RESEARCH PAPER

Conservation agriculture responses to productivity and profitability of mungbean under maize based cropping system in far western region of Nepal

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Key Message: This research evaluates responses of conservation agriculture on productivity and profitability of mungbean under maize based cropping system in far western Nepal.

ABSTRACT: The crop productivity of far western mid hills and river basin region is lower than that of the other regions of Nepal. The existing cultivation practices of this research area are conventional tillage with animal driven ploughing and crop residues removal practices. Low crop productivity results from poor crop management, low soil fertility and climatic variation. Conservation agriculture has been found as an effective crop management practice to rejuvenate soil fertility and increase crop yield. This research was conducted at the research field of Regional Agricultural Research Station, Bhagetada, Dipayal, Doti, Nepal during 2015-2016 with the objective of identifying suitable cereal based crop management practice for high crop productivity and profitability. It was carried out in split-split plot design with four replications at the plot size of 18 m^2 area. The results revealed that the interaction of maize-lentil-mungbean cropping system, conservation agriculture and Kalyan variety of mungbean produced the grain yield of 15.62% (1.11 t ha^{-1}) which were higher than that of the conventional agriculture practice. The interaction of the same cropping system, conservation agriculture and Kalyan variety produced net benefit of 106.69% (US $ 386.71 ha^{-1}) and benefit to cost (B: C) ratio 46.04% (2.03) which were higher than that of conventional practice. Thus the maize-lentil-mungbean cropping system, conservation agriculture and Kalyan variety of mungbean could be appropriate for the farmers of far western river basin agro-environment of Nepal.

Keywords: Benefit to cost ratio, Conservation agriculture, Cropping system, Grain yield, Mungbean

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INTRODUCTION

Mungbean (*Vigna radiata* L. Wilczek) is a nutritious, short duration (60-70 days) and warm season leguminous crop of the country. It provides 24-28% dietary protein and 59-60% carbohydrate on dry weight basis and one kilogram of mungbean contains about 3400 KJ energy (United States Department of Agriculture [USDA], 2010). Sandhu and Lim (2008) reported that mungbean contains more easily digestible starch than that of other leguminous crops such as chickpea (*Cicer arietinum*), pigeon pea (*Cajanus cajan*) and lentil (*Lens culinaris*). It is considered as an iron rich whole food source for baby food due to its palatable taste and nutritional quality (Imtiaz et al., 2011). It is an important source of protein, carbohydrates and micronutrients for the diet of human beings. Methionine is relatively poor in mungbean but it contains lysine (Shi et al., 2016). It not only provides additional income to the farmers, but also supports in the reduction of farm inputs after cultivation. The cultivation of mungbean between wheat and rice added 33-37 kg nitrogen ha^{-1} for succeeding crops in northern part of India (Sekhon et al., 2007).

The total cultivated area of mungbean is 8265 ha with the total production of 10468 t and average productivity of the country is 1.27 t ha^{-1} but the productivity of mungbean varieties namely Pratikshya and

Kalyan is 0.7 t ha^{-1} (Agricultural Information and Communication Center [AICC], 2015). Out of the total cultivated area of mungbean, more than 75% area is concentrated under irrigated area of eastern and central terai of the country (Shrestha et al., 2011). Neupane and Shrestha (2015) reported that mungbean is being grown under different cropping systems in Nepal such as rice-wheat-mungbean, maize-wheat-mungbean and maize-lentil-mungbean cropping systems.

Mungbean is one of the important leguminous crops having significant contribution to improve soil fertility through symbiotic nitrogen fixation process by its root noodles (Singh & Singh, 2011; Ali & Gupta, 2012). Laik et al. (2014) reported that conservation agriculture could be the best management agriculture for improving cereal based production system in the Eastern Indo-Gangetic Plains of India. When mungbean is introduced into the rotation of maize-wheat cropping system with the adoption of conservation tillage, it could be a viable option for attaining high profit, water and energy use efficiency (Parihar et al., 2017a). Improvement in crop productivity, profitability and nutrient uptake in kharif maize was observed in conservation agriculture based tillage agriculture under maize-wheat-sesbania and maize-wheat-mungbean cropping system experimented in similar agro-climatic condition of north-west region of India (Yadav et al., 2016). Out of the studied conservation agriculture based systems, maize-wheat-mungbean cropping system was the best alternative option for sustainable productivity and natural resources conservation with the improvement of soil quality index by 35% (Choudhary et al., 2018). Integration of mungbean with precise irrigation and conservation agriculture under maize-wheat or rice-wheat cropping system indicated positive effects on water and radiation use efficiency (Parihar et al., 2017b). Hassan et al. (2016) concluded that legumes based cropping system could be the sustainable and cost effective agricultural practices for drylands areas of northern Punjab of Pakistan. Conservation agriculture contributes sustainable agriculture and it can play a significant role in increasing food production and livelihoods of rural people (Panday, 2012).

Far western mid hilly region of the country is normally known as food deficit region due to low yield of the crop. Majority of the farmers residing in this region have small land holdings with low soil fertility. Far western mid hilly region is the drought prone region of the country. People living in arid, semiarid and low lying river basin areas are more vulnerable to the effect of climate change (Olmos, 2001). Nepal is the fourth country of the most vulnerable to the effect of climate change in the world (Siddiqui et al., 2012). Conservation agriculture is a good practice for attaining food security and healthy environment (Food and Agriculture Organization [FAO], 2008a). Conservation agriculture has the potentiality of increasing smallholder's productivity by mitigating the effect of climate change. So, this research was carried out with the objective of improving productivity and profitability of mungbean through conservation agriculture in for far western mid hills of Nepal.

MATERIALS AND METHODS

Experimental site

This experiment was carried out in the research field of Regional Agricultural Research Station (RARS), Bhagetada, Dipayal, Doti in 2015 and 2016. It is located at the latitude of N 29^{0}15'16.4" and longitude of E 80^{0}55'59.3" (Prasai et al., 2016). This research station is situated at the bank of Seti River with the altitude of 546 meters above the sea level and it represents the irrigated river basin agro-environment of far western mid hills of the country. This research was carried out in sandy loam soils.

Climatic observation

The maximum temperature of the experimental site during the cropping period of mungbean was lower in April (34.29 $^{\circ}$C) in 2015 than that of 2016 (36.78 $^{\circ}$C) whereas the maximum temperature of May was higher (39.39 $^{\circ}$C) in 2015 than that of 2016 (35.67 $^{\circ}$C). The minimum temperature was higher (20.12 $^{\circ}$C) in May in 2016 than that of 2015 (19.76 $^{\circ}$C). The total rainfall of 2016 was higher (108.3 mm) than that of the total rainfall of 2015 (24.9 mm) (Fig. 1 and Fig. 2). The total 0.3 mm rainfall was recorded in April, 2016 and irrigation was not available due to disorder of water lifting machine.

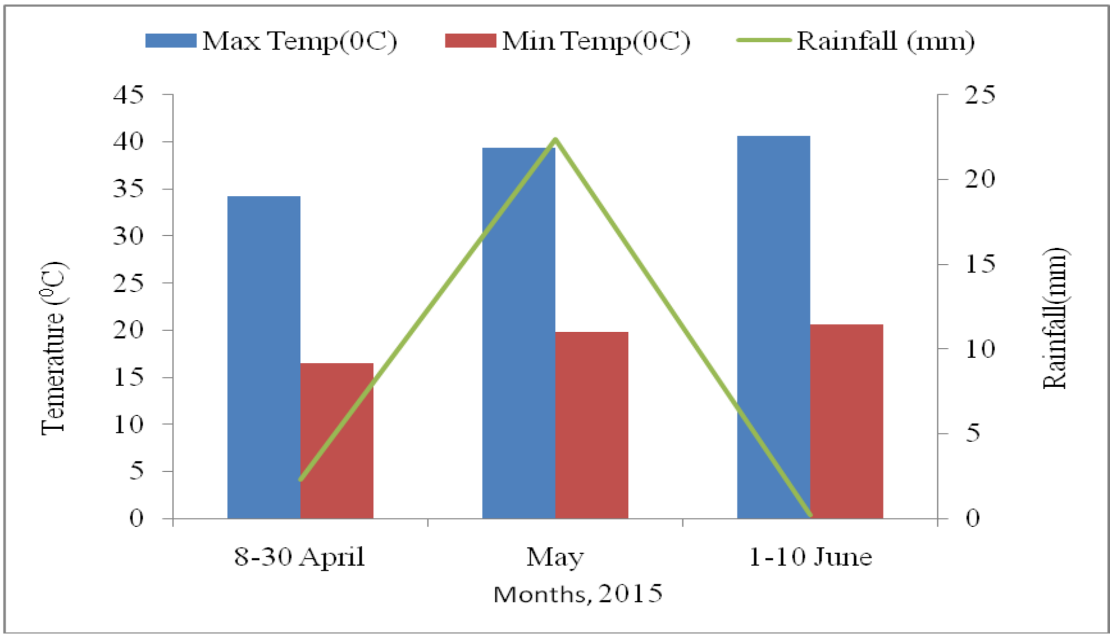

Fig. 1 Temperature and rainfall during mungbean growing period at Dipayal, Doti in 2015

