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Effect of conservation agriculture on grain yield and income of maize under maize based cropping system in far western Nepal

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Abstract. The adoption of Conservation agriculture (CA) contributes to sustainable production and its advantages include lower inputs and stable yields. This study was conducted in the research field of Regional Agricultural Research Station, Bhagetada, Dipayal, Doti during 2014 and 2015 to identify the effect of CA on grain yield and income of maize in Maize based cropping system. Both conservation and conventional agricultural (ConvA) practices were evaluated on two maize based cropping systems namely maize-wheat-mungbean (M-W-MB) and maize-lentil-mungbean (M-L-MB). For this purpose two maize varieties namely Raj Kumar and Arun-2 were used. The average productivity of maize under M-L-MB cropping system was 1.6% higher (5.75 t/ha) than M-W-MB cropping system (5.66 t/ha). The average grain yield of maize under CA was 16.7% higher (6.15 t/ha) than ConvA (5.27 t/ha). Rajkumar produced 43% higher average grain yield (6.73 t/ha) than Arun-2 variety (4.69 t/ha). The average net benefit was slightly higher (US\$ 597.33/ha) under M-L-MB cropping system than M-W-MB cropping system (US\$ 573.89/ha). Similarly, the average net benefit from CA was 102% higher (US\$ 783.67/ha) than ConvA (US\$ 386.79/ha). Rajkumar variety gave 127% higher average net benefit (US\$ 813.49/ha) than Arun-2 (US\$ 357.81/ha). The average benefit - cost (B:C) ratio of M-L-MB cropping system was slightly higher (1.72) than the average B:C ratio of M-W-MB cropping system (1.70). The average B:C ratio of CA was 42% higher (2.01) than ConvA (1.41). The average B:C ratio of Rajkumar variety was found 33% higher (1.95) than Arun-2 (1.46). The higher grain yield, net profit and B:C ratio were found in CA practices under M-L-MB cropping system and Rajkumar variety. This study suggests that hybrid maize planting and the adoption of M-L-MB cropping system should be used to increase grain yield and economic performance under CA practices.

Keywords: maize, cropping system, conservation agriculture, grain yield, net return

Introduction

The agriculture and forestry sector contributes about one third (32.6%) of the total gross domestic product of the country. Maize (*Zea mays* L.) is being cultivated in 928761 ha and it is the second most important cereal crop after rice (1486951 ha) in Nepal. The national average productivity of maize is 2458 kg/ha. Out of the total cereal crops cultivating area (3480052 ha) of the nation, maize occupies 26.68% (ABPSD, 2014). Amongst the total edible food available to each person for a year (227.35 kg), maize provides 60.39 kg/person/year (FSED, 2012/2013).

Maize is the third cereal crop after wheat and rice in terms of area (2748 ha) and production (5221 t) in Doti district, Nepal. The productivity of maize in Doti district is 1900 kg/ha, which is 5.8% and 22.7% lower than the average productivity of the far western hills districts and of the nation, respectively. Out of the total irrigable area (10468 ha), only 3145 ha cultivated area of this district is under irrigation facility (ABPSD, 2013).

Continuous application of conventional production practices contributed to reduce crop productivity and soil organic matter, which ultimately contributed to low profit from farm (Sharma and Datta, 1985; Hobbs and Gupta, 2000; Sharma et al., 2003; Gupta and Sayre, 2007). Therefore, it has become challenging to produce more food from the same unit of land. Hence, researchers should take lead to identify an agricultural production system to produce more food at least cost and resources (Gupta and Seth, 2007). Jat et al. (2009) indicated that conservation agriculture (CA) is that agriculture production practice, which makes it possible to get more food from the same resources at least cost.

Conservation agriculture is being applied in many countries as

a promising package and its coverage is estimated at 124 million hectares globally, that is, United States (27 million ha), Brazil (26 million ha), Argentina (26 million ha), Australia (17 million ha) and Canada (14 million ha) and all these countries represent 87% of the global adoption of CA (Friedrich et al., 2011). Besides these countries, adoption of CA is still in the initial phase and it has expanded to cover about 1.5 million ha in India (Jat et al., 2012). CA practices have been identified as one of the best alternatives to conventional agriculture (ConvA) (Karki et al., 2014). No-tillage maize production system supports to conserve soil and water resources. It also contributed to reduce production cost and improved maize yield. However, very limited works have been done so far in Nepal (Karki and Shrestha, 2014b).

