwan district in Nepal where, Global Pollination Project (GPP-FAO) was successfully implemented for five years (2009-2014). Chitwan district is located in the central region of Nepal at geographical line of 27^{0}35’ North to 84^{0}30’ East Latitude and 27^{0}35’ North to 84^{0}30’ East Longitudes. The climatic situation of the district varies from sub-tropical to tropical giving favorable conditions for growing diverse crop species. Total area of the district is about 223839 ha, of which 25.3% is agricultural land (DADO, 2014). Six Village Development Committees (VDCs) namely Padampur and Jutpani from eastern Chitwan; Phulbari and Mangalpur from Central Chitwan; and Meghauli and Sukranagar from Western Chitwan were selected randomly. These VDCs were among the nine VDCs of GPP-FAO conducted in the district. Western and central parts of Chitwan are more popular in maize-pumpkin mix cropping. Two farmers' group formed under GPP for the promotion of pollination friendly practices, with size of twenty five members in each group were randomly selected from each VDC. Thus a total of 50 farmers from each VDC and 300 farmers in total were the number of farmers selected for study on different pollinator friendly agricultural practices adopting by farmers. These 300 farmers were studied for ten common pollinator friendly practices namely mustard production, buckwheat production, surface seeded mustard production, surface seeded buckwheat production, organic rice production, organic maize production, bitter gourd production, bee keeping, kitchen gardening and maize-pumpkin mix cropping. Among 300 farmers selected under study on pollination friendly practices, 53 were maize-pumpkin mix crop growers. Primary data were collected with the use of structured interview schedule using face to face interview technique in April, 2014. After the collection of necessary information it was coded and entered in SPSS data entry sheet and analyzed by using STATA 12. Collected data were analyzed with descriptive and quantitative methods. The budgeting technique employed in the study was the gross farm income and gross margin. All variable inputs like human labor, tractor labor, seed, inorganic fertilizers, irrigation and organic manures were considered and valued at current market prices to calculate cost of production.

Total variable cost = Clabor+ Ctractor and animal labour+Cseed+ Cfert + Cirri + Cmanure
Where, C_{labor} = Cost on human labor used (NRs./ha), $C_{tractor\ and\ animal\ labour}$ = Cost on tractor labor and bullock lalor used (NRs./ha), C_{seed} = Cost on seed (NRs./ha), C_{fert} = Cost on inorganic chemical fertilizers (NRs./ha), C_{irri} =Cost on irrigation (NRs./ha) and C_{manure} = Cost on organic manures (NRs./ha)

Gross return was calculated by multiplying the total volume of outputs from maize-pumpkin mix cropping by the average price of maize and vegetable forms of pumpkin at harvesting period (Dillon & Hardaker, 1993). Thus gross return and productivity were calculated as maize product equivalent by expressing the value of outputs from pumpkin in terms of maize product. Gross margin calculation was done to have an estimate of the difference between the gross return and variable costs. Gross margin was calculated by using the method as given by Olukosi *et al*. (2006) using following formula;

Gross Margin (NRs./ha) = Gross return (NRs./ha) - Total variable cost (NRs./ha)

Furthermore average cost per Kilogram of maize product equivalent was calculated as the ratio of total variable cost (NRs.) to total production (kg). Similarly average gross margin (NRs./kg) was calculated as the ratio of gross margin(NRs./ha) to productivity (kg/ha).

Benefit cost ratio is the quick and easiest method to determine the economic performance of a business. It is a relative measure, which is used to compare benefit per unit of cost. Undiscounted benefit cost ratio was estimated as a ratio of gross return and total variable cost. Thus, the benefit cost analysis was carried out by using formula;

$$\text{B/C ratio} = \frac{\text{Gross return (NRs.)}}{\text{Total variable cost (NRs.)}}$$

Koutsoyiannis (1977) defined production function as a technical relationship between factor inputs and output. Cobb-Douglas type of production function was used to determine the contribution of different factors on production and to estimate the efficiency of the variable production inputs in maize-pumpkin mix crop production. It is most widely used multiplicative and non linear form of production function used in agricultural research and is convenient for the comparison of the partial elasticity coefficient (Prajneshu, 2008). The marginal productivity of factors, marginal rate of substitution and the efficiency of production can be calculated directly from parameters in Cobb-Douglas type of production function. Thus, Cobb-Douglas production function of the following form was fitted to examine the resource productivity, efficiency and return to scale.

$$Y = aX_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} X_5^{b5} e^u$$

Where, Y= Gross return (NRs./ha), X_1= Cost on human Labor (NRs./ha), X_2= Cost on tractor and bullock labor (NRs./ha), X_3= Cost on organic manures (NRs./ha), X_4= Cost on seed (NRs./ha), X5= Cost on irrigation and fertilizers (NRs./ha), e=Base of natural logarithm, u = Random disturbance term, a=Constant, and b1, b2, ..., b5=Coefficients of respective variables.