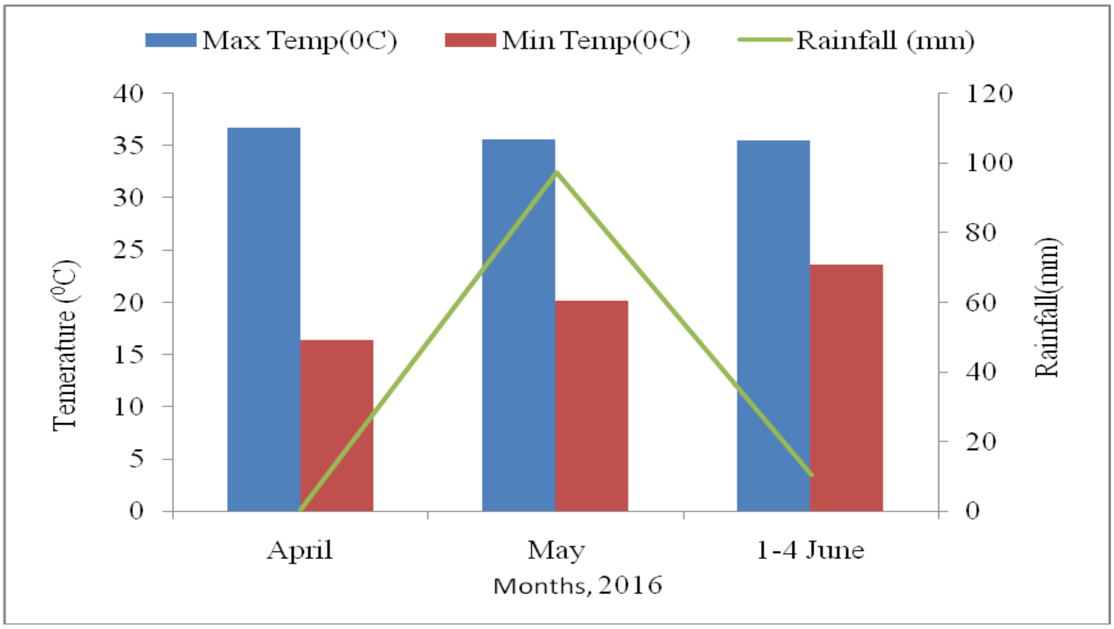

Fig. 2 Temperature and rainfall during mungbean growing period at Dipayal, Doti in 2016

Plant materials

Pratikshya is the variety of mungbean. Its origin is Asian Vegetable Research and Development Center (AVRDC), Taiwan. The year of release of this variety in Nepal is 2006. The pedigree of this variety is VC 6372 (45-8-1). Its yield potential is 0.7 t ha^{-1}. It is commonly recommended for terai to mid hills of Nepal. Similarly, Kalyan is also a variety of mungbean. Its origin is AVRDC, Taiwan. The year of release of this variety in Nepal is 2006. The pedigree of this variety is NM 94. Its yield potential is 0.7 t ha^{-1}. It is commonly recommended for terai to mid hills of Nepal. These two varieties were received from National Grain Legumes Research Program, Khajura, Nepalganj, Nepal.

Crop history of the experimental site

Maize-wheat-fallow cropping system had been adopted in the experimental plots before conducting this conservation agriculture (CA) experiment in the research field of Regional Agricultural Research Station, Dipayal, Doti. The research field was tilled three times by tractor before seeding of each crop and crop residues were removed from the field. The FYM fertilizer was applied at the rate of 5-10 t ha^{-1} depending upon the availability with the neighbouring farmers.

Experimental design, treatments and crop management

The split-split plot design was applied during the layout of the experiment and the experiment was replicated four times. Three factors such as cropping system, cultural practices and variety were applied as main plot, sub plot and sub-sub plot factors, respectively during the randomization of the experiment. Two cropping systems such as maize-wheat-mungbean and maize-lentil-mungbean cropping systems were taken as main plot factor; two cultural practices such as conservation and conventional agriculture were applied as sub plot factor. Similarly, Rajkumar and Arun 2 of maize varieties, Dhaulagiri and WK 1204 varieties of wheat, Shimal and Khajura1 varieties of lentil, and Pratikshya and Kalyan varieties of mungbean were used as sub-sub plot factor. After harvesting of wheat and lentil, and before seeding maize varieties, the mungbean varieties were seeded in the experiment of maize-wheat-mungbean and maize-lentil-mungbean cropping systems. The seed was seeded in 8^{th} April in first year (2015) and 1^{st} April in second year (2016) of the experiment. The Pratikshya and Kalyan varieties were seeded at the rate of 30 kg ha^{-1}. The plot size was of 18 m^2, that is, 6 m length and 3 m width. In conservation agriculture, there was no tillage and residues of the crops were left in the plots whereas conventional experimental plots were tilled and residues of the crops were removed after harvest of each crop. Small furrows were opened with the help of small peg. Farm yard manure and chemical fertilizers were placed into these furrows and were mixed with soil before seeding in the conservation experimental plots. Three times ploughing were done by small hand tractor in the whole plots of the conventional agriculture. The farm yard manure fertilizer was applied at the rate of 5 t ha^{-1} and chemical fertilizers were applied at the rate of 20: 40: 20 NPK kg ha^{-1}. Four rows from each plot were harvested in both cultural practices. The pods of mung were picked up three times from the plants of each conservation and conventional experimental plot. After picking the pods of mungbean, the plants were left in the field of conservation plots whereas the whole plants were cut from the base and were removed from the field of conventional plots. The grain of mungbean was sun dried to maintain the moisture up to 12%. After maintaining the moisture, the grain from each plot was weighted and converted to the yield per hectare.

Grain weight was taken with the help of electronic balance and then converted into kg ha^{-1} using the following formula (Imran et al., 2016):

$$\text{Seed yield (kg ha}^{-1}\text{)} = \frac{\text{Seed weight in four rows}}{\text{R-R distance} \times \text{row length} \times \text{No of rows}} \times 10000$$

Economic analysis

The production cost of mungbean in both maize-wheat-mungbean and maize-lentil-mungbean cropping system was US $ 425.42 ha^{-1} whereas the production cost of conservation agriculture was 24.7% lower (US $ 378.64 ha^{-1}) than that of the production cost of conventional agriculture (US $472.19 ha^{-1}). The production cost of Pratikshya and Kalyan variety of mungbean was US $ 425.42 ha^{-1}. The price of mungbean was determined as per the market price of that time and it was US $ 0.69 kg^{-1}.
The net income was calculated using the formula:
Net income = Gross income – Total cost
Similarly, the cost benefit (B: C) ratio was calculated by the following formula (Bk and Shrestha, 2014):
B: C ratio = Gross income/Total cost
Exchange rate: US $ 1 = NRs.116.52
Date of exchange rate: 25^{th} September, 2018

Statistical analysis

All agronomic data from trials were analyzed by ANOVA using a split split-plot design. The experimental data were processed using Excel 2010 and analyzed by using Genestat software. Least significant difference (LSD $p \leq 0.05$) test was used for mean comparison to identify the significant components of the treatment means (Jan et al., 2009; Sharma et al., 2016). Interaction graph was made using statistical software packages of Minitab ver.17.

RESULTS

EFFECT OF CA ON GRAIN YIELD OF MUNGBEAN

Effect of cropping system on grain yield

The grain yield of mungbean evaluated under maize-wheat-mungbean cropping system was 0.92% higher (1.10 t ha^{-1}) than that of maize-lentil-mungbean cropping system (1.09 t ha^{-1}) in 2015 whereas in 2016, it was 8.7% higher in maize-lentil-mungbean cropping system (1.0 t ha^{-1}) than that of maize-wheat-mungbean cropping system (0.92 t ha^{-1}). The average grain yield of mungbean under maize-lentil-mungbean cropping system was 3% higher (1.04 t ha^{-1}) than that of the average grain yield of maize-wheat-mungbean cropping system (1.01 t ha^{-1}) (Fig. 3).

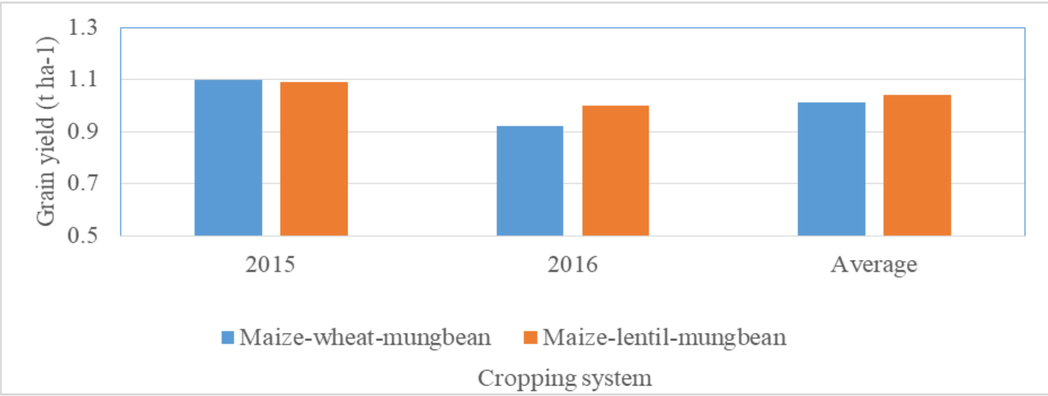

Fig. 3 Effect of cropping system on grain yield of mungbean at CA experiment in 2015-16

Effect of cultural practices on grain yield

The grain yield of mungbean varieties under conservation agriculture was 10% lower (1.04 t ha^{-1}) in 2015 and 15.91% higher (1.02 t ha^{-1}) in 2016 than that of the grain yield of conventional agriculture in 2015 (1.15 t ha^{-1}) and 2016 (0.88 t ha^{-1}). The average grain yield of mungbean under conservation agriculture was 1.98% higher (1.03 t ha^{-1}) than that of the average grain yield of the same varieties tested under conventional agriculture (1.01 t ha^{-1}). Statistically, the difference in grain yield between conservation and conventional agriculture was significant in both of the years (Table 2).

Table 2 Effect of cultural practices on grain yield of mungbean at CA experiment in Bhagetada, Dipayal, Doti during 2015-2016

Cultural practices	Grain yield (t ha^{-1})		
	2015	2016	Mean
Conservation agriculture (CA)	1.04	1.02	1.03
Conventional agriculture (ConvA)	1.15	0.88	1.01
Mean	1.09	0.95	1.02
F test	**	**	ns
LSD (0.05)	0.071	0.076	

Effect of varieties on grain yield

The grain yield of Pratikshya variety was 2.78% higher in 2015 (1.11 t ha^{-1}) and 4.08% lower in 2016 (0.94 t ha^{-1}), respectively than that of the grain yield of Kalyan variety in 2015 (1.08 t ha^{-1}) and 2016 (0.98 t ha^{-1}). The average grain yield of Kalyan was 0.98% higher (1.03 t ha^{-1}) than that of the mean grain yield of Pratikshya (1.02 t ha^{-1}) (Fig. 4).

