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Conservation agriculture for productivity and profitability of wheat and lentil in maize based cropping system in far western Nepal

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Abstract

Zero tillage with crop residue retention which is principle of conservation agriculture (CA) can be a good practice to achieve sustainable and profitable crop yield without affecting soil fertility. This approach was not tested in wheat and lentil based maize-mungbean system in far western Nepal. The effect of CA in the maize-wheat-mungbean and maize-lentil-mungbean cropping systems with two varieties of each of wheat and lentil was studied at Regional Agricultural Research Station, Bhagetada, Dipayal, Doti district of Nepal for two years (2015 and 2016). The average grain yield of wheat and lentil under the CA system was 5.92% higher (2.86 t ha^{-1}) than that of conventional agriculture (2.70 t ha^{-1}). The CA under maize-wheat-mungbean cropping system produced 7.90% higher grain yield (4.78 t ha^{-1}) compared to conventional agriculture and the CA under maize-lentil-mung bean cropping system gave11.11% higher grain yield (1.00 t ha^{-1}). Maize-wheat-mungbean cropping system, conservation agriculture and WK 1204 variety of wheat produced 9.34% higher yield (4.80 t ha^{-1}) than conventional agriculture whereas maize-lentil-mungbean cropping system, conservation agriculture and Khajura1 variety of lentil recorded 11.96% higher grain yield (1.03 t ha^{-1}) than conventional agricultural. The CA system produced 114% higher net benefit (NRs. 40200 ha^{-1}) than that of conventional agriculture. Higher yields of crops in CA system could be associated with improvement of soil properties for minimum soil disturbance and residue retention and profitable yield for reduced cost of production. Thus, the 2-year study suggests that no tillage with previous crop residues retention and use of higher yielding varieties is a potential crop cultivation approach for the maize based cropping system in light textured soil of river basin area of Nepal in order to sustain soil health, crop yield and farm economy.

Introduction

About one third gross domestic product of the country is contributed by agriculture and forestry sector. Wheat (*Triticum aestivum* L.) is the third most important cereals crops of the country and it has the total cultivated area and production is 754474 ha, 1883147 t respectively. The national average productivity of wheat is 2496 kg ha^{-1}. Amongst the total cultivated area (328738 ha) and production (226830 t) of pulse crop of the country, lentil (*Lens culinaris* Medik.) occupies major share in both area (205939 ha) and production (226830 t) with the average productivity of 1101 kg ha^{-1} (ABPSD, 2014).

Out of the total area (34736 ha) and production (67654 t) of cereal crops in Doti district, wheat accounts the major share of area (15950 ha) and production (33510 t). The average productivity of wheat in Doti district is 2101 kg/ha and this productivity is 14.55% high than the productivity of far western hills districts whereas it is 26.52% low than the national productivity of the same crop. Doti district has major share of lentil cultivated area (860 ha) and production (955 t) which accounts 56% and 58% of the total area (1526 ha) and production (1641 t) of far western hills. The productivity of lentil in this district is 1110 kg ha^{-1}, which is 3.25% more than the average productivity far western hill districts (ABPSD, 2014).

Conservation agriculture is considered as a resource saving agriculture production system that encourages to increase production and profitability through rejuvenating fertility of the soil. Conservation agriculture is a system approach which is characterized by three interlinked principles namely minimum soil disturbance, permanent soil cover and crop rotation (FAO, 2010). Minimum soil disturbance and retention of the crop residues effects almost immediately in improving water infiltration, soil moisture content and reduce evaporation (Derpsch *et al.*, 1986; Thierfelder *et al.*, 2005).

Far western agriculture is generally characterized by lower yields and lower inputs use than other development regions of the country. The availability of water is not sufficient during the period of crop production. Generally, the land holdings of far western

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hills is small with low fertility. The existing cultivation practices of Doti district is conventional tillage with animal driven plough and it is tilled for three. The crop residues are removed or used for other purposes. The farmers are being using such tillage practices since the first establishment of agricultural production system. In Doti, majority of the farming system is based on crop and livestock integration where output of one component becomes input for other. Farmers are applying two options for managing crop residues. First, they manage crop residues for livestock feeding especially for dry season and second, remaining crop residues are burnt to clear the field. There are very few scientific studies directly comparing conservation with conventional agriculture practices in different agro-ecological zones and cropping system of the country, particularly focusing to the far western hills agro-environment. So, this research was carried out with the objectives of improving yield of wheat and lentil by improving physical properties of the soil through conservation agriculture based environmental friendly sustainable agricultural technology for far western hills of Nepal.

