PRODUCTION MANAGEMENT AND RESOURCE USE EFFICIENCY IN ORGANIC POTATO CULTIVATION IN BHUTAN: A SCENARIO FROM AN ORGANIC GASA DISTRICT

Tandin Gyeltshen[1], Supaporn Poungchompu[2*] and Panutporn Ruangchoengchum[3]
[1] Department of Agriculture, Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand
[2*]Department of Agricultural Economics, Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand
[3] College of Graduate Study in Management, Khon Kaen University, Khon Kaen, Thailand
*Corresponding author: psuppap@kku.ac.th

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ABSTRACT

Potatoes are one of the most important cash crops in Bhutan, both for export as well as domestic consumption. Understanding the resources used in potato production will enhance growers' efficient allocation of resources. Thus, this study aimed to analyse the economics of production and resource use efficiency of organic potato cultivation in Gasa district of Bhutan. About 90 organic potato farmers were randomly selected from the study area. A pretested questionnaire and face-to-face interviews were used to gather primary data for the 2020 cropping cycle. Descriptive statistics and Cobb-Douglas production function were used for data analysis. Farmers used 0.43 acres of land area for organic potato cultivation out of the average landholding of 3.25 acres. From the cost of production, major cost was incurred on inputs (59.19%) followed by labour (39.91%). Resource use efficiency analysis revealed that farmers were not efficient in using resources in organic potato cultivation. Cultivated area and seeds were under-utilized and therefore increasing the use of those resources could maximize productivity of potatoes. Labour, farmyard manure (FYM) and machinery were over-utilised and decreasing these would lead to better productivity. Labour, FYM, and seed constituted major parts of the cost of production hence optimum use of those resources could also enhance the profitability and resource use efficiency of organic potato cultivation. These findings will help growers in similar agricultural conditions to effectively allocate resources for potato production. The government should strengthen the existing policies to provide assistance to promote organic potato cultivation in the country.

Key words: Cobb-Douglas, cost of cultivation, economic analysis, production cost, productivity.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is the most important crop in the world after wheat, rice, and maize. The historical record of potato cultivation dates back to the 17th century when the East India Company's representative George Boggle visited Bhutan (Roder et al. 2008) while the scale of production increased gradually from 1961 onwards with the onset of Five Year Development Plans (Joshi and Gurung 2009). *Desiree*, *Kufri Jyoti*, *Yusikaap*, and *Khangma Kaap* are the four potato varieties known in Bhutan of which *Desiree* is the most preferred cultivar (Joshi and Gurung 2009). As an important cash crop potato is mostly cultivated at an elevation of 2000-3500 masl (Bajgai 2018). Bhutan produced 45,500.33 metric tonnes of potato from 10,342.26 acres (Ministry of Agriculture and Forests (MoAF) 2020).

Agriculture as an important sector provides 49.9% of employment (National Statics Bureau (NSB) 2020) also contributed 19.23% to the GDP in 2020 (NSB 2021a). With the concerns of food safety and food security, the agriculture sector initiated the institution of the National Organic Programme 2006 (DoA 2006) to mark the beginning of organic farming in Bhutan. The country envisioned to go fully organic by 2020 (McCrae-Hokenson 2014) which could not be achieved. To this, the current government revamped the organic initiative through the National Organic Flagship Programme in the 12th FYP (GNHC 2019). Currently, Bhutan has 1,265 households engaged in organic cultivation in 10,095 acres of land with about 38 agricultural products certified spread across the country (Department of Agriculture (DoA) 2021). As mandated, the agriculture sector emphasizes to increase food production to ensure household food security, alleviate poverty, substitute or reduce imports through increased domestic production, generate a marketable surplus, enhance household income and employment opportunities (DoA 2019). Thus, it is necessary to assess the performance of organic agriculture in the country.