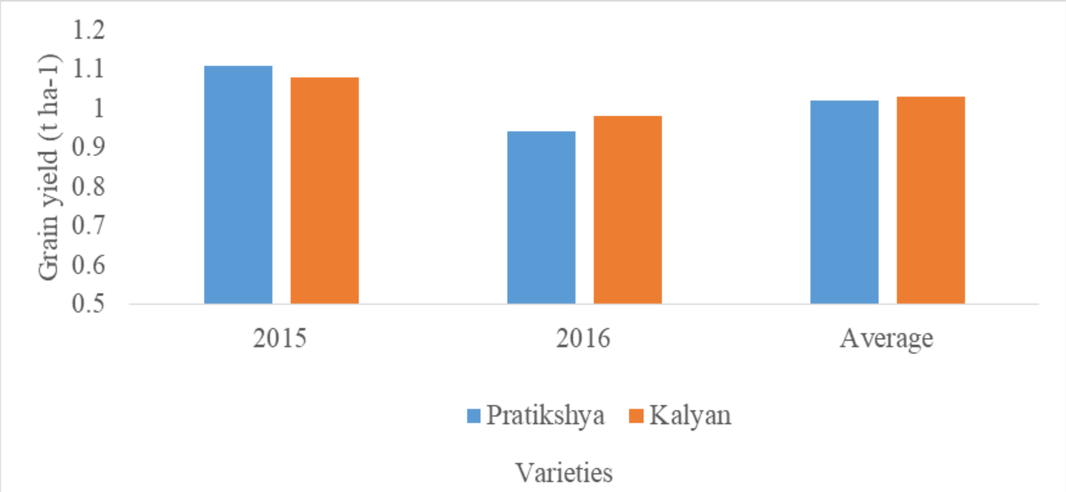

Fig. 4 Effect of varieties of mungbean on grain yield at CA experiment in 2015-2016

Interaction effect of cropping system and cultural practices on grain yield

The grain yield produced from the interaction effect of maize-wheat-mungbean cropping system and conservation agriculture was 15.96% lower (1.0 t ha^{-1}) than that of the grain yield produced from the interaction effect of the same cropping system and conventional agriculture in 2015 (1.19 t ha^{-1}). But the grain yield produced from the interaction effect of maize-wheat-mungbean cropping system, and conservation and conventional agriculture was at par in 2016 (0.96 t ha^{-1}). The average grain yield produced from the interaction effect of maize-wheat-mungbean cropping system and conservation agriculture was 8.57% lower (0.96 t ha^{-1}) than that of the average grain yield produced from the interaction effect of the same cropping system and conventional agriculture (1.06 t ha^{-1}). Similarly, interaction effect of maize-lentil-mungbean cropping system and conservation agriculture produced 7.89% lower and 35.29% higher grain yield in 2015 (1.05 t ha^{-1}) and 2016 (1.15 t ha^{-1}), respectively than that of the grain yield produced from the interaction effect of the same cropping system and conventional agriculture in 2015 (1.14 t ha^{-1}) and 2016 (0.85 t ha^{-1}). The average grain yield produced from the interaction effect of maize-lentil-mungbean cropping system and conservation agriculture was 11.11% higher (1.1 t ha^{-1}) than that of the average grain yield produced from the interaction effect of the same cropping system and conventional agriculture (0.99 t ha^{-1}). The difference in grain yield obtained from the interaction of cropping systems and cultural practices was significant in 2016 and over year analysis (Table 3).

Table 3 Interaction effect of cropping system and cultural practices on grain yield of mungbean at CA experiment in Bhagetada, Dipayal, Doti during 2015-2016

Cropping system	Cultural practices					
	Grain yield of mungbean (t ha^{-1})					
	Conservation agriculture			Conventional agriculture		
	2015	2016	Mean	2015	2016	Mean
Maize-wheat-mungbean	1.00	0.93	0.96	1.19	0.91	1.05
Maize-lentil-mungbean	1.05	1.15	1.10	1.14	0.85	0.99
Mean	1.02	1.04	1.03	1.16	0.88	1.02
F test	ns	**	**			
CV%	5.3	6.4	8.3			
LSD (0.05)		0.158	0.075			

Interaction effect of cropping systems and varieties on grain yield

The grain yield produced from the interaction effect of maize-wheat-mungbean cropping system and Pratikshya variety was 2.70% lower (1.08 t ha^{-1}) than that of the grain yield produced from the interaction effect of the same cropping system and Kalyan variety in 2015 (1.11 t ha^{-1}). The grain yield produced from the interaction effect of maize-wheat-mungbean cropping system and Pratikshya and Kalyan varieties was at par (0.92 t ha^{-1}) in 2016. The average grain yield produced from the interaction effect of maize-wheat-mungbean and Pratikshya variety was 0.99% lower (1.0 t ha^{-1}) than that of the average grain yield produced from the interaction effect of the same cropping system and Kalyan variety (1.01 t ha^{-1}). Interaction effect of maize-lentil-mungbean cropping system and Pratikshya variety produced 10.58% higher and 5.82% lower grain yield in 2015 (1.15 t ha^{-1}) and 2016 (0.97 t ha^{-1}), respectively than that of the grain yield produced from the interaction effect of the same cropping system and Kalyan variety in 2015 (1.04 t ha^{-1}) and 2016 (1.03 t ha^{-1}). The average grain yield produced from the interaction effect of maize-lentil-mungbean cropping system and Pratikshya variety was 2.91% higher (1.06 t ha^{-1}) than that of the average grain yield produced from the interaction effect of the same cropping system and Kalyan variety (1.03 t ha^{-1}) (Fig. 5).

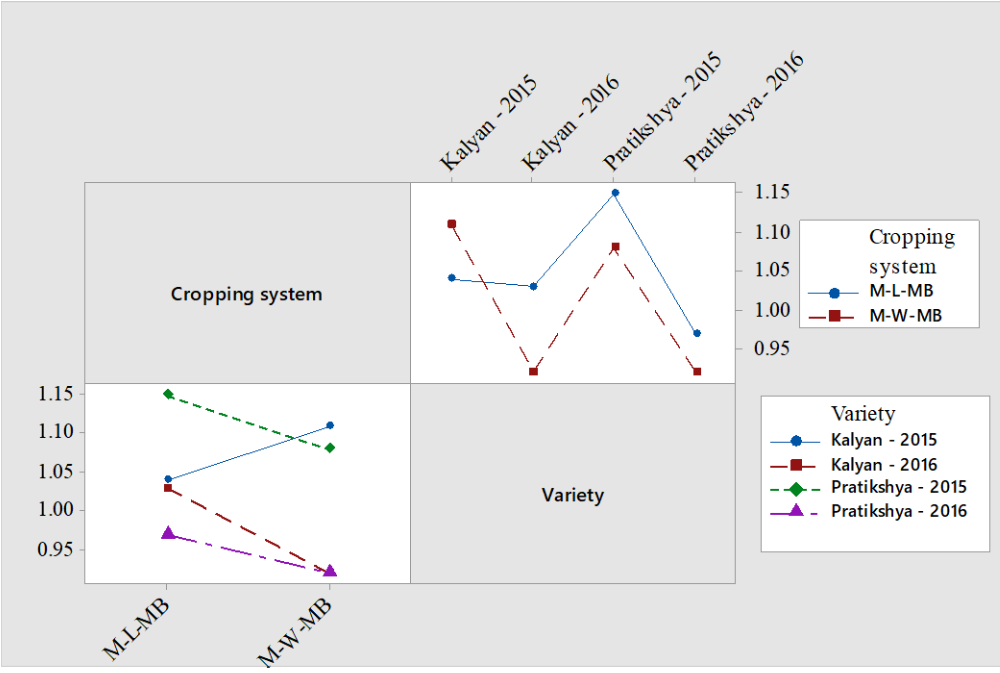

Fig. 5 Interaction effect of cropping system and mungbean varieties on grain yield (t ha^{-1}) of mungbean at CA experiment in 2015-2016

Interaction effect of cultural practices and varieties

Interaction effect of conservation agriculture and Pratikshya variety produced 14.88% lower and 22.35% higher grain yield in 2015 (1.02 t ha^{-1}) and 2016 (1.04 t ha^{-1}), respectively than that of the grain yield produced from the interaction effect of conventional agriculture and Pratikshya variety in 2015 (1.21 t ha^{-1}) and 2016 (0.85 t ha^{-1}). The average grain yield produced from the interaction effect of conservation and conventional agriculture and Pratikshya variety was at par (1.03 t ha^{-1}). Similarly, the grain yield produced from the interaction effect of conservation agriculture and Kalyan variety was 6.31% lower and 12.09% higher in 2015 (1.04 t ha^{-1}) and 2016 (1.02 t ha^{-1}), respectively than that of the grain yield produced from the interaction effect of conventional agriculture and Kalyan variety in 2015 (1.11 t ha^{-1}) and 2016 (0.91 t ha^{-1}). The average grain yield produced from the interaction effect of conservation agriculture and Kalyan variety was 1.98% higher (1.03 t ha^{-1}) than that of the average grain yield produced from the interaction effect of conventional agriculture and Kalyan variety (1.01 t ha^{-1}) (Fig. 6).