Materials and Methods

Experimental site details

This experiment was carried out in the research field of Regional Agricultural Research Station (RARS), Bhagetada, Dipayal, Doti district in 2015 and 2016. It is located at the latitude of N 29°15'16.4" and longitude of E 80°55'59.3" (Prasai *et al.*, 2016). This research station is situated at the bank of Seti River with the altitude of 546 meter above sea level. This research station has lift irrigation system which is completely dependent on the supply of electricity. The rainfall in wheat and lentil growing season was low than the rainfall of 2015 and regularly disturbance in supply of electricity was also observed in 2016 than 2015.

Total rainfall of wheat and lentil growing season of 2014, 2015 and 2016 was recorded as 217.6 mm, 297.6 mm and 75.6 mm respectively. There was no rainfall in November of the above mentioned three years. Total 36.9 mm rainfall was recorded in December of 2014 whereas no rainfall was recorded in the same month of remaining two years. Highest rainfall of the wheat growing season was occurred in March of 2015 (167.7 mm) and lowest rainfall was recorded in January (0.2 mm) and February (0.3 mm) of 2016. Highest rainfall of 2014 (60.9 mm) and 2016 (42.1 mm) was recorded in January and March respectively. The maximum temperature of November, December and January of 2014 and 2015 was found similar. Highest and lowest maximum temperature was recorded in April of 2016 and January of 2015. Similarly, the highest and lowest minimum temperature was recorded in April and January of 2016 (Fig. 1).

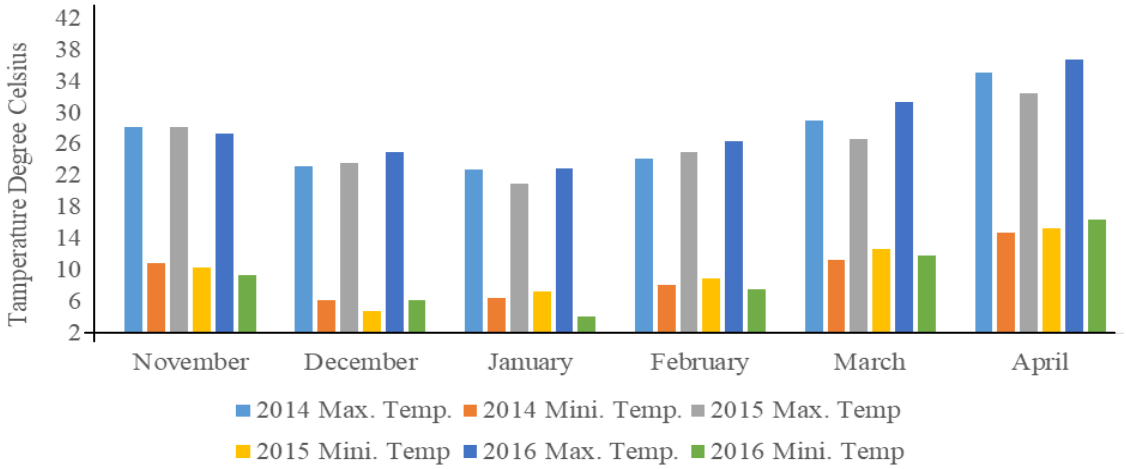

Fig. 1. Minimum and maximum temperature of wheat and lentil growing period at CA experiment in Bhagetada, Dipayal, Doti during 2015–2016

Plant materials

Dhaulagiri is the wheat variety and its origin is Nepal. This variety was released in 2012 in Nepal. The pedigree of this variety is BL 1961/NL 867. Similarly, WK 1204 is the variety of wheat and its origin is Mexico. It was released in 2007 in Nepal. The pedigree of this variety is SW89-3064/Star "S". The seed of Dhaulagiri was received from National Wheat Research Program, Bhairahawa, Nepal and the seed of WK 1204 was collected from Agri-Botany Division, Khumaltar, Kathmandu.