Over the years, potato cultivation has been given immense importance by the Department of Agriculture through the National Potato Program. The initiative included multi-location potato seed varieties, providing training, and seeds to the farmers (DoA 2021). Although the productivity of 4,370 kg/acre (MoAF 2020) is the lowest among south Asian countries, potato cultivation is still a profitable business (Joshi and Gurung 2009). However, Bhutan imported 4910.02 metric tonnes of potato incurring US$ 782,227 to its economy (MoAF 2019). The initiatives for import were to meet the shortage of potatoes in the country. But the source of the import and production regimes were not reliable from the food safety and security perspective. This therefore demanded improvement in the potato production system in the country, particularly for organic production methods. It is very important to understand how well producers are making plans and managing resources to maximize the returns, minimize costs, and improve overall efficiency. Several studies on potatoes such as the productivity and profitability of organic and conventional potato (Lepcha et al. 2021), weed management challenges in potato (Roder et al. 2009), marketing Bhutanese potato (Roder et al. 2007), and market performance of potato (Van Tilburg et al. 2008) were conducted in Bhutan. Besides some economic aspects of organic potato cultivation (Lepcha et al. 2021), the economics of production and resource use efficiency analysis was not covered in any of the studies.

Resource use efficiency refers to using the limited resources in a sustainable manner. Traditionally, it has been determined by calculating ratios of productivity per unit of resource (Sheriff et al. 1995). Rural communities depend on agricultural production for food and income. Natural resources such as land, water, energy, nutrients, and air are essential for agriculture and to sustain life of all living organisms. However, the overutilisation of these limited resources by human activities has called for an urgent scientific management of natural resources in agriculture to enhance use efficiency for sustainable future importance (Rani et al. 2020). The production inputs for potato cultivation such as land, labour, capital, and other inputs have significant influence on the overall yield. Thus, it is important to maximize the benefits of these inputs while minimizing waste due to overutilization or underutilization of the resources. These shortfalls can be augmented through use of optimum level of inputs by way of resource use efficiency (Verma 2007). Thus, the study aimed to analyse the economics of production and resource use efficiency of organic potato cultivation in the Gasa district. This study would help extension people broaden their advisory capacity to the farmers, policy reference directed towards helping potato farmers, and guide producers to best to allocate the scarce resources on the farm.

METHODOLOGY

Study area and data collection. Gasa is in northwestern Bhutan with an elevation ranging between 1500-4500 masl. It has a population of 4,156 with 909 households. About 29.4% its total population is engaged in agriculture (NSB 2021b). The district is further divided into four subdistricts known as

Gewogs namely Laya, Lunana, Goenkhatoed, and Goenkhamed. Gasa has been declared as the first organic areas (Duba et al. 2008) and it has over 14 years of experience in organic farming (Wangmo and Iwai 2018). Thus, two lower Gewogs that were engaged in agricultural farming were purposely selected for the current study on resource use efficiency in organic potato production. Employing the simple random sampling method, 90 households comprised of 30 households from Goenkhatoed Gewog spread across 14 villages and 60 households from Goenkhamed Gewog spread across 18 villages were interviewed for the study (Fig. 1). A structured questionnaire was used for collecting cross-sectional potato production data in February and March 2021.