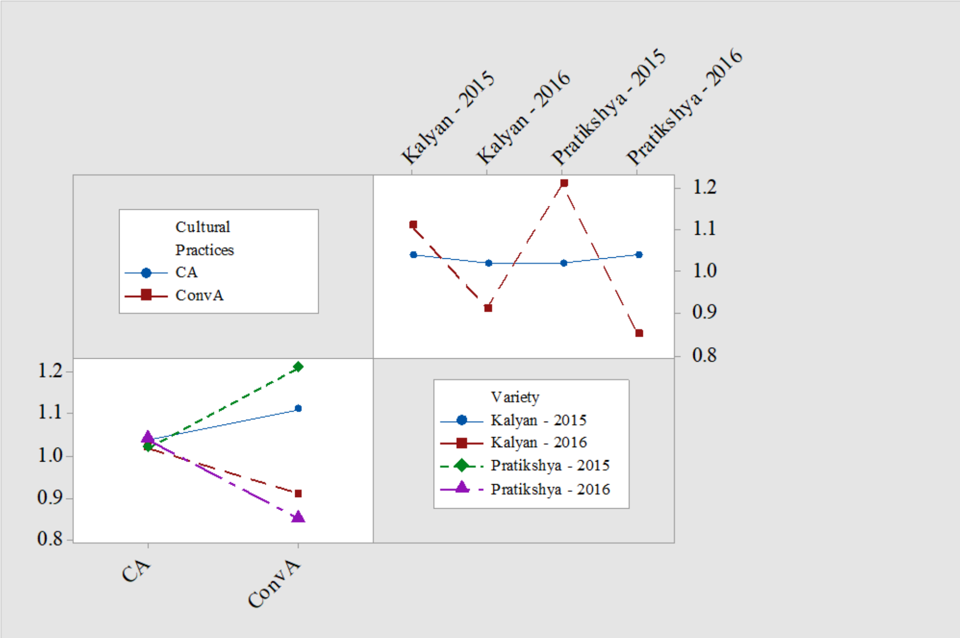

Fig. 6 Interaction effect of cultural practices and mungbean varieties on grain yield (t ha^{-1}) of mungbean at CA experiment in 2015-2016

Interaction effect of cropping systems, cultural practices and varieties on grain yield

Interaction effect of maize-wheat-mungbean cropping system, conservation agriculture and Pratikshya variety produced 17.65% lower and 7.95% higher grain yield in 2015 (0.98 t ha^{-1}) and 2016 (0.95 t ha^{-1}), respectively than that of the grain yield produced from the interaction effect of the same cropping system, conventional agriculture and the same variety in 2015 (1.19 t ha^{-1}) and 2016 (0.88 t ha^{-1}). The average grain yield produced from the interaction effect of maize-wheat-mung cropping system, conservation agriculture and Pratikshya variety was 6.79% lower (0.96 t ha^{-1}) than that of the average grain yield produced from the interaction effect of the same cropping system, conventional agriculture and the same variety (1.03 t ha^{-1}). Similarly, the grain yield produced from the interaction effect of maize-wheat-mungbean, conservation agriculture and Kalyan variety was 14.28 and 4.25% lower grain yield in 2015 (1.02 t ha^{-1}) and 2016 (0.90 t ha^{-1}), respectively than that of the grain yield produced from the interaction effect of the same cropping system, conventional agriculture and same variety in 2015 (1.19 t ha^{-1}) and 2016 (0.94 t ha^{-1}). The average grain yield produced from the interaction effect of maize-wheat-mungbean cropping system, conservation agriculture and Kalyan variety was 9.43% lower (0.96 t ha^{-1}) than that of the average grain yield produced from the interaction of the same cropping system, conventional agriculture and same variety (1.06 t ha^{-1}).

Interaction effect of maize-lentil-mungbean cropping system, conservation agriculture and Pratikshya variety produced 14.52% lower and 38.27% higher grain yield in 2015 (1.06 t ha^{-1}) and 2016 (1.12 t ha^{-1}), respectively than that of the grain yield produced from the interaction effect of the same cropping system, conventional agriculture and same variety in 2015 (1.24 t ha^{-1}) and 2016 (0.81 t ha^{-1}). The average grain yield produced from the interaction effect of maize-lentil-mungbean cropping system, conservation agriculture and Pratikshya variety was 6.86% higher (1.09 t ha^{-1}) than that of the average grain yield produced from the interaction effect of the same cropping system, conventional agriculture and same variety (1.02 t ha^{-1}). Interaction effect of maize-lentil-mungbean cropping system, conservation agriculture and Kalyan variety produced 1.94 and 32.58% higher grain yield in 2015 (1.05 t ha^{-1}) and 2016 (1.18 t ha^{-1}), respectively than that of the grain yield produced from the interaction effect of the same cropping system, conventional agriculture and same variety in 2015 (1.03 t ha^{-1}) and 2016 (0.89 t ha^{-1}). The average grain yield produced from the interaction effect of maize-lentil-mungbean cropping system, conservation agriculture and Kalyan variety was 15.62% higher (1.11 t ha^{-1}) than that of the average grain yield produced from the interaction effect of the same cropping system, conventional agriculture and same variety (0.96 t ha^{-1}) (Fig. 7).

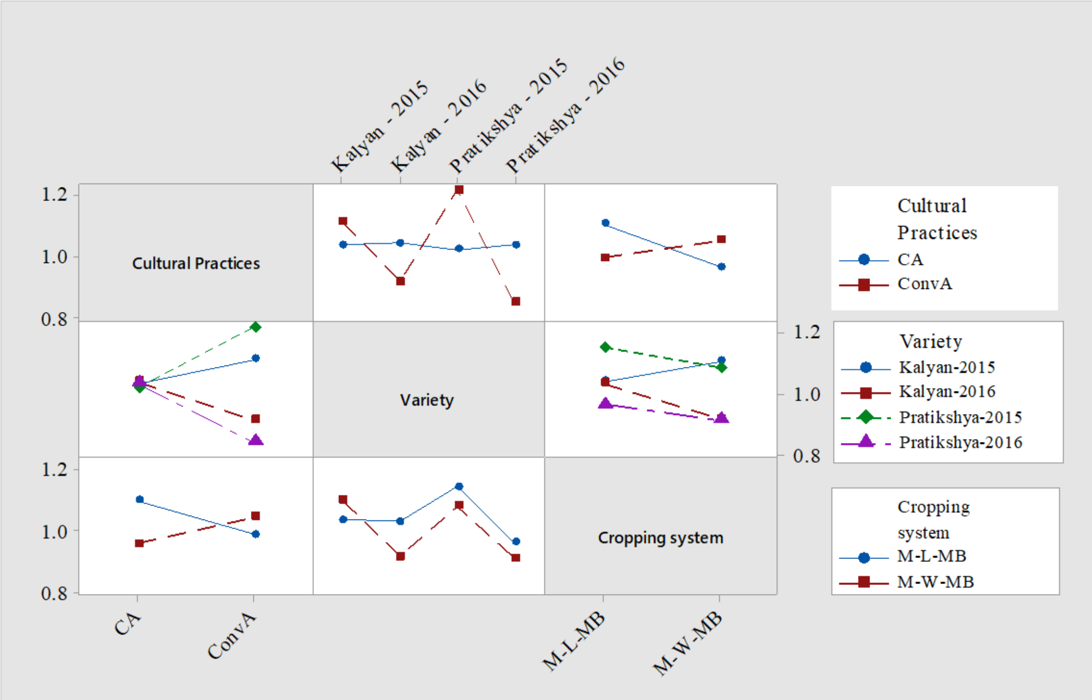

Fig. 7 Interaction effect of cropping system, cultural practices and varieties on grain yield (t ha^{-1}) of mungbean yield at CA experiment in 2015-2016

EFFECT OF CA ON NET BENEFIT FROM MUNGBEAN PRODUCTION

Effect of cropping systems on net benefit

The net benefit obtained from the tested varieties of mungbean under maize-wheat-mungbean and maize-lentil-mungbean cropping system was at par in 2015 (US $ 307.59 ha^{-1}) whereas is 2016, it was 20.13% higher in maize- lentil-mungbean cropping system (US $ 280.12 ha^{-1}) than that of maize-wheat-mungbean cropping system (US $ 223.74 ha^{-1}). The average net benefit obtained from maize-lentil-mungbean cropping system was 10.52% higher (US $ 293.60 ha^{-1}) than that of maize-wheat-mungbean cropping system (US $ 265.66 ha^{-1}) (Fig. 8).

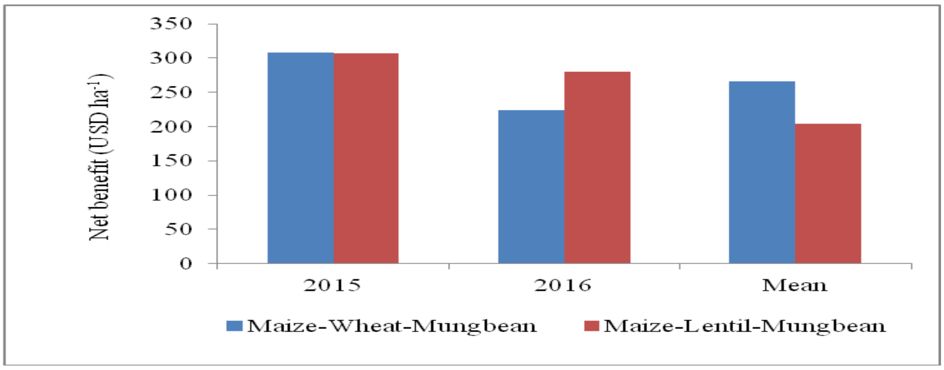

Fig. 8 Effect of cropping systems on net benefit from CA experiment in 2015-2016

Effect of cultural practices on net benefit

The net benefit of the mungbean varieties studied under conservation agricultural experiment was 0.34 and 100% higher in 2015 (US $ 307.84 ha^{-1}) and 2016 (351.59 ha^{-1}), respectively than that of the net benefit obtained from the same varieties studied under conventional agricultural experiment in 2015 (US $ 306.81 ha^{-1}) and 2016 (US $ 150.27 ha^{-1}), respectively. The average net benefit obtained from conservation agriculture was 44.69% higher (US $ 330.67 ha^{-1}) than that of the conventional agriculture (US $ 228.54 ha^{-1}) (Table 4).

Table 4 Effect of cultural practices on net benefit of mungbean varieties at CA experiment in Bhagetada, Dipayal, Doti during 2015-2016

Cultural practices	Net benefit (US $ ha^{-1})		
	2015	2016	Mean
Conservation agriculture (CA)	307.84	353.59	330.67
Conventional agriculture (ConvA)	306.81	150.27	228.24
Mean	307.33	251.89	279.61
F test	ns	**	**
LSD (0.05)		51.85	44.88

Effect of mungbean varieties on net benefit

The net benefit obtained from Pratikshya variety of mungbean was 8.96% higher in 2015 (US $ 320.54 ha^{-1}) and 9.04% lower in 2016 (US $ 239.96 ha^{-1}) than that of the net benefit obtained from Kalyan variety of mungbean in 2015 (US $ 294.19 ha^{-1}) and 2016 (US $ 263.82 ha^{-1}). The average net benefit of Pratikshya variety was similar (US $ 280.21 ha^{-1}) with the average net benefit of Kalyan (US $ 279.01 ha^{-1}) (Fig. 9).

