APPRAISAL OF FARM MECHANIZATION AND FARMER'S FIELD PRACTICE OF MAIZE FARMING AT LAMAHI MUNICIPALITY, DANG, NEPAL

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ABSTRACT

The study compares farm mechanization and farmer's field practice to document the agronomic and economic feasibility of mechanized maize farming. The research was carried out in randomized complete block design with 2 treatments of mechanized practice and farmers practice and 3 replications as location for the winter maize using 10v10 hybrid variety. In agronomic aspect, seed rate and urea application in farmers practice (17.05 kg ha-1 and 186.41 kg ha-1 respectively) were found lower to mechanized practice (30.00 kg ha-1 and 348.00 kg ha-1 respectively). Consequently, lower yield was found in farmers practice (7.56 t ha-1) to mechanized practice (10.43 t ha-1) which was attributed by lower plant population, higher sterility, and smaller cob diameter in farmers' practice. The benefit cost ratio was higher in mechanized practice (3.76) to farmer's practice (2.44). Labour shortage can be mitigated by mechanization through the custom hiring center even in small holder maize growers.

1. INTRODUCTION

Maize (*Zea mays* L.) contributes 28.27% of total cereal's area and 26.96% of total cereal's production in Nepal (MoALD, 2021). In addition to being used as food, there is a growing demand for maize for livestock and poultry feed, as well as for biofuel and starch production (Bhujel & Thakur, 2015). The domestic annual production of the maize is 3.00 million tons (MoALD, 2021) whereas the estimated domestic requirement of maize by accounting for both feed (1.5 million tons) and human consumption (2.9 million tons) is 4.4 million tons (Timsina *et al*., 2016; KC *et al*., 2015).As a result, Nepal imports a significant amount of maize from other countries. To address the demand, winter maize is being promoted under the rice-wheat system in Nepal, with a focus on increasing quality seed, recommended application of farm inputs, farm mechanization, technology adaptation, and improved post-harvest practices. Winter maize produces both qualitative and quantitative grain yield due to low incidence of diseases and pests, and higher carbohydrate production per day per unit land in winter (KC *et al*., 2015). Although many farmers in the Dang region practices winter maize farming, the inadequate input application and labour-intensive production practices compounded with labour shortage and high wage rates has increased the cost of cultivation and thereby, affecting the profitability of maize farming (Dhital, 2017; Bhandari *et al*., 2015; Dawadi and Sah, 2012). The Prime Minister Agriculture Modernization Project (PMAMP) aims to promote commercialization and mechanization of maize farming in Dang, by making Dang region a center for maize production and linking it to industrialization with potential end markets for maize and maize products (MOAD, 2016). One of its interventions is through promoting the mechanization practices in the region. Mechanization can increase the efficiency of farm inputs, alleviate labor shortages, increase productivity and production of maize, and narrow the yield gap and demand deficit (Rijk, 1989). Documenting the agronomic and economic feasibility of mechanized farming will encourage farmers to appreciate the benefits of farm mechanization and motivate them to participate in Custom Hiring Center's activities.

2. MATERIALS AND METHODS

2.1 Selection of study area

The site of the research was Dang district which lies in Lumbini province of Nepal. The selected locations were Satbariya, Sonpur and Keruniya of the Lamahi municipality. The reason for selecting these places is the existence of PMAMP field office in the Lamahi municipality and the collaboration of the farmer's groups with PMAMP. The research was commenced on 31st October 2017 and concluded on 29th May 2018 on 10v10 Indian hybrid maize variety.

2.2 Sample and sampling technique

The research was carried out in randomized complete block design with Two treatments viz: mechanized practice and farmers' field practice and with Three replications as location (Satbariya, Sonpur and Keruniya). The mechanized practice involved implementing all PMAMP recommended agronomic management practice using machines, except for harvesting due to unavailability of maize harvesting machine in the study area. On the other hand, the prevailing farmer's practice represents the blend of different agronomic management practices employed by different farmers in the study area, with limited mechanization particularly during land preparation.