Khajura-1 is the variety of lentil. The origin of this variety is India. It was released in 1999 in Nepal. The pedigree of this variety is LG 198. Its yield potential is 1.5 t ha^{-1}. Shimal is also the variety of lentil and it was released in 1999 in Nepal. The origin of this variety is India. The pedigree of this variety is LG 7. Its yield potential is 1.4 t ha^{-1}. These two varieties were received from National Grain Legumes Research Program, Khajura, Nepalgunj, Nepal.

Experimental design, treatments and crop management

The split-split plot design with four replications was applied during the layout of the experiment. Three factors such as cropping system, cultural practices and variety was 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-mung bean and maize-lentil-mung bean cropping system were taken as main plot factor, two cultural practices that is conservation and conventional practices were applied as sub plot factor. Similarly, Rajkumar as hybrid and Arun 2 as open pollinated maize varieties were used as sub-sub plot factor. After harvesting of maize varieties, Dhaulagiri and WK 1204 varieties of wheat followed by mungbean were sown in the experimental plots of maize-wheat-mungbean cropping system whereas Shimal and Khajura 1 varieties of lentil followed by mungbean were sown in the experimental plots of maize-lentil-mungbean cropping system in both conservation and conventional agriculture practices plots of the experiment in both years. The plot size was of $18m^2$.

In conservation practices, there was no tillage and residues of the crops were left in the plots. The maize and wheat straw were cut 30 cm above the ground and were left in conservation plots during the harvesting period whereas whole plants were removed from the experimental plots of conventional practices. Similarly, pods of lentil were picked up from the plants and the plants were left in the field of conservation plots whereas whole plants were removed from the field of conventional plots. Small lines were open with the help small pointed Kuto and farm yard manure and chemical fertilizers were placed into these furrows and were mixed with soil before seeding in the conservation experimental plots. Seeding was done into the small hole with the help of peg. Three tillage was done by small hand tractor in the whole plots of the conventional practices. The farm yard manure fertilizer was spreaded in the conventional plots before tilling the plots and chemical fertilizers were applied and mixed with soil after tilling the plots. Seeding was done by making furrows in conventional plots. The experimental plots of wheat were irrigated six times. Two rows in each plot of each crop were left as boarder row and remaining crops from each plot of each crop were harvested.

Crop harvest and yield estimation

The grain yield of wheat and lentil were recorded. The price of each crop were determined as per the market price of that time. The market price of wheat and lentil was NRs. 25 kg^{-1} and NRs.100 kg^{-1} respectively. The maize equivalent yield was calculated by applying the following formula (Pradhan *et al.*, 2016)

Maize-equivalent yield (t ha^{-1}) =

$$\frac{\text{Crop yield (kg ha}^{-1}) \times \text{Crop price (NRs kg}^{-1})}{\text{Maize price (NRs kg}^{-1})}$$

Economic analysis

The total cost for different operations based on treatments was accounted. The gross income from each operation in terms of NRs. per hectare was calculated. The net income is calculated by using the following formula:

Net Income = Gross income – Total cost

Statistical analysis

All agronomic data from trials were analyzed using a split split-plot design ANOVA analysis. The experimental data were processed by using Excel 2010 and analyzed by using Genestat 13.2. The treatment means were compared by the Least Significant Difference (LSD) test at 5% level (Gomez and Gomez, 1984; Baral *et al*., 2016).

Results

Effect of cropping systems

Significantly higher grain yield of Dhaulagiri and WK 1204 varieties of wheat studied under maize-wheat-mungbean cropping system was observed in 2015 (4.99 t ha^{-1}) and 2016 (4.22 t ha^{-1}) than the grain yield of Shimal and Khajura1 variety of lentil studied under maize-lentil-mungbean cropping system during 2015 (1.03 t ha^{-1}) and 2016 (0.88 t ha^{-1}) . The difference in grain yield between two cropping systems was found significant ($p<0.01$) in both years and over year analysis (Table 1).