Far western agriculture is generally characterized by lower yields and lower inputs used than other developed regions of the country as well as by greater probability of food deficit and climate extremes such as drought. There is therefore potentiality for CA to improve in existing productivity of crops. 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. The Agricultural Perspective Plan of Nepal for 20 years agreed that agriculture is the main basis of poverty alleviation (NARC, 2018). CA based crop management practices across the various agro-ecologies need to be identified and promoted in Nepal (Karki and Shrestha, 2014a). Improved agricultural technologies is not sufficiently available to marginal groups of farmers but CA presents an option with positive experiences of other countries. The objective of the study was to evaluate the crop yields and economic return of conservation agriculture systems, and to identify suitable cropping system for yield and economic returns under CA system.

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Material and methods

Experimental location

This experiment was carried out in the research field of Regional Agricultural Research Station (RARS), Bhagetada, Dipayal, Doti, Nepal in 2014 and 2015. It is located at the latitude of N 29°15'16.4" and longitude of E 80°55'59.3" (Prasai et al., 2016). RARS is situated at the bank of Seti River with the altitude of 546m above sea level and it represents an irrigated river basin agro-environment of the far western hills of the country.

Plant materials

Two varieties of maize, namely Rajkumar and Arun-2 were used in this study. Rajkumar is a hybrid maize variety, registered in Nepal in 2010. The yield potential of this variety is 8-9 t/ha and maturity is 100-110 days. Similarly, Arun-2 is an open pollinated maize variety, introduced in 1982. The origin of this variety is Mexico CIMMYT (NARC, 2018). Its yield potential is 3 t/ha and maturity is 80-90 days.

Arun-2 was obtained from National Maize Research Program, Rampur, Chitwan, Nepal. Rajkumar was collected from Dawadi Agrovet, Chitwan, Nepal.

Agrometeorological observation

The maximum and minimum temperature of the entire crop growing season that is, seeding to tasseling, tasseling to silking and silking to maturity of Rajkumar variety was found higher in 2014 than 2015. The maximum and minimum temperature during the crop stage of seeding to tasseling and silking to maturity of Arun-2 variety was found higher in 2014 than 2015 whereas the maximum and minimum temperature during tasseling to silking crop stage of Arun-2 variety was found higher in 2015 than 2014 (Table 1).

The total rainfall of maize growing season of both varieties was found higher in 2014 than 2015. The total rainfall during the crop stage of seeding to tasseling and silking to maturity of both varieties was found higher in 2014 than 2015 whereas total rainfall during the crop stage of tasseling to silking of both varieties was found higher in 2015 than 2014 (Table 2).

Table 1. Maximum and minimum temperatures (°C) of maize growing season, 2014-2015

Crop stage	2014				2015			
	Max		Min		Max		Min	
	Rajkumar	Arun-2	Rajkumar	Arun-2	Rajkumar	Arun-2	Rajkumar	Arun-2
Seeding to tasseling	34.7	34.9	23.9	23.9	32.9	32.9	23.1	22.8
Tasseling to silking	33.5	32.6	24.2	23.9	31.7	33.2	23.6	24.5
Silking to maturity	34.1	34.4	21.7	23.4	33.6	34.2	20.4	22.4

Table 2. Rainfall (mm) of maize growing season, 2014-2015

Crop stage	2014		2015	
	Rajkumar	Arun-2	Rajkumar	Arun-2
Seeding to tasseling	367.6	362.1	319.0	311.0
Tasseling to silking	11.4	5.5	61.0	8.0
Silking to maturity	189.6	187.5	82.9	82.9
Total for crop season	568.6	555.1	533.0	401.0

Experimental design and treatment detail

The split-split plot design was applied during the layout of the experiment and the experiment was replicated four times (Table 3). 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 (M-W-MB) and maize-lentil-mungbean (M-L-MB) 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 factors.