Since, uniform agronomic management practice was trialed in the mechanized practice location while, there were heterogeneity in the same for prevailing farmer's practice, only Three samples for mechanized practice and Thirteen samples for prevailing farmer's practice in regard to agronomic management practices and the cost of cultivation data were taken through pre-tested interview schedule. The Three samples were collected from Three different locations for the mechanized practice, while Four samples each from Satbariya and Sonpur, and Five samples from Keruniya were taken for the prevailing farmer's practice.

To collect yield attribute data, the Three mechanized practice field samples were outlined into a total of Thirteen harvest plots. Among these, Four harvest plots were outlined each in Satbariya and Sonpur while, Five harvest plots were in Keruniya, from where 10 dehusked maize were selected from each individual plot (10 m^2). Likewise, each of the Thirteen prevailing farmer's practice field samples were further outlined into Three harvest plots of 10 m^2 each. A total of 10 dehusked maize were selected from combined Three harvest plots. Thus,130 cob samples from each two set of treatments were taken.

2.3 Types and time of data collection

Agronomic practices and the cost of cultivation data for land preparation, seed and sowing, intercultural operations including irrigation, fertilizer, pesticide and harvesting; its frequencies, time duration and cost per unit were recorded at respective periods.

Yield attribute data on plant population, cob bearing plant population, total cob number, total cob weight, selected individual cob weight, cob length, grain length, mid-diameter of cob, row-line, number of grains, weight of grains and their moisture percentage were recorded at the time of harvest.

2.4 Statistical Analysis

The data gathered were coded, analyzed, and tabulated through Excel (version 15.0) and SPSS (version 20.0). Graphs, tables, and charts were used to interpret the results.

3. RESULTS AND DISCUSSION

3.1 Agronomic management practice

A shown in Table 1, the seed rate of mechanized practice was higher (30 kg ha-1) than farmers practice (17.05 kg ha-1) and was found significantly different at 0.1% level of significance. This was chiefly due to the difference in seed sowing practice. The farmers mostly sow the seed by using wooden plough or by using rope and hoe to carve the line where seed is sown by using hand, which results in lower application of seed compared to tractor operated eight row seed cum fertilizer drill. The date of weeding of mechanized practice was 33.33 days after sowing (DAS) which was higher than farmers practice (27.33 DAS) but was found statistically non-significant. The date of thinning of mechanized practice was higher (30.00 DAS) than farmers practice (21.25 DAS) and was found statistically non-significant. Earthing up was practiced only in mechanized practice at 33.33 DAS because farmers in the region did not perceive it to be beneficial. The total number of irrigations was higher in farmers practice (3.92) than mechanized practice (3) but was found statistically non-significant. Similarly, among the fertilizer application, only urea rate was found significantly different at 5% level of significance with mechanized practice applying higher (348.00 kg ha-1) than farmers practice (186.41 kg ha-1). While DAP and MOP both were found higher in mechanized practice i.e., 130.50 kg ha-1 and 66.00 kg ha-1 respectively than farmers practice i.e., 112.25 kg ha-1 and 25.61 kg ha-1 respectively but was found statistically non-significant in both cases. The low dosage of fertilizer in farmers practice was due to inadequate knowledge to farmers about recommended dose and lack of availability of sufficient fertilizer to the farmers. The number of nitrogen split was higher in mechanized practice (3.00) than farmers practice (2.25) but was statistically non-significant. The physiological maturity of mechanized practice was lower (172.66 DAS) than farmers practice (177.33 DAS) and was statistically non-significant.

Table 1. Agronomic management practices of sample plots of maize Superzone area of Lamahi, Dang, 2018

SN	Agronomic management practices	Farmers practice	Mechanized practice	t value
1	Seed rate (kg ha^{-1})	17.05±1.37	30±0.00	4.59***
2	Weeding (DAS)	27.33±2.84	33.33±3.33	0.99
3	Thinning (DAS)	21.25±3.15	30.00±8.66	1.07
4	Earthing up (DAS)	N/A	33.33±3.33	
5	Total number of irrigations	3.92±0.45	3.00±0.00	-0.99
6	Fertilizer application			
	Urea rate (kg ha^{-1})	186.41±31.12	348.00±0.00	2.52*
	DAP (kg ha^{-1})	112.25±21.13	130.50±0.00	0.42
	MOP (kg ha^{-1})	25.61±9.99	66.00±0.00	1.96
	Number of Nitrogen split	2.25±0.22	3.00±0.00	1.67
7	Physiological maturity (DAS)	177.33±4.23	172.66±4.66	-0.52

*** indicates significance difference at 0.1 percent level; * indicates significance difference at 5 percent level, N/A indicates non-availability, and value after ± indicates standard error of mean

The fertilizer dose comparison is also illustrated in Figure 1.