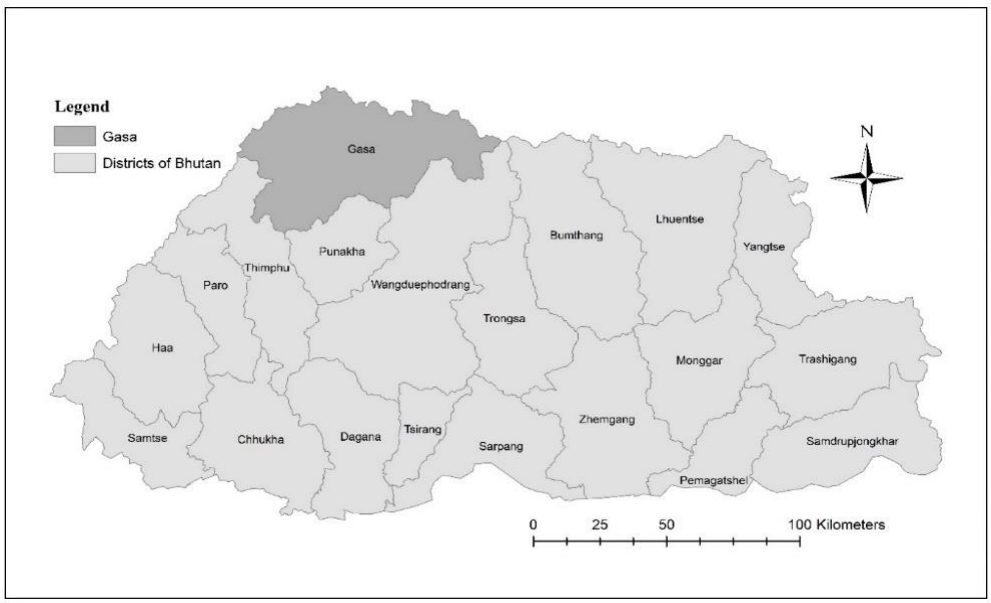

Fig. 1. Map of Bhutan with 20 districts
Source: National Statistics Bureau, 2017

Data analysis. Multiple regression analysis was employed to find the factors influencing organic potato cultivation and for evaluating the economic efficiency of resources. The linear stochastic form of the specified Cobb-Douglas function is given as:

$$Y = aX_1^{b_1}X_2^{b_2}X_3^{b_3}X_4^{b_4}X_5^{b_5}u_i \quad (1)$$

Where:
Y = Production per acre (Kg)
X_1 = Seed (Kg)
X_2 = Farmyard manure (Kg)
X_3 = Cultivated area
X_4 = Total labour (Labour hours)
X_5 = Power tiller use (Hours)
U_1 = stochastic error term
a = Intercept and b_1 to b_5 are the elasticity of coefficients.

Resource use efficiency. The estimated coefficients of significant independent variables were used to compute marginal value products (MVP). It is the marginal physical product (MPP) multiplied by the product price. The price of one unit of input is called marginal factor cost (MFC). The resource-use efficiency (r) was worked out as (Rahman and Lawal 2003):

$$r = \frac{MVP}{MFC} \quad (2)$$

where, $MVP_i = \beta_i \frac{\overline{Y}}{\overline{X}_i} * P_y$

MVP_i = Marginal value product of the i^{th} input,
β_i = Estimated co-efficient of i^{th} input,
$\overline{Y}$ = Geometric mean of the value of output,
$\overline{X}_i$ = Geometric mean of the i^{th} input, and
P_y = Price of output.

The decision rule for the efficiency analysis is if:

r = 1 resource has been used efficiently
r>1 resource is under-utilised, and increased utilisation will increase profit
r< resource is over-utilised and decreased utilisation will increase profit.

RESULTS AND DISCUSSION

Socioeconomic characteristics of farmers. Age, gender, education, family size, family labours, experience, area under cultivation, and total landholding were assessed in the study (Table 1). The age of farmers ranged from 26 to 75, with a mean of 48.8 years. This shows that majority of the farmers (76.67%) fall within the energetic age group of 20 to 60 indicating the ability to meet the physical works required for agricultural works. The female respondents constituted 77.78% followed by 22.22% of male respondents. The literacy rate of the study area was low with 72.22% of the respondents being illiterate. Majority of the households (54.44%) have the family size of 1-3 members followed by 33 households with 4-6 members, and about 7.78% households with members ranging from 7-9 and 1.11% with 10-12 members. In line with the household members, family labours are crucial for agricultural activities and relates to the dependency on hired labours. Majority of the respondents (76.67%) had 1-2 family labours followed by 21.11% of respondents had 3-4 family labours, and only two households had a family labour of 5-6 members. Farmers also had a range of years' experience in organic potato production. The minimum range of 1-5 years' experience have 24.44% of households in organic potato production. Majority (46.67%) of the farmers had experience between 6-10 years.