Table 1. Effects of cropping systems on grain yield of wheat and lentil at CA experiment in Bhagetada, Dipayal, Doti during 2015–2016

Treatments	Grain yield (t ha^{-1})		
Cropping system	2015	2016	Mean
Maize-wheat-mung bean (M-W-MB)	4.99	4.22	4.60
Maize-lentil-mung bean (M-L-MB)	1.03	0.88	0.95
Mean	3.01	2.55	2.77
F test	**	**	**
CV%	8.50	3.40	13.69
LSD(0.05)	0.57	0.20	0.33

Regarding net benefit of the studied varieties, the average net benefit of Dhaulagiri and WK 1204 variety of wheat examined under maize-wheat-mungbean cropping system was found 10.24% higher (NRs.30890 ha^{-1}) than the mean net benefit of Shimal and Khajura1 variety of lentil tested under maize-lentil-mungbean cropping system (NRs. 28020 ha^{-1}). The difference in net benefit between two cropping systems was non-significant and CV% was observed 19.50, 10.71 and 35.78 of 2015, 2016 and mean respectively.

The maize equivalent yield (MY) of Dhaulagiri and WK 1204 varieties of wheat examined under maize-wheat-mungbean cropping system was found 20.97% higher in 2015 (6.23 t ha^{-1}) and 19.45% higher in 2016 (5.28 t ha^{-1}) than the MEY of tested Shimal and Khajura1 varieties of lentil under maize-lentil-mungbean cropping

system in 2015 (5.15 t ha-1) and 2016 (4.42 t ha-1). The average MEY of maize-wheat -mungbean cropping system was found 20.29% higher (5.75 t ha^{-1}) than maize-lentil-mungbean cropping system (4.78 t ha^{-1}). The difference in MEY between two cropping systems was found significant ($p<0.05$ to $p<0.01$) in both years and over year analysis (Table 2).

Table 2. Effects of cropping systems on maize equivalent yield of wheat and lentil at CA experiment in Bhagetada, Dipayal, Doti during 2015–2016

Treatments	Maize equivalent yield (t ha^{-1})		
Cropping system	2015	2016	Mean
Maize-wheat-mungbean (M-W-MB)	6.23	5.28	5.75
Maize-lentil-mungbean (M-L-MB)	5.15	4.42	4.78
Mean	5.69	4.85	5.26
F test	*	*	**
CV%	6.20	2.50	10.0
LSD(0.05)	0.79	0.28	0.52

Effect of agricultural practices The grain yield of Dhaulagiri and WK 1204 variety of wheat and Shimal and Khajura1 variety of lentil studied under conservation agricultural practices was found 6.16% higher in 2015 (3.10 t ha^{-1}) and 5.22% higher in 2016 (2.62 t ha^{-1}) compared with the grain yield of same varieties studied under conventional agricultural practices in 2015 (2.92 t ha^{-1}) and 2016 (2.49 t ha^{-1}). The mean grain yield of the same varieties studied under conservation agricultural practices was found 5.92% higher (2.86 t ha^{-1}) than conventional agricultural practices (2.70 t ha^{-1}). The difference in grain yield of tested wheat and lentil varieties between conservation and conventional agricultural practices was found significant ($p<0.05$) in 2016 and over year analysis whereas it was non-significant in 2015 (Table 3).

Table 3. Effects of cultural practices on grain yield of wheat and lentil at CA experiment in Bhagetada, Dipayal, Doti during 2015–2016

Treatments	Grain yield (t ha^{-1})		
Cultural practices	2015	2016	Mean
Conservation agriculture (CA)	3.10	2.62	2.86
Conventional agriculture (ConvA)	2.92	2.49	2.70
Mean	3.01	2.55	2.78
F test	ns	*	*
LSD(0.05)		0.09	0.25

The average net benefit of Dhaulagiri and WK 1204 variety of wheat and Shimal and Khajura1variety of lentil examined under conservation agricultural practices was found 114.97% higher (NRs.40200 ha^{-1}) than conventional agricultural practices (NRs.18700 ha^{-1}). The difference in net benefit between conservation and convention agricultural practices was found significant ($p<0.01$) in 2015 and 2016 as well as over years analysis (Table 4).