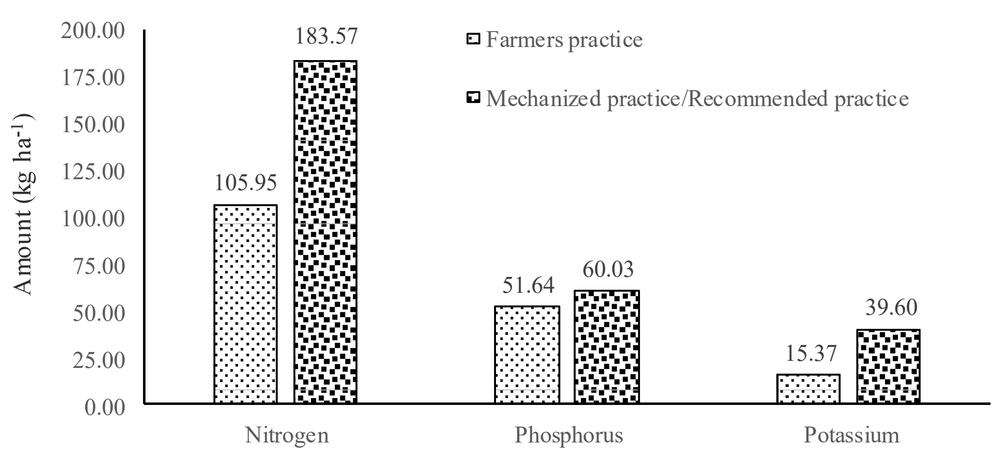

Figure 1. NPK comparison of mechanized and farmers' practice

The application of nitrogen, phosphorus and potassium in farmers practice was 105.95 kg ha-1, 51.64 kg ha-1 and 15.37 kg ha-1 respectively while in mechanized practice was 183.57 kg ha-1, 60.03 kg ha-1 and 39.60 kg ha-1 respectively. The fertilizer application in mechanized practice is also the recommended practice. Thus, above figure 1 shows comparable difference in nitrogen and potassium application between these two practices.

3.2 Yield Attributes

As shown in Table 2, the average plant population per individual plot (10 m2) was higher in mechanized practice (70.18) than farmers practice (53.70) and was found significantly different at 5% level of significance. This was due to the difference in seed rate and plant spacing of farmers and mechanized practice. Though the average number of cob bearing plants per 10 m2 was higher in mechanized (65.53) than farmers practice (50.85) but it was statistically non-significant. The average cob length was higher in mechanized (16.32 cm) than farmers practice (16.16 cm) and was statistically non-significant. Similarly, average sterility was found higher in farmers (6.79%) than mechanized practice (3.83%) and was found significantly different at 5% level of significance. One of the possibility of higher sterility in farmers practice was due to lower application of Nitrogen to the maize (Marahatta, 2020). The average cob diameter was found higher in mechanized (4.78 cm) than farmer practice (4.66 cm) and was found significantly different at 5% level of significance. This was due to the difference in urea application of farmers practice and mechanized practice. The average number of kernel row per cob was found higher in mechanized (15.64) than farmers practice (14.94) but was statistically non-significant. The average number of kernels per kernel row was higher in mechanized (28.52) than farmers practice (27.44) and was found statistically non-significant. The average thousand kernels weight was found higher in mechanized practice (388.83) than farmers practice (370.25) but was statistically non-significant. Lastly the average yield was found higher in mechanized (10427.62 kg ha-1) than farmers practice (7563.75 kg ha-1) resulting in yield difference of 27.46% and was found significantly different at 1% level of significance. The difference in yield was due to variance in yield attribute which was in turn affected by agronomic practices especially seed rate and urea application which were found significantly different in between farmers practice and mechanized practice. A similar study in winter maize cv rampur composite reveals the similar effect of cropping density and nitrogen at 55,555 ha-1 with 100 Kg N ha-1 and 66.666 ha-1 with 200 kg N ha-1 on yield is increment by 33.98% in later (Shrestha, 2014).A similar study on hybrid maize cv Dijamant 6 reveals the effect of crop density at 51,020 ha-1 and 71,429 ha-1 on yield is increment by 11.35% in later (Mandic *et al*., 2015).