Majority of the organic potato farmers were female. This is evident because Goenkhatoed and Goenkhamed gewogs has more female than male population (National Statistics Bureau (NSB 2018) and also it has been observed that male population are out into off farm activities (GCF 2019). Majority of the respondents were illiterate and this is supported by NSB (2018) whereby Gasa has the lowest literacy rate according to the population and housing census 2017. The study area had two household labour on average indicating the shortage of labour-intensive organic potato cultivation (Jansen 2000) and having to rely on hired labour. Less family labour is due to migration (NSB 2018) and this agrees with the study by Karim and Muhammad (2018). Farmers were well experienced in organic potato cultivation with average of 8 years into the venture advantaged with regular trainings from the agriculture department. On average each household owned 3.25 acres, of which 2.62 acres were under cultivation. Only 0.43 acres (13.09%) of the total landholding was found to be under potato cultivation.

Table 1. Characteristics of the sampled households

Particulars		Frequency	Percent
Number of Households		90	100
Age, years	<20	0	0.0
	20-59	69	76.67
	60-69	17	18.89
	70>	4	4.44
Gender	Male	20	22.22
	Female	70	77.78
Education	Illiterate	65	72.22
	Literate	25	27.78
Family size	1 - 3	49	54.44
	4 - 6	33	36.67
	7 - 9	7	7.78
	10 - 12	1	1.11
Family labour	1 - 2	69	76.67
	3 - 4	19	21.11
	5 - 6	2	2.22
Farming experience (Years)	1 - 5	22	24.44
	6 - 10	42	46.67
	11 - 15	19	21.11
	16 - 20	5	5.56
	20>	2	2.22
Average area under potato (Acres)	0.43		
Average cultivated area (Acres)	2.62		
Average landholding (Acres)	3.25		

Economic analysis of organic potato cultivation. The average of various cost items of organic potato production is presented in Table 2. The cost covers both fixed and variable costs. The constituents of variable costs are human labour, power tiller hire charges, and materials cost such as cost of seed and farmyard manure. Rental value of the cultivated area and tax were the fixed cost incurred for organic potato cultivation in the study area.

Total inputs cost constituted the highest share (59.19%) followed by labour cost (39.91%) of the variable costs. The highest labour hour for organic potato production was for harvesting with mean 95.27 followed by weeding and earthing up with the mean of 94.45. Planting incurred 6.60% followed by land preparation with 6.22% of total costs. Total cost of production per acre of organic potato was found to be US$ 965.14. The average yield of organic potato in the study area was 1,666.67 kg per acre. The output input ratio was found to be 1.01.

The study found that majority of the cost components were from variable costs while the fixed cost was insignificant. This agrees with the findings of Kahan (2013) where small holder farmers cost are variable costs. Labour costs incurred significantly constituting about 37.12% of the total cost.

Labour was incurred more in harvesting followed by weeding and earthing, planting, land preparation, FYM application, fencing, and transportation respectively. The results of the labour-intensive nature of the organic cultivation agrees with findings of Jansen (2000), Kassali (2011), and Tashi and Wangchuk (2016). The average yield of organic potato (2,275.91 kg/acre) was much lower than the national average yield. The findings were consistent with the studies by Ierna and Parisi (2014), Lepcha et al. (2021), and Maggio et al. (2008) that reported the overall low productivity in organic production system. Despite low productivity compounded by high production cost of $ 0.58 per kg, organic potato cultivation is still profitable indicated by the output-input ratio of 1.01 indicating the profit of $ 0.01 from investment of $ 1 in organic potato cultivation. This agrees with the studies by Tashi and Wangchuk (2016) and Crowder and Reganold (2015) on the profitability of organic cultivation. Thus, increasing the land under organic potato cultivation would increase in the returns to the farmers.