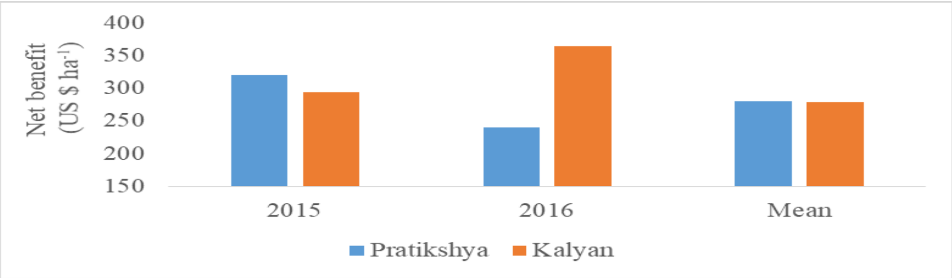

Fig. 9 Effect of mungbean varieties on net benefit at CA experiment in 2015-2016

Interaction effect of cropping system and cultural practices on net benefit

The net benefit obtained from the interaction effect of maize-wheat-mungbean cropping system and conservation agriculture was 10.97% lower and 64.6% higher in 2015 (US $ 289.73 ha^{-1}) and 2016 (US $ 280.98 ha^{-1}), respectively than that of the net benefit obtained from the interaction effect of the same cropping system and conventional agriculture in 2015 (US $ 325.44 ha^{-1}) and 2016 (US $ 170.70 ha^{-1}). The average net benefit obtained from the interaction effect of maize-wheat-mungbean cropping system and conservation agriculture was 15.05% higher (US $ 285.36 ha^{-1}) than that of the average net benefit obtained from the interaction effect of the same cropping system and conventional agriculture (US $ 248.03 ha^{-1}). Similarly, interaction effect of maize-lentil-mungbean cropping system and conservation agriculture produced 13.10 and 231.75% higher in 2015 (US $ 325.95 ha^{-1}) and 2016 (US $ 430.98 ha^{-1}), respectively than that of the net benefit obtained from the interaction effect of the same cropping system and conventional agriculture in 2015 (US $ 288.19 ha^{-1}) and 2016 (US $ 129.76 ha^{-1}). The average net benefit obtained from the interaction effect of maize-lentil-mungbean cropping system and conservation agriculture was 80.98% higher (US $ 378.22 ha^{-1}) than that of the average net benefit obtained from the interaction effect of the same cropping system and conventional agriculture (US $ 208.98 ha^{-1}) (Table 5).

Table 5 Interaction effect of cropping system and cultural practices on net benefit of mungbean at CA experiment in Bhagetada, Dipayal, Doti during 2015-2016

Cropping system	Cultural practices					
	Net benefit (US $ ha^{-1})					
	Conservation agriculture			Conventional agriculture		
	2015	2016	Mean	2015	2016	Mean
Maize-wheat-mungbean	289.73	280.98	285.36	325.44	170.70	248.03
Maize-lentil-mungbean	325.95	430.48	378.22	288.19	129.76	208.98
Mean	307.84	355.73	331.79	306.81	150.19	228.46
F test	ns	**	**			
CV%	13.00	16.80	20.85			

LSD (0.05)	108.31	52.09

Interaction effect of cropping system and varieties on net benefit

The net benefit obtained from the interaction effect of maize-wheat-mungbean cropping system and Pratikshya variety was 5.77 and 1.41% lower in 2015 (US $ 298.32 ha^{-1}) and 2016 (US $ 222.11 ha^{-1}), respectively than that of the net benefit obtained from the interaction effect of the same cropping system and Kalyan variety in 2015 (US $ 316.86 ha^{-1}) and 2016 (US $ 225.28 ha^{-1}). The average net benefit obtained from the interaction effect of maize-wheat-mungbean cropping system and Pratikshya variety was 3.99% lower (US $ 260.21 ha^{-1}) than that of the average net benefit obtained from the interaction effect of the same cropping system and Kalyan variety (US $ 271.03 ha^{-1}). Similarly, the net benefit obtained from the interaction effect of maize-lentil-mungbean cropping system and Pratikshya variety was 26.72% higher in 2015 (US $ 342.69 ha^{-1}) and 14.76% lower in 2016 (US $ 257.81 ha^{-1}) than that of the net benefit obtained from the interaction effect of the same cropping system and Kalyan variety in 2015 (US $ 271.46 ha^{-1}) and 2016 (US $ 302.44 ha^{-1}). The average net benefit obtained from the interaction effect of maize-lentil-mungbean cropping system and Pratikshya variety was 4.64% higher (US $ 300.21 ha^{-1}) than that of the average net benefit obtained from the interaction effect of the same cropping system and Kalyan variety (US $286.90 ha$^{-1)}$ (Fig. 10).

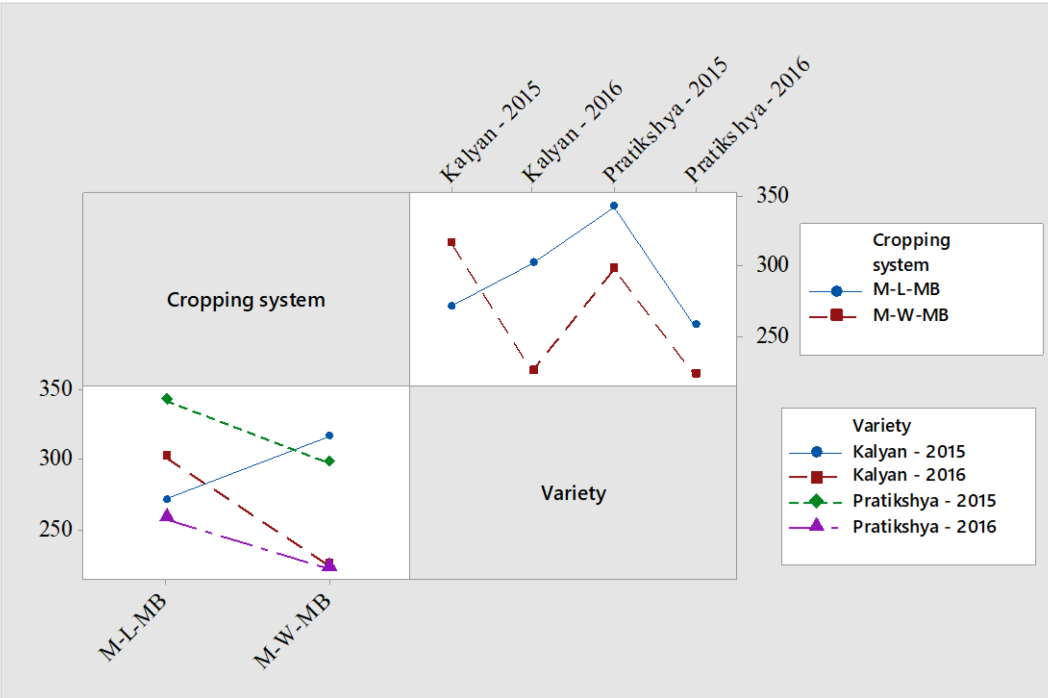

Fig. 10 Interaction effect of cropping systems and varieties on net benefit (USD $ ha^{-1}) at CA experiment in 2015-2016

Interaction effect of cultural practices and varieties on net benefit

The net benefit obtained from the interaction effect of conservation agriculture and Pratikshya variety was 11.76% lower in 2015 (US $ 300.46 ha^{-1}) and 175% higher in 2016 (US $ 352.04 ha^{-1}) than that of the net benefit obtained from the interaction effect of conventional agriculture and Pratikshya variety in 2015 (US $ 340.52 ha^{-1}) and 2016 (US $ 127.87 ha^{-1}). The average net benefit obtained from the interaction effect of conservation agriculture and Pratikshya variety was 39.29% higher (US $ 326.25 ha^{-1}) than that of the average net benefit obtained from the interaction effect of conventional agriculture and Pratikshya variety (US $ 234.21 ha^{-1}). Similarly, the net benefit obtained from the interaction effect of conservation agriculture and Kalyan variety was 15.36 and 105.76% higher in 2015 (US $ 315.14 ha^{-1}) and 2016 (US $ 355.13 ha^{-1}), respectively than that of the net benefit obtained from the interaction effect of conventional agriculture and Kalyan variety in 2015 (US $ 273.17 ha^{-1}) and 2016 (US $ 172.59 ha^{-1}). The average net benefit obtained from the interaction effect of conservation agriculture and Kalyan variety was 59.34% higher (US $ 335.13 ha^{-1}) than that of the average net benefit obtained from the interaction effect of conventional agriculture and Kalyan variety (US $ 222.88 ha^{-1}) (Fig. 11).