Table 2. Average yield Attributes and yield influenced of sample plots in maize Superzone area of Lamahi, Dang, 2018

SN	Average yield attributes and yield	Farmers practice	Mechanized practice	t value
1	Plant population per 10 m2	53.70±4.65	70.18±5.09	2.39*
2	Number of cob bearing plants per 10 m2	50.85±5.36	65.53±5.74	1.869
3	Cob length (cm)	16.16±0.05	16.32±0.49	0.318
4	Sterility (%)	6.79±0.57	3.83±0.88	-2.831*
5	Cob diameter (cm)	4.66±0.04	4.78±0.03	2.651*
6	Number of Kernel row per cob	14.94±0.28	15.64±0.72	0.897
7	Number of kernels per kernel row	27.44±0.12	28.52±0.65	1.621
8	Thousand kernels weight (g)	370.25±5.33	388.83±22.66	0.798
9	Yield (kg ha-1)	7563.75±436.73	10427.62±537.57	3.6**

** indicates significance difference at 1 percent level; * indicates significance difference at 5 percent level, and value after ± indicates standard error of mean

3.3 Cost of Inputs

For each ha of land as shown in Table 3, the cost of rotavator was higher in farmers practice (NPR 5,310.00) than mechanized practice (NPR 3,391.67) but was statistically non-significant. Similarly, cultivator cost was more in farmers practice (NPR 4,347.43) than mechanized practice (NPR 2,366.67) and was statistically non-significant. The price dissimilarity was due to frequency of tillage by machine. In farmers practice who used machine, majority used either rotavator or cultivator and when used alone, they tilled the soil twice therefore individual cost of operating rotavator and cultivator were higher while in mechanized practice, one till of rotavator was followed by single till by cultivator. The use of power tiller and draft during land preparation was limited to only farmers practice with the cost of NPR 10,183.73 and NPR 15,000.00 respectively. Thus, the overall land preparation cost for ha of land was found out to be higher in farmers practice (NPR 9,677.57) than mechanized practice (NPR 5,758.33) but was statistically non-significant. The cost of seed of mechanized practice was found higher (NPR 14,000.00) than farmers practice (NPR 8,365.16) and was found significantly different at 1% level of significance. This was due to a higher seed rate in mechanized practice (30.00 kg ha^{-1}) than farmers practice (17.05 kg ha^{-1}). For seeding equipment aspect, the mechanized practice used Seed cum fertilizer drill which cost NPR 2,173.34 during seed sowing operation while almost all did not use any machine, Jab planter was found in one case of farmers practice cost NPR 100.00. During intercultural operation, the mechanized practice used mini tiller which cost NPR 1,833.34 while in the farmers practice no machinery cost was incurred. During irrigation, cost was found to be higher in farmers practice (NPR 4,071.75) than mechanized practice (NPR 3,150.00) but was statistically non-significant. Similarly, among the fertilizer, urea cost in mechanized practice was found higher (NPR 5,939.20) than farmers practice (NPR 3,284.42) and was found significantly different at 5% level of significance. While DAP and MOP cost was found to be higher in mechanized practice i.e., NPR 6,194.40 and NPR 2,244.00 respectively than farmers practice i.e., NPR 5,283.98 and NPR 746.04 respectively but was statistically non-significant. The dissimilarity of cost of fertilizer was due to difference in fertilizer dose between these practices. Also, the pesticide cost in mechanized practice was higher (NPR 862.50) than farmers practice (NPR 266.67) because of difference in product.