The Cobb-Douglas production function in the form expressed above was linearised in to logarithmic function with a view of getting a form amenable to practical purposes using Ordinary Least Square (OLS) technique as expressed below;

$$\ln Y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + u$$

Where, ln= Natural logarithm, and u= Error term

For the calculation of return to scale on maize-pumpkin mix crop production, coefficients from Cobb-Douglas production function was used and calculated using formula;

$$\text{Return to scale (RTS)} = \sum bi$$

Where, bi = Coefficient of i^{th} explanatory variables.

Return to scale with value greater than unity represents increasing return to scale, value equal to unity represents constant return to scale and vale less than unity represents decreasing return to scale. The allocative efficiency of a resource used was determined by the ratio of Marginal Value Product (MVP) of variable input and the Marginal Factor Cost (MFC) for the input and tested for its equality to one i.e. (MVP/MFC)=1. Following Goni *et al*. (2007) the efficiency of resource use was calculated as;

r= MVP/MFC

Where, r= Efficiency ratio, MVP= Marginal value product of a variable input and
MFC= Marginal factor cost.

The standard way to examine such efficiency is to compare MVP with the MFC of each variable input. If MFC_{Xi} divides MVP_{Xi}, the result will be equal to the value of MVP_{Xi} because MFC at all cases is equal to 1. As the MFC is price of input per unit, the MFCs of all the inputs will vary while calculating the ratio of MVP to MFC. However, the denominator will always be one, and therefore, the ratio will be equal to their respective MVP (Majumder *et al*., 2009). The marginal value productivity of a particular resource represents the additional to gross return in value term caused by an additional one unit of that resource, while other inputs are held constant. The most variable, perhaps the most useful estimate of MVP is obtained taking resources, as well as gross return at their geometric means (Dhawan & Bansal, 1977). Since all the variables of the model were measured in monetary term, the slope coefficients of the explanatory variables in the function represent the MVP, which was computed by multiplying the production coefficient (elasticity, in this particular case) of a given resource with the ratio of geometric mean value of output and input variables (Rabbani *et al*., 2013).
Therefore, MVP_{xi}= dy/dxi, which is the product of regression coefficient with ratio of geometric mean of gross return to the level of use of i^{th} resource.
According to the conventional neo-classical test of economic efficiency, decision rule for resource use efficiency is that a efficiency ratio (r) equal to unity indicates the optimum use of that factor, the ratio more than unity indicates that gross return could be increased by using more of the resource and the ratio of less than unity indicates the excess use of resource which should be decreased to minimize the loss (Eze, 2003; Mbansor, 2002; Olayide & Heady, 1982; Okon, 2005).

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

D= (1-MFC/MVP) × 100

Or, D= (1-1/r)× 100

Where, D= absolute value of percentage change in MVP of each resource and r
= efficiency ratio (Mijindadi, 1980).

RESULTS AND DISCUSSION

Cost of production

Human labor was an important and largely used input for growing maize-pumpkin mix crop. It was required for different operations such as land preparation, seed sowing, fertilizer application, harvesting, threshing. irrigation, cleaning etc. It was computed in terms of man day and converted to monetary term valuating at prevailing wage rate. The cost of human labor in production of maize-pumpkin in mix cropping system per hectare was estimated at about NRs. 16280 (Table 1). Labor cost accounted about 38% of total variable cost in maize-pumpkin mix crop production. It has shown that maize-pumpkin production activity in the study area is labor intensive. Tractor is labor saving modern tillage technology. In the study area, all the farmers used tractor or bullock as primary tillage equipment for their land preparation. Per hectare costs of tractor and bullock was about NRs. 9799, which accounted about 23% of total variable cost of maize-pumpkin production. Per hectare costs of organic manures was about NRs. 10672 which constituted about 25% of the total variable cost (Table 1). Major types of organic manures used in the study area were farm yard manure and poultry manure.