Table 2. Cost and return analysis of organic potato cultivation in Gasa district, Bhutan in 2020.

Variable costs (VC)	**Value (USD/Acre)**	**Percentage**
Inputs costs		
Seeds	168.60	17.47
FYM	179.05	18.55
Machinery	97.92	10.15
Other inputs	125.76	13.03
Total	**571.33**	**59.20**
Labour costs		
Fencing	16.00	1.66
Land preparation	60.06	6.22
FYM application	48.49	5.02
Planting	63.68	6.60
Irrigation	0.07	0.01
Pest/disease management	0.59	0.06
Weeding and earthing	94.45	9.79
Harvesting	95.27	9.87
Transportation	6.62	0.69
Total	**385.23**	**39.91**
Fixed Costs (FC)		
Land tax	0.21	0.02
Land lease	8.38	0.87
Total	**8.59**	**0.89**
Total Cost (FC+VC)	**965.14**	**100.00**
Yield (Kg/Acre)	1666.67	
Return ($/Acre)	975.66	
Output-input ratio	**1.01**	

Note: 1 US$ = BTN 76.41

Farmers in the study area used extensive FYM and practised crop rotation for maintaining soil health. Similar results were obtained by crop rotation, intercropping, fertility building crops, crop residues, FYM, compost, and complete recycling methods adopted to retain soil organic matter (Heckman 2013; Watson et al. 2002). Farmers in the study area also practised pasturing animals in the fallow area, burning weeds, weed biomass, and crop residues to replenish the soil nutrient loss with removal of crops from the field which are consistent with the findings of Stark et al. (2020) and Roder et al. (2006). Organic potato farmers relied solely on rainwater knowing that potatoes require less water compared to water intensive crops like wetland rice. Most importantly the practices in the study area were in conformity with the package of organic practices (NCOA 2020). National Plant Protection Centre reported that popular insects, diseases, and animals that harm the potatoes in Bhutan are peach potato aphid, potato tuber moth, red ant, white grub, early and late blight, potato virus, and wild boars (NPPC 2018). However, only 12% of respondents reported nuisance from wild pigs on organic potato production while other pests were insignificant in Gasa district. Farmers applauded government's assistance in providing electric fencing to reduce the organic potato damage by wild animals. This finding is consistent with the national assessment electric fencing by Dorjee et al. (2021). Organic potato farmers also used mechanical, cultural, and biological methods to manage pest infestation. The mechanical methods include picking up pests as well as removing the part or whole of the infested plants by pests. The cultural method such as crop rotation, deep ploughing, proper use of fertilisers, timely or late sowing, and proper harvesting of potatoes seemed more effective to control pests. Farmers reported that these methods were easy to adopt. Similar findings were reported in the studies by Bond and Grundy (2001), Watson et al. (2002), and Wyss et al. (2005).

Distribution channels of organic potatoes. Organic potatoes from the study area were sold in the regional markets of Gasa, Punakha, Wangduephodrang, Thimphu, and Phuentsholing respectively. The channels of distribution of organic potatoes from the study area were presented in Fig. 2.

Producers refer to the organic potato farmers in the study area. Channel 1 was used by 34% of farmers to sell their products to consumers directly. About 16% traded through Channel 2, 34% through Channel 3 and 8.89% via Channel 4. Others in Channel 4 refers to the organic potatoes being sold to the institutions or other marketplaces that were adopted either through the farmers' own initiative or with the assistance of agriculture extension officers.