Table 3. Cost of inputs (NPR Per ha) of sample plots in maize production in Superzone area of Lamahi, Dang, 2018

SN	Inputs	Farmers practice	Mechanized practice	t value
1	Land Preparation	9677.57±1398.62	5758.33±1025.14	-1.35
	Rotavator	5310.00±763.39	3391.67±559.08	-1.532
	Cultivator	4347.43±1784.15	2366.67±491.03	-1.07
	Power Tiller	10183.73±2458.84	N/A	
	Draft	15000.00±0.00	N/A	
2	Seed	8365.16±948.89	14000.00±1000.00	2.817**
3	Seed equipment	100.00±0.00	2173.34±261.73	
	Seed drill cum fertilizer	N/A	2173.34±261.73	
	Jab Planter	100.00±0.00	N/A	
4	Intercultural			
	mini tiller	N/A	1833.34±440.96	
5	Irrigation	4071.75±900.43	3150.00±1441.35	-0.471
6	Fertilizer	9314.46±1453.17	14377.60±112.91	1.69
	Urea	3284.42±523.75	5939.20±23.20	2.46*
	Diammonium phosphate	5283.98±985.54	6194.40±96.88	0.45
	Murate of Potash	746.06±351.34	2244.00±0.00	2.07
7	Pesticide	266.67±68.87	862.50±337.50	2.94*
	Total Cost of Inputs	31570.62±2366.80	41867.60±1366.24	

** indicates significance difference at 1 percent level; * indicates significance difference at 5 percent level, N/A indicates non-availability, and value after ± indicates standard error of mean

3.4 Cost of Labour

For each ha of land as shown in Table 4, the cost of labour during seed sowing in farmers practice was NPR 5,371.28 compared to sample plot in mechanized practice where no labour was used financially, because seed cum fertilizer drill where labour wage of operators are inclusive in hiring charge with significant difference at 0.1% level of significance. Also, the cost of labour during intercultural operation in farmers practice was higher (NPR 11,461.27) than mechanized practice (NPR 433.33) and was found significantly different at 1% level of significance. This is because in farmers practice, manual hoe was used for weeding while in mechanized mini tiller was used whose hourly charge is inclusive of labour wage of operator. However, the cost attributed in mechanized field was due to manual thinning operation. The cost of labour during irrigation aspect was more in farmers practice (NPR 4,493.05) than mechanized practice (NPR 3,600.00) but was statistically non-significant. While in the pesticide aspect the cost of labour were equal i.e., NPR 800.00 attributing to same practice employed in both practices. The cost of labour for harvesting aspect was higher in mechanized practice (NPR 9,200.00) than farmers practice (NPR 8,819.85) and was statistically non-significant.

Table 4. Cost of labour (NPR per ha) of sample plots in maize production in Superzone area of Lamahi, Dang, 2018

SN	Inputs	Farmers practice	Mechanized practice	t value
1	Seed sowing aspect	5371.28±641.96	0.00±0.00	-4.07***
2	Intercultural aspect	11461.27±1386.17	433.33±16.67	-3.87**
	Thinning	N/A	433.33±16.67	
	Weeding	11461.27±1386.17	N/A	
3	Irrigation aspect	4493.05±676.90	3600.00±0.00	-0.64
4	Pesticide aspect	800.00±0.00	800.00±0.00	
5	Harvesting aspect	8819.85±674.62	9200.00±200.00	0.273
	Total cost of labour	30878.80±1411.43	14566.67±420.65	

*** indicates significance difference at 0.1 percent level; ** indicates significance difference at 1 percent level, N/A indicates non-availability, and value after ± indicates standard error of mean

3.5 Economic Analysis

The economics of crop production shown in Table 5, the cost of cultivation of farmer practice was higher (NPR 62,449.42) than mechanized practice (NPR 56,434.27) which were not found significantly different. And the gross return of mechanized practice was higher (NPR 211,137.40) than farmer practice (NPR 151,274.95) but the difference was not statistically significant. But the Net return of mechanized practice was higher (NPR 154,703.13) than farmer practice (NPR 88,825.53) at the current market price of NPR 20 kg^{-1} maize grain and was found significantly different at 5% level of significance. Similarly, the benefit-cost ratio (B:C ratio) of mechanized practice was higher (3.76) than farmer practice (2.44) and was found significantly different at 5% level of significance. Cost of cultivation was not found significant due to fact that in mechanized practice, absence of harvesting machine led to increase cost of cultivation through use of labour instead and in farmer practice, low amount of seed and urea by 43.17% and 46.4% respectively lead to low cost of cultivation in farmer practice of seed aspect by 40.2% and urea by 44.7%. This, however, in farmer practice led to a yield gap of 27.46%. This resulted in a significant difference in net return and B:C ratio.