Table 4. Effects of cultural practices on net benefit of wheat and lentil at CA experiment in Bhagetada, Dipayal, Doti during 2015–2016

Treatments	Net benefit (NRs.000 ha^{-1})		
Cultural practices	2015	2016	Mean
Conservation agriculture (CA)	49.01	31.39	40.20
Conventional agriculture (ConvA)	22.25	14.46	18.70
Mean	35.63	22.92	29.45
F test	**	**	**
LSD(0.05)	10.35	3.87	9.83

The average maize equivalent yield (MEY) of Dhaulagiri and WK 1204 variety of wheat and Shimal and Khajura1variety of lentil studied under conservation agricultural practices was found 2.11% higher (5.32 t ha^{-1}) than conventional agricultural practices (5.21 t ha^{-1}). The difference in MEY of the same varieties between conservation and convention agricultural practices was non-significant in both years.

Interaction effect of cropping system and cultural practices The grain yield of Dhaulagiri and WK 1204 variety of wheat resulted from the Interaction effect of maize-wheat-mungbean cropping system and conservation agricultural practices was found 6.19% in 2015 (5.14 t ha^{-1}) and 12.43% higher in 2016 (4.52 t ha^{-1}) than conventional agricultural practices in 2015 (4.84 t ha^{-1}) and 2016 (4.02 t ha^{-1}). The average grain yield produced from the interaction effect of same cropping system and conservation agricultural practices was found 7.90% higher (4.78 t ha^{-1}) than conventional agricultural practices (4.43 t ha^{-1}). Similarly, the grain yield of Shimal and Khajura1 variety of lentil produced from the interaction effect of maize-lentil-mungbean cropping system and conservation agricultural practices was found 5% higher in 2015 (1.05 t ha^{-1}) and 18.52% higher in 2016 (0.96 t ha^{-1}) than conventional agricultural practices in 2015 (1.00 t ha^{-1}) and 2016 (0.81 t ha^{-1}). The average grain yield produced from the interaction of same cropping system and conservation agricultural practices was found 11.11% higher (1.00 t ha^{-1}) than conventional agricultural practices (0.90 t ha^{-1}). The difference in grain yield resulted from the interaction effect of cropping system and cultural practices was non-significant in both years but it was significant ($p<0.01$) in over year analysis (Table 5).

Table 5. Interaction effect of cropping system and cultural practices on grain yield of wheat and lentil at CA experiment in Bhagetada, Dipayal, Doti during 2015–2016

Treatments	Grain yield (kg ha^{-1})		
Cropping system x Cultural practices	2015	2016	Mean
M-W-MB x Conservation Agriculture	5.14	4.52	4.78
M-W-MB x Conventional Agriculture	4.84	4.02	4.43
M-L-MB x Conservation Agriculture	1.05	0.96	1.00
M-L-MB x Conventional Agriculture	1.00	0.81	0.90
Mean	3.00	2.58	2.78
F test	ns	ns	**
CV%	7.80	3.00	8.88
LSD(0.05)			0.19

The average net benefit of Dhaulagiri and WK 1204 varieties of wheat produced from the interaction effect of maize-wheat-mungbean cropping system and conservation agricultural practices was found 183.96% higher (NRs.45690 ha^{-1}) than conventional agricultural practices (NRs.16090 ha^{-1}). Similarly, the average net benefit of Shimal and Khajura1 variety of lentil produced from the interaction effect of maize-lentil-mungbean cropping system and conservation agricultural practices was found 62.88% higher (NRs.34710 ha^{-1}) than conventional agricultural practices. The difference in net profit resulted from the interaction effect of cropping systems and cultural practices was found significant ($p<0.01$) in 2016 and over year analysis but it was non-significant in 2015 (Table 6).