Table 3. Treatment details of the experiment

S.N.	Particulars
Main plot	Cropping system
1.	Maize-wheat-mungbean (M-W-MB)
2.	Maize-lentil-mungbean (M-L-MB)
Sub plot	Cultural practices
1.	Conservation agriculture (CA)
2.	Conventional agriculture (ConvA)
Sub sub plot	Variety
1.	Rajkumar
2.	Arun-2

Cultural practices

The whole experimental area was irrigated before seeding of the experiment. In conservation practices, there was no tillage of the plots and small furrows were open with the help of a small pointed kuto. Farm yard manure and chemical fertilizers were placed into furrows and were mixed with soil before seeding in the conservation plots whereas conventional plots were tilled. A small hole was made with the help of a peg and seed was dropped into the hole and was covered with soil. The maize stover were cut above 30cm above and spreaded over plots of conservation agriculture whereas the stoves were cut from ground surface and were removed from the plots of

conventional practices. Three tillage was done by small hand tractor in the whole plots of the conventional practices. The farm yard manure fertilizer was sprayed in the conventional plots before tilling the plots and chemical fertilizers were applied and mixed with soil after tilling the plots. Row to row and plant to plant spacing was maintained by 75×25cm. The farm yard manure was applied at the rate of 10 t/ha and chemical fertilizer was applied at the rate of 120:60:40 NPK kg/ha. Nitrogen fertilizer was applied in two split doses whereas phosphorus and potassium fertilizers were applied as basal dose. Three irrigations; before seeding, 30 and 60 days after seeding were applied in all experimental plots. The plot size was 18m². The detail of the production cost was as below (Table 4).

Table 4. Production cost of maize in the conservation and conventional agriculture experimental plots

Production variables	Production cost (US\$/plot*)			
	Conservation practices		Conventional practices	
	Rajkumar	Arun-2	Rajkumar	Arun-2
Land preparation	-	-	0.17	0.17
Compost	0.15	0.15	0.15	0.15
Urea, DAP, Potash	0.24	0.24	0.24	0.24
Seed	0.14	0.03	0.14	0.03
Plot preparation and seeding	0.36	0.36	0.41	0.41
Cost of residues	0.05	0.05	-	-
Intercultural operation + irrigation	0.15	0.15	0.30	0.30
Harvesting shelling	0.28	0.28	0.28	0.28
Seed drying	0.06	0.06	0.06	0.06
Total cost	1.43	1.32	1.75	1.64

*US\$ 1= NRs. 119.03

Data collection

Using the formula below adopted by Carangal (1971), Shrestha et al. (2018) and Kandel et al. (2018) grain yield (kg/ha) at 15% moisture content was estimated:

$$\text{Grain yield } \left(\frac{\text{kg}}{\text{ha}} \right) = \frac{\text{F.W. (plot)} \times (100 - \text{HMP}) \times \text{S} \times 10000}{(100 - \text{DMP}) \times \text{NPA}}$$

Where:

F.W. = Fresh weight of ear in kg per plot at harvest;

HMP = Grain moisture percentage at harvest;

DMP = Desired moisture percentage, 15%;

NPA = Net harvest plot area, m²;

S = Shelling coefficient, 0.8.

Economic analysis

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

Net Income = Gross income – Total cost.

Similarly, the benefit-cost ratio (B:C) ratio was calculated by the following formula adopted by BK and Shrestha, 2014 and Shrestha,

2015.

B:C ratio = Gross income/Total cost.

The NRs was converted to US \$, where US\$ 1= NRs. 119.03 at exchange rate of 11 October, 2018.

Soil moisture content

Soil sample was taken from 0-15cm depth from each plot and the sample was put into the soil moisture box and the moisture boxes were of 100g capacity. After weighting and recording the fresh weight of the sample, it was dried in an oven at constant temperature of 105°C for 72h to get constant dry weight. Soil moisture content was calculated by using the formula of Balasubramaniyan and Palaniappan (2014):

$$\text{Soil moisture content (\%)} = \frac{\text{Weight of moist sample (g)} - \text{Weight of oven dry sample (g)}}{\text{Weight of oven dry sample (g)}} \times 100$$

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 significance differences among the means were tested using least significance difference (LSD) at 5% (Williams and Abdi, 2010; Baral et al., 2016).