Almost all the farmers used chemical fertilizers, mainly urea and DAP. Per hectare costs of inorganic fertilizer was estimated at about NRs. 3950, which accounted about 9% of total variable cost. Similarly, few maize-pumpkin growers irrigate their crop as they used to grow in unirrigated land in summer season after winter crops. As regards the production from maize-pumpkin mix crop production, the per hectare cost on seed accounted about NRs. 2021, which constituted about 5% of total variable cost of production (Table 1).

Table 1: Average cost of production in maize-pumpkin mix cropping system (NRs./ha)

Items of cost	Mean	Percent of total cost
Human labor	16280.09	37.84
Machinery and animal labour	9798.63	22.77
Seed	2020.53	4.70
Organic manures	10671.54	24.80
Irrigation	307.03	0.71
Fertilizers	3950.34	9.18
Total cost	43028.16	100.00

Source: Field survey 2014

Returns from maize-pumpkin mix cropping

Farmers in the study area were practicing maize-pumpkin mix cropping on an average at 0.44 hectare of land with per hectare physical volume of output as 2.83 ton in maize equivalent basis (Table 2). The average farm gate price of maize was NRs. 2400 per quintal. Per hectare gross return and total variable cost were estimated at about NRs. 67955 and NRs. 43028, respectively. Per hectare gross margin of maize-pumpkin production was estimated at about NRs. 24927. Cost and gross margin were also estimated on per kilogram basis and they were estimated at NRs. 15.19 and NRs. 8.80, respectively. It was observed that the overall undiscounted benefit cost ratio considering total variable cost was 1.58. Thus, it was found that maize-pumpkin mix crop production was profitable in the study area.

Resource use efficiency on maize-pumpkin mix cropping

Agricultural production is the result of a combination of different inputs used. The individual effect of these inputs can be explained to certain degree by multiple regression analysis, but the isolation of the effect of each variable may be very difficult in tabular technique (Islam & Dewan, 1987). Estimated values of the coefficients and related statistics of Cobb-Douglas production function are shown in Table 3. Five explanatory variables namely human labor cost, tractor and bullock use cost, seed cost, organic manure cost and irrigation cum fertilizer costs were considered to show their effects on maize-pumpkin mix crop production. Out of these five variables organic manure cost and irrigation cum fertilizer cost and seed cost were significant at 1% level. The regression coefficient for organic manure cost was 0.151, which had depicted that with 100% increase in cost on organic manure, gross return could be increased by about 15%. Similarly, with the increase in seed cost by 100%, gross return from maize-pumpkin mix cropping could be increased by about 30% as its coefficient is 0.297, which might be resulted from the higher productivity contributed due to better seeds purchased at market. Expenditure on fertilizer and irrigation could increase the gross return by about 14% and with the increase in their use by 100%. Similar to this, Baloyi *et al*. (2012) using production function reported fertilizer, tractor power, labor and seed as significant factors on small scale maize production in South Africa. of cashew in Ghana.

Table 2: Economic statement of maize-pumpkin mix cropping in the study area

Measuring criteria	Average value
Area (ha.)	0.44
Productivity-maize equivalent (t/ha)	2.83
Gross return (NRs./ha)	67954.97
Total variable cost (NRs./ha)	43028.16
Gross margin (NRs./ha)	24926.81
Average cost (NRs./qt)	1519.65
Average revenue (NRs./kg)	2400.00
Average profit (Rs./qt)	880.35
Benefit cost ratio	1.58

Source: Field survey 2014

Table 3: Estimated value of coefficients and related statistics of Cobb-Douglas production function of maize-pumpkin mix cropping

Factors	Coefficient	Std. Error	t-value
Constant	3.755**	0.861	4.36
Human labor cost (NRs./ha)	0.085	0.086	0.99
Tractor and bullock cost (NRs./ha)	0.183	0.105	1.74
Organic manure cost (NRs./ha)	0.151**	0.052	2.89
Seed cost (NRs./ha)	0.297**	0.113	2.63
Cost on fertilizer and irrigation (NRs./ha)	0.141**	0.047	2.97
F-value	31.79**		
R square	0.771		
Adjusted R-square	0.747		
Return to scale	0.857		

Note: **Significant at 1% level of confidence

Source: Field survey 2014

The coefficient of multiple determination (R^2) is a summary measure which tells how well the sample regression line fits the data (Gujarati, 1995). The coefficient of multiple determination R^2 of the model was 0.771 for maize-pumpkin mix crop production. It indicates that about 77% of variations in gross return have been explained by the explanatory variables, which were included in the model. The value of adjusted R square was 0.747 indicating that after taking into account the degree of freedom (df) about 78% of the variation in the dependent variable explained by the explanatory variables included in the model. The measures of the overall significance of the estimated regression F value was 31.79 and it was significant at 1% level implying that all the explanatory variables included in the model are important for explaining the variation of the dependent variable in maize-pumpkin production.