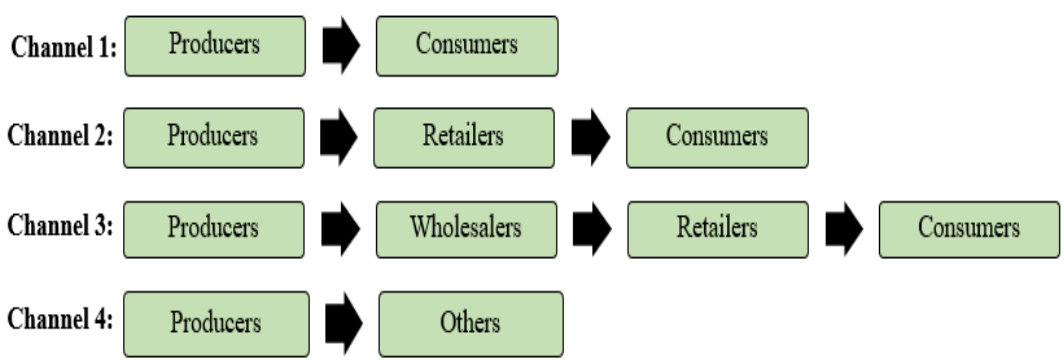

Fig. 2. Distribution channels of organic potatoes.

Resource use efficiency of organic potato cultivation. Resource use efficiency deals about how farmers' effectively use resources for agricultural production processes. The estimated coefficients and other statistics concerning the resource use employing the Cobb-Douglas production function are presented in Table 3. Five explanatory variables namely cultivated area, seeds, farmyard manure

(FYM), machinery, and labour were used in the estimation. From the analysis, seed and area cultivated were found to be underutilised as indicated by greater than unity ratio. Increasing the investment on seed and land for cultivation would lead to profit maximisation. Efficiency ratio indicated over utilisation of resources in terms of FYM (0.91), labours (0.03), and machinery (0.01) respectively.

The requirement of human labour in organic potato cultivation starts from fencing to land preparation until the harvest and storage. Potato farmers spent lot of labour hours for weeding and harvest. The most popular machine used in the study area is power tiller for land preparation in organic potato cultivation which traditionally were carried out by human labour or use of animal power, similar to findings reported by Phuntsho et al. (2022). However, the use of power tiller is less efficient due to high gradients. Power tillers were used with additional manpower to carry out the land preparation to reduce full dependency on man and animal power in organic potato cultivation. The respondents on average use 14.63 hours of power tillers per acre for land preparation in organic potato cultivation. The timing includes ploughing and rotatory by power tiller in the cultivation area. The farmers use no other machineries in other processes of organic potato cultivation; in other words, other activities such as fencing, weeding, earthling up, irrigation, and harvesting were all carried out using traditional methods.

The overutilisation of these factors would be neutralised by minimising the use of these resources or increasing the utilisation of land and seeds for better economic returns. Regarding, in the plain area, power tillers or tractors can be used to their full potential without the involvement of human labour but Bhutan being a mountainous country, the use of power tillers become less efficient. Although power tiller reduces the workload on human labour especially for land preparation in organic potato cultivation by significant time yet the dependency on human labour for other work processes in organic potato cultivation is more. That is why the ratio of efficiency results in the overutilization of both labour and machinery in organic potato cultivation.

Table 3. Efficiency of resource use in potato production

Particulars	Geometric Mean	AVP	Coefficient	MPP	MVP	MFC	r
Returns	1730.58						
Cultivated area (Acre)	0.31	5661.88	0.01	66.41	2970.62	652.00	4.56
Seeds (Kg)	304.47	5.68	0.96	5.46	244.07	30.83	7.92
FYM (Kg)	4873.21	0.36	0.11	0.04	1.81	1.98	0.91
Machinery (BTN)	4448.04	0.39	-0.30	-0.12	-5.16	462.78	-0.01
Labour (Hours)	304.05	5.69	0.01	0.05	2.17	76.89	0.03

Note: Price of output is 44.73 BTN/kg.

Land lease rate of Nu. 640 per acre per annum was adapted from the Government rate as the potato growing communities do not have land lease practise (NLCS 2009).