Results

Effect of conservation agriculture on maize yield

Conservation agriculture (CA) practice produced 25% higher grain yield (5.79 t/ha) than conventional (4.62 t/ha) in 2014. Similarly, CA recorded about 10% higher grain yield (6.50 t/ha) than conventional agriculture (ConvA) practice (5.91 t/ha) in 2015, too. The difference in grain yield between conservation and conventional

practices was found significant ($p<0.05$ - $p<0.01$) in both years. The mean grain yield of maize produced under M-L-MB cropping system was found 1.6% higher (5.75 t/ha) than M-W-MB cropping system (5.66 t/ha). In case of variety, Rajkumar produced 43.5% higher average grain yield (6.73 t/ha) than Arun-2 (4.69 t/ha) and statistically the difference in grain yield between the two varieties was found significant ($p<0.01$) in both years (Table 5).

Table 5. Individual effects of cropping systems, cultural practices and varieties on grain yield of maize at conservation agriculture experiment, 2014-2015

Cropping system	Grain yield of maize (t/ha)						
	2014	2015	Mean	Varities	2014	2015	Mean
M-W-MB	5.10	6.23	5.66	Rajkumar	6.20	7.25	6.73
M-L-MB	5.32	6.19	5.75	Arun-2	4.21	5.16	4.69
Mean	5.21	6.21	5.71	Mean	5.21	6.21	5.71
F test	**	ns	ns	F test	**	**	**
CV, %	0.7	4.0	6.19	LSD (0.05)	0.347	0.424	0.259
LSD (0.05)	0.082						
Cultural practices							
Conservation agriculture	5.79	6.50	6.15				
Conventional agriculture	4.62	5.91	5.27				
Mean	5.21	6.21	5.71				
F test	**	*	**				
LSD (0.05)	0.595	0.392	0.318				

*Values are significantly different at 5% level of significance, **highly significantly different at 1% level of significance, ns: Non significant, M-W-MB: Maize-wheat-mungbean, M-L-MB: Maize-lentil-mungbean

Interaction effect of cropping systems and cultural practices indicated that interaction of M-L-MB cropping system and CA practices resulted in 1.6% higher mean grain yield (6.19 t/ha) than the average grain yield obtained from the interaction of M-W-MB cropping system and CA practices (6.09 t/ha). Similarly, interaction effect of M-W-MB cropping system and CA practices produced 16% higher mean grain yield (6.09 t/ha) compared with the mean grain yield obtained from the interaction effect of same cropping system and ConvA practices (5.22 t/ha). Interaction of M-L-MB cropping

system and CA practices resulted in 16% higher average grain yield (6.19 t/ha) than the average grain yield recorded from the interaction of the same cropping system and ConvA practices (5.31 t/ha). Interaction effect of CA practice with both cropping systems indicated 16% higher grain yield (6.14 t/ha) compared with the average grain yield (5.26 t/ha) resulting from the interaction effect of ConvA practices with both cropping systems (Table 6).

Table 6. Interaction effect of cropping system and cultural practices on grain yield of maize at conservation agriculture experiment, 2014-2015.

Cropping system	Cultural practices					
	Grain yield of maize (t/ha)					
	Conservation agriculture			Conventional agriculture		
	2014	2015	Mean	2014	2015	Mean
M-W-MB	5.79	6.40	6.09	4.40	6.05	5.22
M-L-MB	5.79	6.60	6.19	4.85	5.78	5.31
Mean	5.79	6.50	6.14	4.62	5.91	5.26
F test	ns	ns	ns			
CV, %	9.3	5.2	10.23			

*ns: Non-significant, M-W-MB: Maize-wheat-mungbean, M-L-MB: Maize-lentil-mungbean

Regarding the interaction effect of cropping systems with varieties, about 4% higher mean grain yield was produced from the interaction of M-L-MB cropping system with Rajkumar variety (6.85 t/ha) than grain yield recorded from the interaction effect of M-W-MB cropping system with Rajkumar (6.60 t/ha). Similarly, 1.5% higher

grain yield was recorded from the interaction effect of M-L-MB cropping system with Arun-2 variety (4.72 t/ha) than the mean grain yield (4.65 t/ha) in the interaction of the same variety with M-W-MB cropping system (Table 7).