Table 6. Interaction effect of cropping system and cultural practices on net benefit of wheat and lentil at CA experiment in Bhagetada, Dipayal, Doti during 2015–2016

Treatments	Net benefit (NRs.000 ha^{-1})		
Cropping system x Cultural practices	2015	2016	Mean
M-W-MB x Conservation Agriculture	53.21	38.17	45.69
M-W-MB x Conventional Agriculture	24.85	7.34	16.09
M-L-MB x Conservation Agriculture	44.81	24.62	34.71
M-L-MB x Conventional Agriculture	21.05	21.58	21.31
Mean	35.98	22.93	29.45
F test	ns	**	**
CV%	23.50	13.80	30.65
LSD(0.05)		5.49	10.50

The mean MEY of Dhaulagiri and WK 1204 varieties resulted from the interaction effect of maize-wheat-mungbean cropping system and conservation agricultural practices was found 7.96% higher (5.97 t ha^{-1}) compared with the mean MEY of conventional agricultural practices (5.53 t ha^{-1}). The average MEY of Shimal and Khajura1 varieties produced from the interaction effect of maize-lentil-mungbean cropping system and conservation agricultural practices was found 11.53% higher (5.03 t ha^{-1}) than conventional agricultural practices (4.51 t ha^{-1}). The difference in MEY obtained from the interaction effect of cropping systems and cultural practices was found significant ($p<0.01$ to $p<0.05$) in 2016 and over year analysis but it was non-significant in 2015 (Table 7).

Table 7. Interaction effect of cropping system and cultural practices on maize equivalent yield of wheat and lentil at CA experiment in Bhagetada, Dipayal, Doti during 2015–2016

Treatments	Maize equivalent yield (t ha^{-1})		
Cropping system x Cultural practices	2015	2016	Mean
M-W-MB x Conservation Agriculture	6.42	5.53	5.97
M-W-MB x Conventional Agriculture	6.04	5.03	5.53
M-L-MB x Conservation Agriculture	5.27	4.79	5.03
M-L-MB x Conventional Agriculture	4.99	4.04	4.51
Mean	5.68	4.85	5.26
F test	ns	**	*
CV%	7.40	3.33	8.57
LSD(0.05)		0.27	0.49

Interaction effect of cropping system, cultural practices and varieties of wheat and lentil

The grain yield produced from the interaction effects of maize-wheat-mungbean cropping system, conservation and conventional agricultural practices and varieties of wheat (Dhaulagiri and WK 1204) were non significant. Interaction effect of maize-lentil-mungbean cropping system, conservation and conventional agricultural practices and varieties of lentil (Shimal and Khajura1) were non significant for grain yield (Table 8).

Table 8. Interaction effect of cropping system, cultural practices and varieties on grain yield of wheat and lentil varieties at CA experiment in Bhagetada, Dipayal, Doti during 2015–2016

Cropping system x cultural practices x varieties	Grain yield (t ha^{-1})		
	2015	2016	Mean
M-W-MB x Conservation Agriculture x Dhaulagiri	5.06	4.46	4.76
M-W-MB x Conventional Agriculture x Dhaulagiri	4.91	4.04	4.47
M-W-MB x Conservation Agriculture x WK 1204	5.21	4.39	4.80
M-W-MB x Conventional Agriculture x WK 1204	4.76	4.01	4.39
Mean	4.98	4.22	4.60
M-L-MB x Conservation Agriculture x Shimal	1.00	0.96	0.98
M-L-MB x Conventional Agriculture x Shimal	0.95	0.81	0.88
M-L-MB x Conservation Agriculture x Khajura1	1.11	0.95	1.03
M-L-MB x Conventional Agriculture x Khajura1	1.04	0.80	0.92
Mean	1.02	0.88	0.95
F test	ns	ns	ns
CV %	10.00	7.90	9.24

The average net benefit produced from the interaction effect of maize-wheat-mungbean cropping system, conservation and conventional agricultural practices and varieties of wheat (Dhaulagiri and WK 1204) were non significant. Similarly, the average net benefit resulted from the interaction effect of maize-lentil-mungbean cropping system, conservation and conventional agricultural practices and varieties of lentil (Shimal and and Khajura 1) were non significant (Table 9).