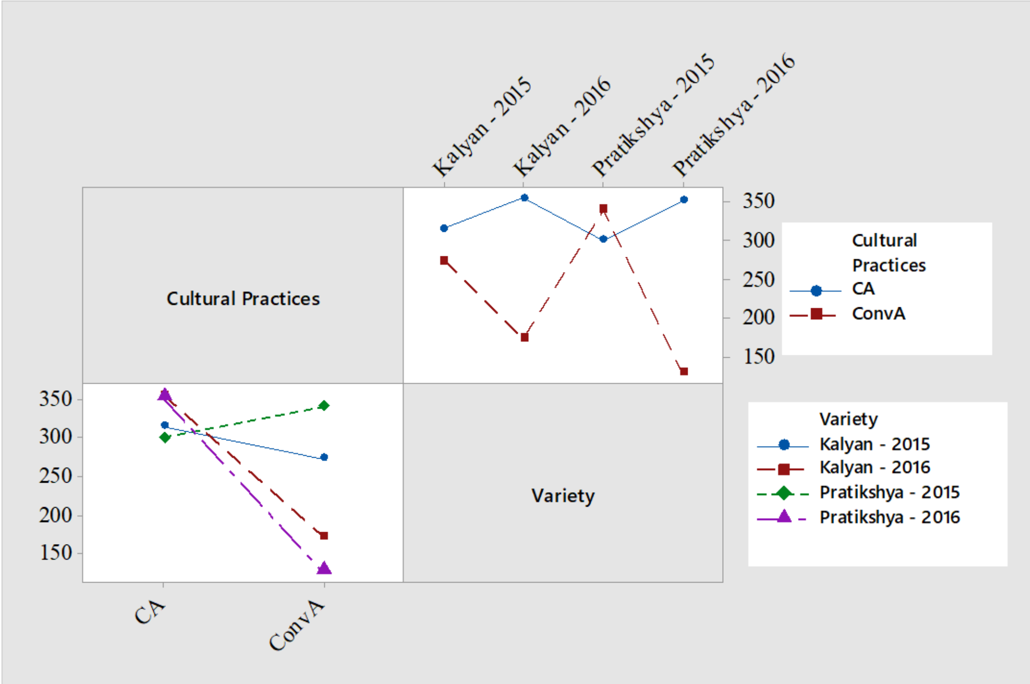

Fig. 11 Interaction effect of cultural practices and varieties on net benefit (US \$ ha^{-1}) at CA experiment in 2015-2016

Interaction effect of cropping systems, cultural practices and varieties on net benefit

Interaction effect of maize-wheat-mungbean cropping system, conservation agriculture and Pratikshya variety produced 15.25% lower in 2015 (US \$ 236.69 ha^{-1}) and 91.94% higher net benefit in 2016 (US \$ 292.05 ha^{-1}) than that of the net benefit obtained from the interaction effect of the same cropping system, conventional agriculture and the same variety in 2015 (US \$ 322.95 ha^{-1}) and 2016 (US \$ 152.16). The average net benefit obtained from the interaction effect of maize-wheat-mungbean cropping system, conservation agriculture and Pratikshya was 19.08% higher (US \$ 282.87 ha^{-1}) than that of the average net benefit produced from the interaction effect of the same cropping system, conventional agriculture and same variety (US \$ 237.55 ha^{-1}). The net benefit obtained from the interaction effect of maize-wheat-mungbean cropping system, conservation agriculture and Kalyan variety was 6.78% lower in 2015 (US \$ 305.78 ha^{-1}) and 38.20% higher in 2016 (US \$ 261.41 ha^{-1}) than that of the net benefit obtained from the interaction effect of the same cropping system, conventional agriculture and same variety in 2015 (US \$ 328.01 ha^{-1}) and 2016 (US \$ 189.15 ha^{-1}). The average net benefit obtained from the interaction effect of maize-wheat-mungbean cropping system, conservation agriculture and Kalyan variety was 9.66% higher (US \$ 283.56 ha^{-1}) than that of the average net benefit obtained from the interaction effect of the same cropping system, conventional agriculture and same variety (US \$ 258.58 ha^{-1}).

Similarly, interaction effect of maize-lentil-mungbean cropping system, conservation agriculture and Pratikshya variety produced 8.63% lower and 297.75% higher net benefit in 2015 (US \$ 327.24 ha^{-1}) and 2016 (US \$ 412.03 ha^{-1}), respectively than that of the net benefit produced from the interaction effect of the same cropping system, conventional agriculture and Pratikshya variety in 2015 (US \$ 358.14 ha^{-1}) and 2016 (US \$ 103.59 ha^{-1}). The average net benefit produced from the interaction effect of maize-lentil-mungbean cropping system, conservation agriculture and Pratikshya variety was 60.11% higher (US \$ 369.64 ha^{-1}) than that of the average net benefit produced from the interaction effect of the same cropping system, conventional agriculture and same variety (US \$ 230.86 ha^{-1}). The net benefit obtained from the interaction effect of maize-lentil-mungbean cropping system, conservation agriculture and Kalyan variety was 48.92 and 187.69% higher in 2015 (US \$ 325.01 ha^{-1}) and 2016 (US \$ 448.85 ha^{-1}), respectively than that of the net benefit obtained from the interaction effect of the same cropping system, conventional agriculture and same variety in 2015 (US \$ 218.12 ha^{-1}) and 2016 (US \$ 156.02 ha^{-1}). The average net benefit obtained from the interaction effect of maize-lentil-mungbean cropping system, conservation agriculture and Kalyan variety was 106.74% higher (US \$ 386.71 ha^{-1}) than that of the average net benefit obtained from the interaction effect of the same cropping system, conventional agriculture and same variety (US \$ 187.09 ha^{-1}) (Fig. 12).

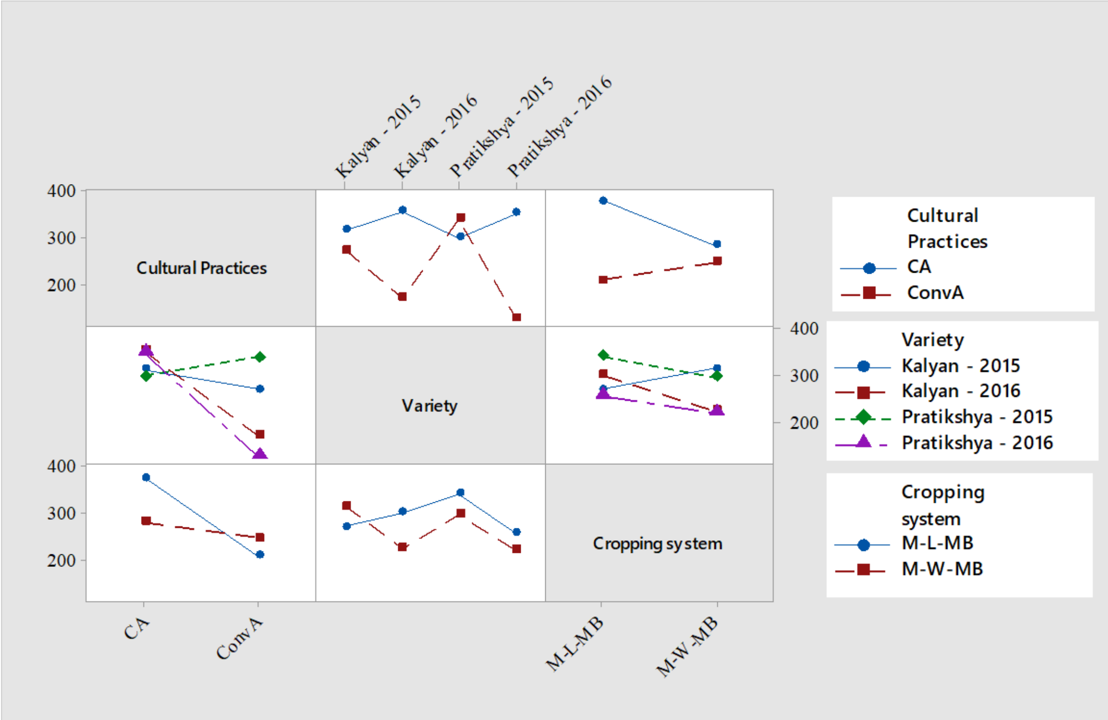

Fig. 12 Interaction effect of cropping systems, cultural practices and varieties on net benefit (US $ ha^{-1}) at CA experiment in 2015-2016.

EFFECT OF CONSERVATION AGRICULTURE ON BENEFIT TO COST RATIO

Effect of cropping system on benefit to cost (B: C) ratio

The B: C ratio of mungbean varieties examined under maize-wheat-mungbean and maize-lentil-mungbean cropping system was at par (1.7) in 2015 whereas in 2016, the B: C ratio obtained from maize-wheat-mungbean cropping system was 9.77% lower (1.57) than that of the B: C ratio obtained from maize-lentil-mungbean cropping system (1.74). The average B: C ratio of mungbean varieties studied under maize-lentil-mungbean cropping system was 5.52% higher (1.72) than that of the B: C ratio of the same varieties studied under maize-wheat-mungbean cropping system (1.63).

Effect of cultural practices on benefit to cost ratio

The B: C ratio of mungbean varieties examined under conservation agriculture was 9 and 45% higher in 2015 (1.77) and 2016 (1.98), respectively than that of the B: C ratio of the same varieties examined under conventional agriculture in 2015 (1.62) and 2016 (1.33). The average B: C ratio of the tested mungbean varieties under conservation agriculture was 27% higher (1.87) than that of the average B: C ratio of the same varieties studied under conventional agriculture (1.47). The difference in B: C ratio between conservation and conventional agriculture was significant in both years (Table 6).

Table 6 Effect of cultural practices on benefit to cost ratio of mungbean varieties at CA experiment in Bhagetada, Dipayal, Doti during 2015-2016

Cultural practices	Benefit to cost ratio		
	2015	2016	Mean
Conservation agriculture (CA)	1.77	1.98	1.87
Conventional agriculture (ConvA)	1.62	1.33	1.47
Mean	1.69	1.65	1.67
F test	**	**	**
LSD (0.05)	0.101	0.147	0.190

Effect of mungbean varieties on benefit to cost ratio

The benefit to cost ratio of Pratikshya variety was 2.99 and 2.78% higher in 2015 (1.72) and 2016 (1.11), respectively than that of the B: C ratio obtained from Kalyan variety in 2015 (1.67) and 2016 (1.08). The average benefit to cost ratio of Pratikshya variety was 18% higher (1.62) than that of the average B: C ratio (1.37) of Kalyan.

Interaction effect of cropping system and cultural practices on B: C ratio

The benefit to cost (B: C) ratio produced from the interaction effect of maize-lentil-mungbean cropping system and conservation agriculture was 14.46 and 70.54% higher in 2015 (1.82) and 2016 (2.20), respectively than that of the B: C ratio produced from the interaction effect of the same cropping system and conventional agriculture in 2015 (1.59) and 2016 (1.29). The average B: C ratio produced from the interaction effect of maize-lentil-mungbean cropping system and conservation agriculture was 39.58% higher (2.01) than that of the average B: C ratio obtained from the interaction effect of the same cropping system and conventional agriculture (1.44). Similarly, the B: C ratio produced from the interaction effect of maize-wheat-mungbean cropping system and conservation agriculture was 4.22 and 28.26% higher in 2015 (1.73) and 2016 (1.77), respectively than that of the B: C ratio produced from the interaction effect of the same cropping system and conventional agriculture in 2015 (1.66) and 2016 (1.38). The average B: C ratio produced from the interaction effect of maize-wheat-mung cropping system and conservation agriculture was 15.13% higher (1.75) than that of the B: C ratio produced from the interaction effect of the same cropping system and conventional agriculture (1.52) (Table 7).