Table 7. Interaction effect of cropping system and varieties on grain yield of maize in conservation agriculture experiment, 2014-2015

Cropping system	Grain yield of maize (t/ha)					
	Rajkumar			Arun-2		
	2014	2015	Mean	2014	2015	Mean
M-W-MB	5.99	7.21	6.60	4.22	5.09	4.65
M-L-MB	6.42	7.29	6.85	4.20	5.24	4.72
Mean	6.20	7.25	6.72	4.21	5.16	4.68
F test	ns	ns	ns			

*ns: Non-significant, M-W-MB: Maize-wheat-mungbean, M-L-MB: Maize-lentil-mungbean

Interaction of CA practices with Rajkumar variety recorded 17% higher average grain yield (7.27 t/ha) than the grain yield resulting from interaction of ConvA practices with the same variety (6.18 t/ha). Similarly, 15% higher mean grain yield resulted from the interaction

effect of CA practice with Arun-2 variety (5.02 t/ha) compared with the average grain yield produced from the interaction effect of ConvA practices with the same variety (4.35 t/ha) (Table 8).

Table 8. Interaction effect of cultural practices and varieties on grain yield of maize at conservation agriculture experiment, 2014-2015

Cultural practices	Grain yield of maize (t/ha)					
	Rajkumar			Arun-2		
	2014	2015	Mean	2014	2015	Mean
CA	6.91	7.62	7.27	4.67	5.37	5.02
ConvA	5.50	6.87	6.18	3.75	4.96	4.35
Mean	6.20	7.24	6.72	4.21	5.16	4.68
F test	ns	ns	ns			

*ns: Non-significant, CA: Conservation agriculture, ConvA: Conventional agriculture

Regarding the interaction effect of cropping systems, cultural practices and varieties on grain yield of maize, interaction effect of M-W-MB cropping system and CA practice with Rajkumar variety produced 17% higher mean grain yield (7.13 t/ha) than the mean grain yield of ConvA practices (6.07 t/ha). Similarly, interaction effect of M-W-MB cropping system and CA with Arun-2 variety recorded 15% higher grain yield (5.06 t/ha) than ConvA practices (4.39 t/ha). Interaction effect of M-L-MB cropping system and CA practice with Rajkumar variety produced 17% higher mean grain yield (7.40 t/ha) than the mean grain yield from interaction with ConvA practices (6.30 t/ha) whereas 15% higher mean grain yield of maize was produced from interaction effect of M-L-MB cropping system and CA practices with Arun-2 (4.98 t/ha) than ConvA practices (4.32 t/ha). Interaction effect of M-L-MB cropping system, CA practices and Rajkumar variety recorded about 4% higher mean grain yield than from interaction effect of M-W-MB cropping system with the same cultural practices and variety whereas interaction effect M-L-MB

cropping system and CA practices with Arun-2 variety recorded 1.6% lower mean grain yield than from interaction of M-W-MB cropping system with the same cultural practices and variety (Table 9).

Effect of conservation agriculture on profitability from maize crop

Production cost of maize. The average production cost of maize seeded in 2014-2015 under M-W-MB and M-L-MB cropping systems was found at par (US\$ 886.58/ha). The average production cost of maize seeded under CA practices was found 18.7% lower (US\$ 764.68/ha) than ConvA practices (US\$ 941.36/ha). Similarly, the production cost of Rajkumar variety was found 7% higher (US\$ 882.38/ha) than the production cost of Arun-2 (US\$ 823.57/ha). The production cost of Rajkumar variety was high due to the high price of seed of hybrid variety than open pollinated (Figure 1).