The average MEY produced from the interaction effect of maize-wheat-mungbean cropping system, conservation and conventional agricultural practices and varieties of wheat (Dhaulagiri, and WK 1204) were non significant. Similarly, interaction effect of maize-lentil-mungbean cropping system, conservation and conventional agricultural practices and varieties of lentil (Shimal and Khajura1) was non significant for MEY (Table 10).

Table 9. Interaction effect of cropping system, cultural practices and varieties of net benefit of wheat and lentil varieties at CA experiment in Bhagetada, Dipayal, Doti during 2015–2016

Cropping system x cultural practices x varieties	Net benefit (NRs.000 ha^{-1})		
	2015	2016	Mean
M-W-MB x Conservation Agriculture x Dhaulagiri	51.34	38.98	45.16
M-W-MB x Conventional Agriculture x Dhaulagiri	26.26	7.73	17.17
M-W-MB x Conservation Agriculture x WK 1204	55.09	37.36	46.22
M-W-MB x Conventional Agriculture x WK 1204	23.09	6.96	15.02
Mean	38.94	22.76	30.89
M-L-MB x Conservation Agriculture x Shimal	39.10	22.79	30.94
M-L-MB x Conventional Agriculture x Shimal	16.68	21.75	19.21
M-L-MB x Conservation Agriculture x Khajura1	50.52	24.44	37.48
M-L-MB x Conventional Agriculture x Khajura1	25.43	21.42	23.42
Mean	32.93	22.60	27.76
F test	ns	ns	Ns
CV %	27.70	31.41	29.56

Table 10. Interaction effect of cropping system, cultural practices and varieties of net benefit of wheat and lentil varieties at CA experiment in Bhagetada, Dipayal, Doti during 2015–2016

Cropping system x cultural practices x varieties	Maize equivalent yield (t ha^{-1})		
	2015	2016	Mean
M-W-MB x Conservation Agriculture x Dhaulagiri	6.33	5.57	5.95
M-W-MB x Conventional Agriculture x Dhaulagiri	6.13	5.05	5.59
M-W-MB x Conservation Agriculture x WK 1204	6.51	5.49	6.00
M-W-MB x Conventional Agriculture x WK 1204	5.96	5.01	5.48
Mean	6.23	5.28	5.75
M-L-MB x Conservation Agriculture x Shimal	4.99	4.80	4.89
M-L-MB x Conventional Agriculture x Shimal	4.77	4.05	4.41
M-L-MB x Conservation Agriculture x Khajura1	5.56	4.78	5.17
M-L-MB x Conventional Agriculture x Khajura1	5.20	4.03	4.61
Mean	5.13	4.41	4.77
F test	ns	ns	ns
CV %	8.81	7.43	8.27

Discussion

The average grain yield, net profit and MEY of the studied wheat and lentil varieties under conservation agricultural practices were found 5.93%, 114.97% and 2.41% higher than the mean grain yield, net profit and MEY of the same varieties of wheat and lentil under conventional agricultural practices. Similarly, the mean grain yield, net profit and MEY of conservation agricultural practices were found 2.88%, 36.50% and 1.04% higher than the overall average grain yield, net profit and MEY of both conservation and conventional agricultural practices respectively.

Interaction effect of maize-wheat-mungbean and conservation agricultural practices produced 7.90%, 183.96% and 9.96% higher average grain yield, net profit and MEY of Dhaulagiri and WK 1204 variety of wheat than the mean grain yield, net profit and MEY produced from the interaction of same cropping system and conventional agricultural practices respectively. Similarly, the average grain yield, net profit and MEY produced from the interaction effect of same cropping system and conservation agricultural practices was found 378%, 31.63% and 18.69% higher compared with the average grain yield, net profit and MEY produced from the interaction effect of maize-lentil-mungbean cropping system and conservation agricultural practices respectively and 71.94%, 55.14% and 13.49% higher than the overall average grain yield, net profit and MEY resulted from the interaction effect of both cropping systems and cultural practices respectively.