Table 7 Interaction effect of cropping system and cultural practices on benefit to cost ratio of mungbean at CA experiment in Bhagetada, Dipayal, Doti during 2015-2016

Cropping system	Cultural practices					
	Benefit to cost ratio					
	Conservation agriculture			Conventional agriculture		
	2015	2016	Mean	2015	2016	Mean
Maize-wheat-mungbean	1.73	1.77	1.75	1.66	1.38	1.52
Maize-lentil-mungbean	1.82	2.20	2.01	1.59	1.29	1.44
Mean	1.77	1.98	1.88	1.62	1.33	1.48
F test	ns	**	**			
CV%	4.90	5.30	8.67			
LSD (0.05)		0.287	0.160			

Interaction effect of cropping system and varieties on benefit to cost ratio

The B: C ratio produced from the interaction effect of maize-wheat-mungbean cropping system and Pratikshya variety was 2.91% lower (1.67) than that of the B: C ratio produced from the interaction effect of the same cropping system and Kalyan (1.72) in 2015 whereas in 2016, the B: C ratio produced from the interaction effect of the same cropping system and Pratikshya and Kalyan variety was at par (1.57). The average B: C ratio produced from the interaction effect of maize-wheat-mungbean cropping system and Pratikshya variety was 1.22% lower (1.62) than that of the average B: C ratio produced from the interaction effect of the same cropping system and Kalyan variety (1.64). Similarly, the B: C ratio produced from the interaction of maize-lentil-mungbean cropping system and Pratikshya variety was 14.46% higher (1.82) in 2015 and 6.11% lower (1.69) in 2016 than that of the B: C ratio produced from the interaction effect of the same cropping system and Kalyan variety in 2015 (1.59) and 2016 (1.80). The average B: C ratio produced from the interaction effect of maize-lentil-mung cropping system and Pratikshya variety was 3.55% higher (1.73) than that of the average B: C ratio produced from the interaction effect of the same cropping system and Kalyan variety (1.69) (Fig. 13).

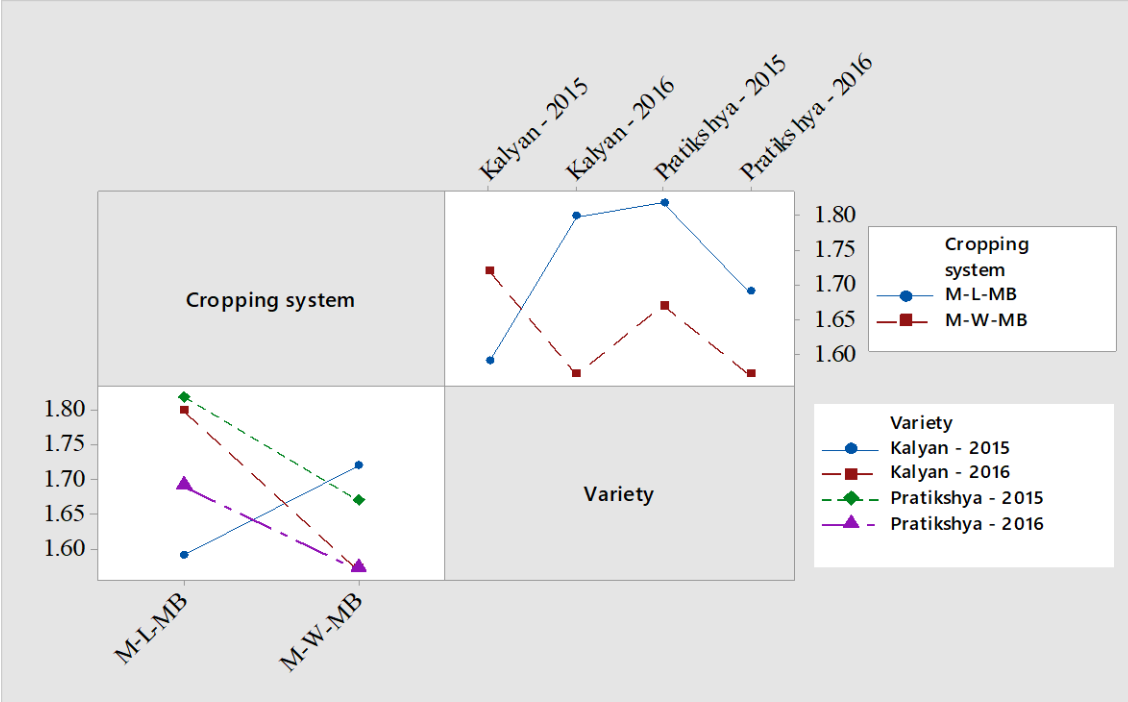

Fig. 13 Interaction effect of cropping system and varieties on benefit to cost ratio at CA experiment in Bhagetada, Dipayal, Doti during 2015-2016

Interaction effect of cultural practices and varieties on benefit to cost ratio

The B: C ratio produced from the interaction effect of conservation agriculture and Pratikshya variety was 3.98% lower (1.69) in 2015 and 54.69% higher (1.98) in 2016 than that of the B: C ratio produced from the interaction effect of conventional agriculture and Pratikshya variety in 2015 (1.76) and 2016 (1.28). The average B: C ratio produced from the interaction effect of conservation agriculture and Pratikshya variety was 20.39% higher (1.83) than that of the average B: C ratio produced from the interaction effect of conventional agriculture and same variety (1.52). Similarly, the B: C ratio produced from the interaction effect of conservation agriculture and Kalyan variety was 14.74 and 44.20% higher in 2015 (1.79) and 2016 (1.99), respectively than that of the B: C ratio produced from the interaction effect of conventional agriculture and Kalyan variety in 2015 (1.56) and 2016 (1.38). The average B: C ratio produced from the interaction effect of conservation agriculture and Kalyan variety was 28.57% higher (1.89) than that of the average B: C ratio produced from the interaction effect of conventional agriculture and same variety (1.47) (Fig. 14).

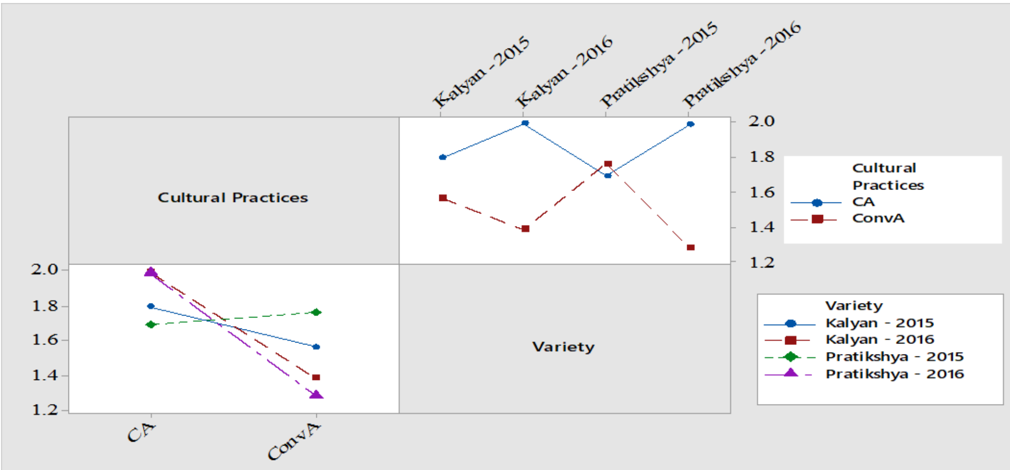

Fig. 14 Interaction effect of cultural practices and varieties on benefit to cost ratio at CA experiment in Bhagetada, Dipayal, Doti during 2015-2016

Interaction effect of cropping systems, cultural practices and varieties on benefit to cost ratio

The B: C ratio produced from the interaction effect of maize-wheat-mungbean cropping system, conservation agriculture and Pratikshya variety was 1.77% lower (1.66) in 2015 and 35.07% higher (1.81) in 2016 than that of the B: C ratio produced from the interaction effect of the same cropping system, conventional agriculture and Pratikshya variety in 2015 (1.69) and 2016 (1.34). The average B: C ratio produced from the interaction effect of maize-wheat-mungbean cropping system, conservation agriculture and Pratikshya variety was 14.57% higher (1.73) than that of the average B: C ratio produced from the interaction effect of the same cropping system, conventional agriculture and same variety (1.51). The B: C ratio produced from the interaction effect of maize-wheat-mungbean cropping system, conservation agriculture and Kalyan variety was 5.65% lower (1.67) in 2015 and 21.83% higher (1.73) in 2106 than that of the B: C ratio produced from the interaction effect of the same cropping system, conventional agriculture and Kalyan variety in 2015 (1.77) and 2016 (1.42). The average B: C ratio produced from the interaction effect of maize-wheat-mungbean cropping system, conservation agriculture and Kalyan variety was 6.92% higher (1.70) than that of the B: C ratio produced from the interaction effect of the same cropping system, conventional agriculture and same variety (1.59) (Fig. 15).

Similarly, the B: C ratio produced from the interaction effect of maize-lentil-mungbean cropping system, conservation agriculture and Pratikshya variety was 4.94% lower (1.73) in 2015 and 74.79% higher (2.15) in 2016 than that of the B: C ratio produced from the interaction effect of the same cropping system, conventional agriculture and same variety in 2015 (1.82) and 2016 (1.23). The average B: C ratio produced from the interaction effect of maize-lentil-mungbean cropping system, conservation agriculture and Pratikshya variety was 27.63% higher (1.94) than that of the average B: C ratio produced from the interaction effect of the same cropping system, conventional agriculture and same variety (1.52). The B: C ratio produced from the interaction effect of maize-lentil-mungbean, conservation agriculture and Kalyan variety was 26.39 and 67.91% higher in 2015 (1.82) and 2016 (2.25), respectively than that of the B: C ratio produced from the interaction effect of the same cropping system, conventional agriculture and same variety in 2015 (1.44) and 2016 (1.34). The average B: C ratio produced from the interaction effect of maize-lentil-mungbean cropping system, conservation agriculture and Kalyan variety was 46.04% higher (2.03) than that of the average B: C ratio produced from the interaction effect of the same cropping system, conventional agriculture and same variety (1.39) (Fig. 15).