A study conducted in Pakistan determined that in mechanized practice, the total production cost for maize was PKR 16,805.0 ha^{-1} (NPR 17,813.3 ha^{-1}) which gave the gross income of PKR 31,025.0 ha^{-1} (NPR 32,886.5 ha^{-1}) and yielded net profit of PKR 14,220.0 ha^{-1} (NPR 15,073.2 ha^{-1}) with B:C ratio of 1.84. For the traditional farms, cost of production was PKR 16,450.0 ha^{-1} (NPR 17,537.0 ha^{-1}) which gave the gross income of PKR 24,555.0 ha^{-1} (NPR 26,028.3 ha^{-1}) and yielded net profit of PKR 8,105.0 ha^{-1} (NPR 8,591.3 ha^{-1}) with B:C ratio of 1.49 (Aurangzeb, Nigar, & Shah, 2007).

Table 5. Economics of crop production per hector of sample plots in maize production in Superzone area of Lamahi, Dang, 2018

SN	Economic variables	Farmers practice	Mechanized practice	t value
1	Cost of cultivation (NPR ha^{-1})	62449.42±2970.32	56434.27±1424.44	-0.98
2	Gross return (NPR ha^{-1})	151274.95±14776.92	211137.40±17465.10	1.91
3	Net return (NPR ha^{-1})	88825.53±14093.52	154703.13±18884.44	2.19*
4	B:C ratio	2.44±0.24	3.76±0.40	2.58*

* indicates significance difference at 5 percent level, and value after ± indicates standard error of mean

The cost of maize farming across various stages is illustrated in Figure 2.