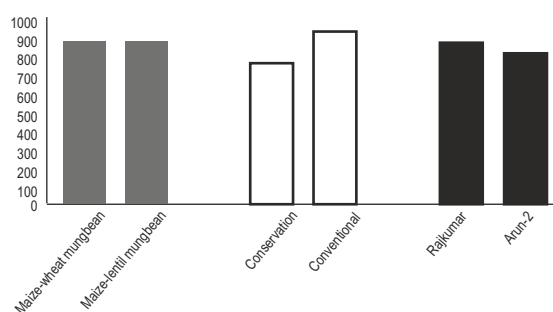


Figure 1. Production cost (US\$/ha) of maize crop under conservation agriculture experiment, 2014-2105

Table 9. Interaction effect of cropping system, cultural practices and varieties on grain yield of maize at conservation agriculture experiment, 2014-2015

Cultural practices	Cropping system											
	Maize-wheat-mungbean						Maize-lentil-mungbean					
	Grain yield (t/ha)						Grain yield (t/ha)					
	Rajkumar			Arun-2			Rajkumar			Arun-2		
	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean
CA	6.86	7.41	7.13	4.72	5.39	5.06	6.96	7.86	7.40	4.72	5.35	4.98
ConvA	5.12	7.01	6.07	3.68	5.10	4.39	5.88	6.73	6.30	3.81	4.82	4.32
Mean	5.99	7.21	6.60	4.20	5.24	4.72	6.42	7.29	6.85	4.26	5.08	4.65
F test	ns	ns	ns									
CV, %	8.6	8.9	8.80									

*ns: Non-significant, CA: Conservation agriculture, ConvA: Conventional agriculture

Table 10. Individual effects of cropping systems, cultural practices and varieties on net benefit and benefit - cost ratio of maize crop in conservation agriculture experiment, 2014-2015

Cropping system	Net benefit (US \$/ha)			Benefit - cost ratio (B:C)		
	2014	2015	Mean	2014	2015	Mean
M-W-MB	431.40	716.46	573.89	1.54	1.86	1.70
M-L-MB	487.52	707.13	597.33	1.59	1.85	1.72
Mean	459.46	711.75	585.57	1.56	1.85	1.71
F test	**	ns	ns	**	ns	ns
CV, %	2.0	8.7	15.2	0.4	3.9	6.06
LSD (0.05)	20.67			0.013		
Cultural practices						
CA	694.78	874.15	784.46	1.90	2.13	2.01
ConvA	224.15	549.36	386.75	1.23	1.58	1.41
Mean	459.46	711.75	585.60	1.56	1.85	1.71
F test	**	**	**	**	**	**
LSD (0.05)	150.05	99.97	80.23	0.16	0.13	0.12
Varieties						
Rajkumar	681.51	945.48	813.49	1.81	2.10	1.95
Arun-2	237.42	478.11	357.81	1.32	1.61	1.46
Mean	459.46	711.75	585.65	1.56	1.85	1.70
F test	**	**	**	**	**	**
LSD (0.05)	87.37	107.45	65.36	0.09	0.13	0.11

**highly significantly different at 1% level of significance, ns: Non-significant, M-W-MB: Maize-wheat-mungbean, M-L-MB: Maize-lentil-mungbean

Net benefit and benefit - cost ratio of maize production under CA experiment. The average net benefit from maize crop seeded under the experimental plots of M-L-MB cropping system was found 4% higher (US\$ 597.33/ha) than M-W-MB cropping system (US\$ 573.89/ha). Similarly, benefit - cost (B:C) ratio of maize crop studied under M-L-MB cropping system was found 1.72 whereas it was 1.70 in M-W-MB cropping system. The net benefit from the maize crop studied under the experimental plots of CA was found 200% higher (US\$ 694.78/ha) than CA (US\$ 224.15/ha) in 2014 and in 2015, it was 59% higher (US\$ 874.15/ha) than ConvA (US\$ 549.36/ha). The difference in net benefit between CA and ConvA agriculture was found significant ($p < 0.01$) in both years. Similarly, the B:C ratio of the maize crop studied under CA was found 54% higher (1.90) than ConvA (1.23) in 2014 whereas it was 34% higher (2.13) in CA than ConvA (1.58) in 2015. The difference in B:C ratio between conservation and conventional agriculture was found statistically significant ($p < 0.01$) in both years. The variety Rajkumar recorded 127% higher average net benefit (US\$ 813.49/ha) than Arun-2 (US\$ 357.81/ha). The difference in net benefit between the two varieties was found significant ($p < 0.01$) in both years. The average benefit -