The average grain yield, net profit and MEY produced from the interaction effect of maize-wheat-mungbean cropping system, conservation agricultural practices and WK 1204 variety of wheat were found 0.84%, 2.35% and 0.84% higher than the mean grain yield, net profit and MEY obtained from the interaction effect of same cropping system, conservation agricultural practices and Dhaulagiri variety of wheat respectively, 7.38%, 106.19% and 7.33% higher than the average grain yield, net benefit and MEY resulted from the interaction effect of same cropping system, conventional agricultural practices and Dhaulagiri variety of wheat and 4.35%, 49.63% and 4.35% higher than the overall average grain yield, net profit and MEY resulted from the interaction effect of maize-wheat-mungbean cropping system, conservation and conventional agricultural practices and Dhaulagiri and WK 1204 variety of wheat respectively.

Similarly, interaction effect of maize-lentil-mungbean cropping system, conservation agricultural practices and Khajura1 variety of lentil produced 5.10%, 22.14% and 5.73% higher average grain yield, net benefit and MEY than the mean grain yield, net profit and MEY produced from the interaction effect of same cropping system, conservation agricultural practices and Shimal variety of lentil respectively, 17.04%, 95.11% and 17.23% higher than the average grain yield, net profit and MEY resulted from the interaction effect of same cropping system, conventional agricultural practices and Shimal variety of lentil respectively and 8.42%, 35.01% and 8.38% higher than the overall average grain yield, net benefit and MEY resulted from the interaction effect of maize-lentil-mungbean cropping system, conservation and conventional agricultural practices and Shimal and Khajura1 variety of lentil respectively. The average

grain yield, net profit and MEY produced from the interaction effect of maize-wheat-mungbean cropping system, conservation agricultural practices and WK 1204 variety of wheat was found 366.01%, 23.32% and 16.05 higher than the average grain yield, net benefit and MEY resulted from the interaction effect of maize-lentil-mungbean, conservation agricultural practices and Khajura1 variety lentil respectively. So, this experimental results suggest to adopt maize-wheat-mungbean cropping system, conservation agricultural practices and WK 1204 variety of wheat for high grain yield and net profit.

Various researchers also agreed that conservation agriculture contributes to higher crop yield due to increased water holding capacity of soil, improvement in soil fertility and water and nutrient use efficiency. Chaudhary *et al.* (2018) reported maize-wheat-mungbean cropping system is the effective CA base management system. Lumpkin and Sayre (2009) reported 17% saving of water requirement in wheat by the application of CA than conventional agriculture. Soil completely covered with wheat stubbles supports to reduce evaporation loss by 65% compared to bare soil (Klocke *et al.*, 2009). Movement of water through plant is necessary for improving crop growth and yield (Klocke *et al.*, 2009). Water and nutrient use efficiency was observed high in no tilled and stubble mulched field (Hunag *et al.*, 2008). Similarly, Baunhardt *et al.* (2013a; Baunhardt *et al.*, 2013b) reported higher water use efficiency in straw mulched field of both rain-fed and irrigated agriculture. Zero till on wheat cultivation increased production and productivity by 4-10% (Gathala *et al.*, 2011) and enhanced in water and nutrient use efficiency (Jat *et al.*, 2012; Saharawat *et al.*, 2012). Ghosh *et al.* (2015) reported 79% higher grain yield of wheat (1700 kg ha^{-1}) in conservation agriculture than conventional (950 kg ha^{-1}). Bashour *et al.* (2016) reported increase in wheat and lentil yield by 27 and 27.7% under the experimental plots of conservation agriculture than conventional. The same author reported reduction in production cost of wheat and lentil by 23.3 and 17.5% under conservation agriculture than conventional and production return was increase by 28 and 27.7% in wheat and lentil under conservation agriculture than conventional. The same author found output to input ratio of wheat and lentil 3.11 and 7.85 under CA whereas it was 1.86 and 5.07 under conventional agriculture respectively.

Conclusion

The result of this two years experiment suggests to farmers of irrigated river basin agro-environment of far western particularly west Seti river basin areas to adopt maize-wheat-mungbean cropping system, conservation agricultural practices and WK 1204 variety of wheat to achieve high yield and profit.

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