The concept of return to scale was applied to the production function to determine the stages of production in which farmers were allocating their resources. Returns to scale reflect the degree to which a proportional change in all inputs caused proportional change in the output. The summation of all production coefficients indicate return to scale. The sum of the coefficients of different inputs stood at 0.857 for maize-pumpkin production. This indicates that the production function exhibited a decreasing return to scale implies that if all the inputs specified in the function are increased by 100% income will increase by about 86%. Similar to this the findings of Obasi (2007), Wosor & Nimoh (2012) and Rabbani *et al*. (2013) who have reported decreasing return to scale on arable crops, chilli and mustard production, respectively. Contrary to this Wongnaa & Ofori (2012), Saikumar *et al.* (2012) and Goni *et al.* (2007) have found the increasing return to scale on cashew production, tank command farming system and rice, respectively in Ghana, India and Nigeria. The estimated MVP of different inputs used in maize-pumpkin production is presented in Table 4. Given the level of technology and prices of both inputs and output, the study revealed that ratio of MVP to MFC of tractor and bullock cost, seed cost and expenditure on fertilizer and irrigation were positive and greater than one indicating their under-utilization. It had implied that more profit could be obtained by increasing on their level of use. Human labor input was over utilized as its efficiency ratio is smaller than unity. Study result showed that the efficiency ratio for organic manure cost was near to one and had revealed that it is optimally utilized in practical sense.

Table 4: Estimates of measures of allocative efficiency of inputs used in maize-pumpkin mix cropping

Inputs	Geometric mean	Coefficient	MVP	MFC	MVP/MFC	Efficiency	Percent adjustment required
Human labor cost (NRs./ha)	28516.45	0.085	0.200	1.00	0.200	Over utilized	399.789
Tractor and bullock cost (NRs./ha)	9697.51	0.183	1.267	1.00	1.267	Under utilized	21.056
Organic manure cost (NRs./ha)	10211.98	0.151	0.993	1.00	0.993	Over utilized	0.749
Seed cost (NRs./ha)	2004.80	0.297	9.944	1.00	9.944	Under utilized	89.944
Expenditure on fertilizer and irrigation (NRs./ha)	4218.97	0.141	2.243	1.00	2.243	Under utilized	55.424

Source: Field survey 2014

The adjustment in the MVPs for optimal resource use in Table 4 indicated that for optimal allocation of resources expenditure on seed and fertilizer cum irrigation were required to increase by about 90% and 55% respectively. The increase in the cost on seed has suggested for more expenditure on seed to purchase improved seed as compared with the own farm produced seed. Similar results of under utilization of fertilizer and seed were assessed by Gani & Omonana (2009) on the production of maize in Nigeria. But the results in this study were contrary for labor inputs. Chapke *et al*. (2011) also reported that for optimum allocation of resources about 88% increase in fertilizer and more than 30% increase in agrochemicals was needed for sorghum production in India but the results disagrees with the findings for adjustment on irrigation and seed inputs in the same study. Arriving to the concluding remarks, the study showed that maize-pumpkin production is a reasonably profitable enterprise, although its productivity is still low. However, higher gross return from per hectare of land can be realized by increasing the level of resources applied to maize-pumpkin mix crop production principally seed, fertilizer, irrigation and tractor power. The analysis of resource use efficiency on maize-pumpkin mix crop production shows that all the resources considered in the study are inefficiently utilized. Thus, to obtain economic advantage, farmers are to be encouraged for increase in underutilized inputs and reduce the use of over-utilized inputs. The level of adjustments for use of various resources to earn optimum returns will serve as a bench-mark guideline for the maize-pumpkin growers in the area, government agencies, and agro-based companies. Thus if proper uses of resources could be ensured, maize-pumpkin mix cropping could be a more viable and attractive commercial enterprise for the promotion of food, income, forage for pollinators and import substitution.

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