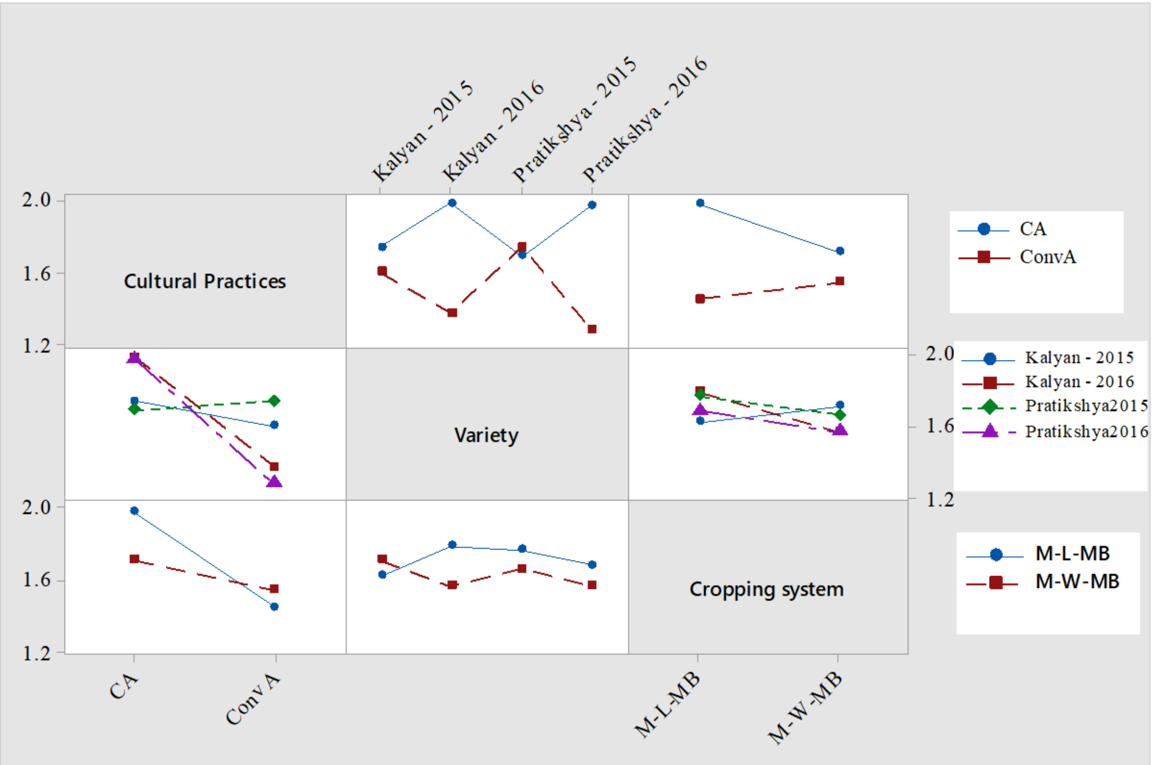

Fig. 15 Interaction effect of cropping systems, cultural practices and varieties on benefit to cost ratio at CA experiment in Bhagetada, Dipayal, Doti during 2015-2016

DISCUSSION

Under conservation agricultural practices, the productivity of Kalyan and Pratikshya varieties of mungbean under maize-lentil-mungbean cropping system was 15.62 and 13.54% higher, respectively than that of the productivity of the same varieties under maize-wheat-mungbean cropping system. Conversely, under conventional agricultural practices the productivity of Kalyan and Pratikshya variety of mungbean under maize-lentil-mungbean cropping system was 9.43 and 0.97% lower, respectively than that of the productivity of the same varieties under maize-wheat-mungbean cropping system. The yield of mungbean varieties varied under different cultural practices. The tillage system significantly affected grain yield of mungbean (Imran et al., 2016). Comparable yields of different crops under conventional and conservation tillage systems have also been reported by Schlegel et al. (1999); Zorita (2000); Baumhardt & Jones (2002); Ijaz & Ali (2007).

Under conservation agricultural practices, the net benefit of the mungbean varieties under different cropping systems (cereal-legume-legume and cereal-cereal-legume) showed that the net benefit of Kalyan and Pratikshya variety under maize-lentil-mungbean cropping system was 36.38 and 30.67% higher, respectively than that of the net benefit of the same varieties studied under maize-wheat-mungbean cropping systems. But under conventional agricultural practices, the net benefit of Kalyan and Pratikshya varieties of mungbean under maize-lentil-mungbean cropping system was 27.64 and 2.82% lower, respectively than that of the net benefit of the same varieties under maize-wheat-mungbean cropping systems. Under conservation agricultural practices, the benefit to cost ratio of Kalyan and Pratikshya varieties of mungbean under maize-lentil-mungbean cropping system was 19.41 and 12-41% higher, respectively than that of the benefit to cost ratio of the same varieties under maize-wheat-mungbean cropping system whereas the B: C ratio of Kalyan and Pratikshya varieties under maize-lentil-mungbean cropping system with conventional agricultural practices was 12.58 and 0.66% lower, respectively than that of the B: C ratio of the same varieties under maize-wheat-mungbean cropping system with same agricultural practices.

The benefit cost ratio was higher in conservation agricultural practices than that under conventional agricultural practices. This finding was similar to the findings reported by Karki et al. (2014). The benefit cost ratio of 1.7 in conventional tillage with residue removed and 2.5 in no tillage with residue kept were recorded in the second year. The grain yield of the mungbean varieties under same cropping systems and different cultural practices showed that the productivity of Kalyan and Pratikshya variety under maize-lentil-mungbean cropping systems and conservation agricultural practices was 15.62 and 6.97% higher, respectively than that of the productivity of the same varieties under maize-lentil-mungbean cropping system and conventional agricultural practices. The productivity of Kalyan and Pratikshya varieties under maize-wheat-mungbean cropping system under conservation agricultural practices was 9.43 and 6.70% higher, respectively than that of the productivity of the same varieties under maize-wheat-mungbean cropping system under conventional agricultural practices.

Similarly the net benefit of Kalyan and Pratikshya varieties under maize-lentil-mungbean cropping system and conservation agricultural practices was 106.69 and 60.11% higher, respectively than that of the net benefit of the same varieties under maize-lentil-mungbean cropping system and conventional agricultural practices whereas, the net benefit of Kalyan and Pratikshya variety of mungbean under maize-wheat-mungbean cropping system and conservation agricultural practices was 9.66 and 19.07% higher, respectively than that of the net benefit of the same varieties under maize-wheat-mungbean cropping system and conventional agricultural practices. The B: C ratio of Kalyan and Pratikshya varieties of mungbean under maize-lentil-mungbean cropping system and conservation agricultural practices was 46.04 and 27.63% higher, respectively than that of the B: C ratio of the same varieties under same cropping system and conventional agricultural practices. Similarly, the B: C ratio of Kalyan and Pratikshya varieties under maize-wheat-mungbean cropping system and conservation agricultural practices was 6.92 and 14.57% higher, respectively than that of the B: C ratio of the same varieties under maize-wheat-mungbean cropping system and conventional agricultural practices.

Various researchers also reported that conservation agriculture produced higher yield and profit than that of conventional agriculture. Conservation agriculture aims to produce crop yields by reducing production costs, maintaining the soil fertility and conserving water (Hossain et al., 2015). The conservation system determined the obtaining of higher production of crops compared to the conventional agriculture system because this system has the advantage to preserve water and under the condition of a water deficit during the vegetation period, it contributes to a more efficient use of fertilizers. Conservation agriculture improves water infiltration, moisture of the soil, and minimizes water runoff and evaporation in a short period (Thierfielder et al., 2005). Water and nutrient use efficiency was higher in no till and residue retained plot than that of tilled and residue removed (Huang et al, 2008; Baumhardt et al., 2013a; 2013b). No till and residue retained soil can hold moisture up to 35 days whereas till soil can hold only for 15 days (Mrabet, 2000). Kassam et al. (2009); Derpsch et al. (2010) reported 20-120% higher yield in conservation agriculture. Conservation agriculture contributes to high production with less labor and this is the basis of earning more profit in CA than that of conventional (Ito et al., 2007; Haggblade et al., 2011; Mazvimavi, 2011). FAO (2010) reported higher annual return from conservation agriculture than that of conventional agriculture in Zambia. FAO (2008b); Derpsch et al. (2010) found 249% higher annual return (US \$ 213 ha^{-1}) from CA than that of conventional agriculture (US \$ 61 ha^{-1}). Shetto and Owenya (2007) reported 50-75% lower cost of production in conservation agriculture than that of conventional agriculture. Higher gross margin was in CA than that of conventional (Tshuma et al., 2010). CA produced 39% higher grain yield than that of conventional (Mazvimavi et al., 2012). Rusinamhodzi et al. (2011) concluded 7.3% more grain yield in no till, residue retention and crop rotation cultivation agriculture in dry land climates.

CONCLUSION

The conservation agriculture was found to be more beneficial as compared to conventional agriculture practices in term of crop production and economic return. The interaction effect of maize-lentil-mungbean cropping system, conservation agriculture and Pratikshya and Kalyan varieties of mungbean recorded 6.8 to 15.6% higher grain yield and 60-100% higher net benefit and 27-46% higher benefit to cost ratio than that of conventional agriculture. So, these research findings suggest that the farmers should apply maize-lentil-mungbean cropping system, conservation agriculture and Kalyan variety of mungbean for high productivity and profitability in far western river basin agro-environment of mid hills of Nepal.

Author Contribution Statement: Hari Kumar Prasai generated the idea, conducted research, analyzed data and wrote the manuscript. Shrawan Kumar Sah supervised the research, helped in statistical analysis of collected data and edited the manuscript. Anand Kumar Gautam and Anant Prasad Regmi supervised research and edited the manuscript. All the authors read and approved the manuscript.

Conflict of Interest: The authors declare that there is no conflict of interests regarding the publication of this article.

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