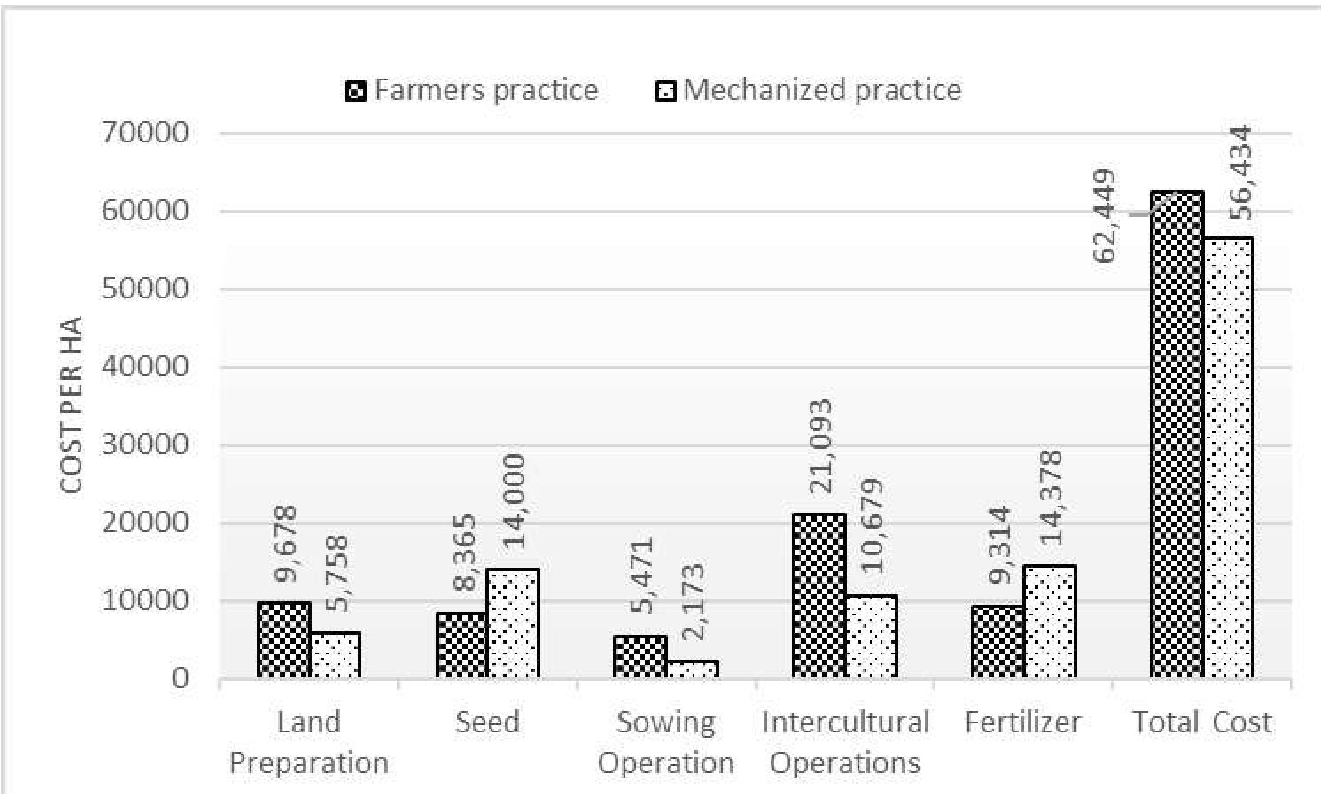

Figure 2. Comparison of cost of maize farming across mechanized and farmers' practice

Aside from the cost of inputs which is seed and fertilizer, which has been underused in farmer's practice, the cost related to operations can be clearly seen under the scope of reducing in farmer's practice. During land preparation, instead of using machinery such as power tiller or standalone rotavator and cultivator, concurrent use of rotavator and cultivator has the scope of reducing the cost. Likewise, during sowing operation, the use of tractor operated seed cum fertilizer drill is strongly advised to reduce the cost in the study area. Mini tiller, instead of manual labour, would reduce cost by more than half during the intercultural operation. The use of recommended machinery and the agronomic practice is an ideal way to reduce costs as well as increase yield in the study area.

3.6 Socio-economic aspects of mechanization

There can be inference regarding socioeconomic demerits of mechanization like in short run due to farm labour replacement, but it is crucial to recognize that mechanization also creates new employment opportunities in the form of skilled labour, machineries operation, maintenance, repair, and technology support. As agriculture becomes more mechanized, there is scope of skilled labour to operate and maintain complex machinery. This presents an opportunity for skill development programmes and vocational training initiatives. Likewise, adoption of farm mechanization leads to higher agricultural output and surplus production. This surplus can be directed towards value-added processing, agribusiness ventures, and export markets, stimulating economic growth and creating opportunities for all associated agribusiness actors. The revenue can be redirected towards the local economy to support essential services. Similarly, by reducing physical labour and opportunity cost of spending less time on field, mechanization has potential to improve the living conditions of the farmers by allowing them to focus on other important activities such as crop management, marketing, and planning. Also, in the context of higher out-migration of men and increased participation of women in farm activities, mechanization reduces physical demand of farming tasks thereby, contributing towards gender inclusivity and empowerment in agriculture. Thus, by investing in skill development, promoting economic diversification, and improving living conditions, the adoption of mechanization can contribute to overall socioeconomic progress. However, it is crucial to ensure that appropriate policies and support mechanisms are in place to mitigate the potential negative effects and facilitate a smooth transition for workers and communities.

4. CONCLUSION

The study shows that not only the yield was found to be lower in the farmer's sample field but also the cost of cultivation was found to be higher too. This concludes PMAMP should disseminate information on recommended seed rate and fertilizer application practices to farmers for increasing the yield. The cost of cultivation can be reduced by minimizing the cost of labour through adopting recommended mechanization. Thus, the problem of labor unavailability and higher wage can be mitigated through mechanization in maize cultivation along with effectively reducing the time spent on field. Thus, it will be beneficial for farmers to hire the machines for cultivation through Custom hiring center (CHC) for higher economic return even in small holder maize growers.

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