cost ratio of Rajkumar variety was found 33% higher (1.95) than Arun-2 (1.46). The difference in benefit - cost ratio between the two varieties was found significant ($p < 0.01$) in both years (Table 10).

Interaction effect of M-W-MB cropping system and CA recorded 106% higher average net benefit (US\$ 772.1/ha) than the net benefit obtained from the interaction effect of the same cropping system and ConvA (US\$ 373.9/ha). Similarly, the interaction effect of M-L-MB cropping system and CA resulted in 100 higher average net benefit (US\$ 797.3/ha) than the net benefit resulting from the interaction effect of the same cropping system and ConvA practices (US\$ 397.4/ha). Regarding the interaction effect of cropping system and cultural practices on benefit-cost ratio, the interaction effect of M-W-MB cropping system and CA recorded 43.9% higher average B:C ratio (2.00) than the average B:C ratio obtained from the interaction effect of the same cropping system and ConvA (1.39). Similarly, interaction of M-L-MB cropping system and CA recorded 43.9% higher average B:C ratio (2.03) than the average B:C ratio (1.41) obtained from the interaction of the same cropping system and ConvA (Table 11).

Table 11. Interaction effect of cropping system and cultural practices on net benefit and benefit - cost ratio of maize crop in conservation agriculture experiment, 2014-2015

Cropping system	Cultural practices											
	Net benefit (US \$/ha)						Benefit - cost ratio (B:C)					
	CA			ConvA			CA			ConvA		
	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean
M-W-MB	694.8	848.5	772.1	162.9	584.7	373.9	1.90	2.10	2.00	1.17	1.61	1.39
M-L-MB	694.8	899.8	797.3	280.6	515.0	397.4	1.90	2.16	2.03	1.29	1.54	1.41
Mean	694.8	873.7	784.7	221.8	549.4	385.6	1.90	2.13	2.01	1.23	1.57	1.40
F test	ns	ns	ns				ns	ns	ns			
CV, %	26.7	11.5	25.2				8.5	5.7	10.2			

*ns: Non-significant, CA: Conservation agriculture, ConvA: Conventional agriculture, M-W-MB: Maize-wheat-mungbean, M-L-MB: Maize-lentil-mungbean

Interaction effect of M-W-MB cropping system and Rajkumar variety recorded 112% higher average net profit (US\$ 780.5/ha) compared with the average net profit obtained from the interaction of the same cropping system and Arun-2 (US\$ 367.1/ha). Similarly, interaction effect of M-L-MB cropping system and Rajkumar variety indicated 142% higher average net profit (US\$ 846/ha) than the average net profit resulting from the interaction effect of M-L-MB cropping system and Arun-2 (US\$ 348.6/ha). Regarding the interaction effect of cropping system and varieties on benefit - cost

ratio, 30.6% higher average B:C ratio was found from the interaction effect of M-W-MB cropping system and Rajkumar (1.92) than the average benefit - cost ratio revealed from the interaction effect of the same cropping system and Arun-2 (1.47) whereas interaction effect of M-L-MB cropping system and Rajkumar variety recorded 37% higher average B:C ratio (1.99) compared with the average B:C ratio resulting from the interaction of the same cropping system and Arun-2 (1.45) (Table 12).