Resource use efficiency analysis was carried out employing the Cobb-Douglas production function on organic potato production. Similar studies on potato were carried out in Nepal (Sapkota and Bajracharya 2018) and Bangladesh (Sujan et al. 2017) while analysis on other crops were carried out using the Cobb-Douglas production function (Bapari 2016; Barmon and Islam 2017; Sapkota et al. 2020; Subedi et al. 2020; Sharma et al. 2021). The analysis revealed that farmers underutilised cultivated area and seed used for organic potato cultivation. Farmers in the study area have difficulty in

getting quality seeds due to high price and lesser supply during the plantation season. It has been reported that agriculture extension helps to supply seeds during the season, but the quantity supplied were inadequate. Thus, increase in the seed supply would enhance the efficiency of seed thereby increasing the profitability. Similar results on underutilisation of land were reported by Adebayo et al. (2020) and Tasila et al. (2019) while reported on underutilisation of seeds have been reported (Sharma et al. 2018; Subedi et al. 2020; Rana et al. 2016). As majority of the Bhutanese farmers practice self-sustaining, integrated and subsistence agricultural production system with small land holdings, farmers rear livestock to meet their household requirements where the current study area is not an exception. That is the reason for over utilisation efficiency ratio of FYM. Barmon and Islam (2017) and similar results indicated taking advantage of the FYM availability by increasing the land size for cultivation (Sapkota and Bajracharya 2018). Labour, which accounted for a substantial portion of the cost of production in the study area were also overutilized. Similar results were reported by Sapkota and Bajracharya (2018) and Khanal et al. (2020). The overutilisation of labour is due to small land size for organic potato cultivation and which involved mostly family labour. For maximisation of economic benefits from organic potato production, it is recommended to increase the area under cultivation and supply of good quality seeds.

Power tillers were the most used farm machinery ever since its distribution started in Bhutan 1984 (Thinley et al. 2011). The use of power tillers can till almost four times more area coverage than by ploughing with animal power. While many other farm machineries and tools were used in paddy and other crops, potato production relied only on power tillers mostly for land preparation in Bhutan. As in the case of Bangladesh (Sarker and Barton 2006) and other South Asian countries (Aryal et al. 2021), use of power tillers immensely benefited farmers in reduction of cost of production and agricultural productivity including potato production. However, the efficiency ratio machinery in the form of power tiller (0.01) indicated slightly over utilisation in the study area due to the inadequate supply of power tillers (Tobgay 2016), and thus, many farmers have to rely on hired power tillers from state owned enterprise and private owners. The potato farmers in the study area depended mostly on hire of power tillers from their neighbours. The farmers reported that, in certain cases, the hire charges include the actual working hours in the field and the transportation time of power tiller to and from the actual working field. Secondly, due to rugged terrain, the field sizes are small and the efficiency of power tillers are not efficient as they used to be in bigger fields (Tobgay 2006). Thirdly, the average area under potato cultivation is minimal compared to the total average landholding per household. Therefore, the farmers should increase the area under potato cultivation and use of seeds to get optimum resource efficiency from FYM, labour, and machinery usage.

CONCLUSION AND RECOMMENDATIONS

This study provides an analysis of economics of production and resource use efficiency of organic potato cultivation in Bhutan. The area under cultivation has significant influence on the overall productivity of organic potato. Farmers underutilised area for cultivation and seeds in organic potato production resulting in higher expenses on resources such as machinery, FYM, and labour. Investing more in land under cultivation and obtaining adequate seed would improve the inefficient use of FYM, labour, and machinery used in organic potato production and would lead to maximum economic benefit from the production. Due to time and resource constraints, the current study could only cover organic potato production in the study area. Further research on the other vegetables grown by the farmers in the study would give a clearer picture of the resource allocation and farming efficiency.

It is recommended that policies be directed to improve availability and accessibility of adequate high-quality seeds, either for free or subsidised, to obtain higher returns. Such actions from the government would resolve the problem of overutilization of machinery, FYM, and labour in organic potato production and enhance economic returns from production. In addition, the government should

increase subsidies in organic agriculture to encourage more farmers to adopt organic farming to enhance national food security.

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