Table 12. Interaction effect of cropping system and varieties on net benefit and benefit - cost ratio of maize crop at conservation agriculture experiment, 2014-2015

Cropping system	Net benefit (US \$/ha)						Benefit - cost ratio (B:C)					
	Rajkumar			Arun-2			Rajkumar			Arun-2		
	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean
M-W-MB	626.7	935.1	780.5	236.1	498.2	367.1	1.75	2.09	1.92	1.32	1.62	1.47
M-L-MB	735.9	956.1	846.0	238.6	457.9	348.6	1.87	2.12	1.99	1.32	1.58	1.45
Mean	681.3	945.1	813.2	236.9	478.0	357.9	1.81	2.10	1.95	1.32	1.60	1.46
F test	ns	ns	ns				ns	ns	ns			

*ns: Non-significant, M-W-MB: Maize-wheat-mungbean, M-L-MB: Maize-lentil-mungbean

Interaction effect of CA and Rajkumar variety indicated 77% higher average net benefit (US\$ 1041.7/ha) compared with the average net benefit obtained from the interaction effect of ConvA and the same variety (US\$ 588.1/ha). Similarly, interaction effect of CA and Arun-2 variety showed 186% higher average net benefit (US\$ 530.1/ha) than the average net benefit revealed from the interaction of ConvA and the same variety (US\$ 185.7/ha).

Regarding the interaction effect of cultural practices and varieties on B:C ratio, interaction effect of CA and Rajkumar variety indicated 43.7% higher average B:C ratio (2.30) than the B:C ratio obtained from the interaction effect of ConvA and the same variety (1.60) whereas interaction effect of CA and Arun-2 variety recorded 43.3% higher average B:C ratio (1.72) than the B:C ratio resulting from the interaction effect of ConvA and the same variety (1.20) (Table 13).

Table 13. Interaction effect of cultural practices and varieties on net benefit and benefit - cost ratio of maize crop at conservation agriculture experiment, 2014-2015

Cultural practices	Net benefit (US \$/ha)						Benefit - cost ratio (B:C)					
	Rajkumar			Arun-2			Rajkumar			Arun-2		
	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean
CA	946.8	1138.3	1041.71	441.9	618.3	530.1	2.19	2.42	2.30	1.60	1.84	1.72
ConvA	415.9	760.3	588.1	32.8	337.7	185.7	1.43	1.78	1.60	1.04	1.37	1.20
Mean	681.3	949.3	815.8	236.9	478.0	357.8	1.81	2.10	1.95	1.32	1.60	1.46
F test	ns	ns	ns				*	ns	ns			
LSD (0.05)							0.18					

*Values are significantly different at 5% level of significance, ns: Non-significant, CA: Conservation agriculture, ConvA: Conventional agriculture

Regarding the interaction effect of cropping system, cultural practices and varieties, interaction effect of M-W-MB cropping system and CA with Rajkumar variety resulted in 79.8% higher average net benefit (US\$ 1003.9/ha) than the average net benefit obtained from the interaction effect of the same cropping system and ConvA with the same variety (US\$ 557.8/ha). Similarly, the interaction effect of M-W-MB cropping system and CA with Arun-2 variety indicated 177% higher average net benefit (US\$ 539.4/ha) compared with the average net benefit recorded from the interaction effect of the same cropping system and ConvA with the same variety

(US\$ 194.9/ha). The interaction effect of M-L-MB cropping system and CA with Rajkumar variety recorded 73% higher average net benefit (US\$ 1073.7/ha) than the average net benefit produced from the interaction effect of the same cropping system and ConvA with the same variety (Rs.US\$ 618.3/ha) whereas the interaction effect of the same cropping system and CA with Arun-2 variety recorded 195% higher average net benefit (US\$ 520.9/ha) compared with the average net benefit recorded from the interaction effect of the same cropping system and ConvA with the same variety (US\$ 176.6/ha) (Table 14).

Table 14. Interaction effect of cropping system, cultural practices and varieties on net benefit of maize crop at conservation agriculture experiment, 2014-2015

Cultural practices	Cropping system											
	Maize-wheat-mungbean						Maize-lentil-mungbean					
	Net benefit (US \$/ha)						Benefit - cost ratio (B:C)					
	Rajkumar			Arun-2			Rajkumar			Arun-2		
	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean
CA	942.6	1073.7	1003.9	455.3	623.4	539.4	960.3	1187.1	1073.7	429.3	612.4	520.9
ConvA	318.4	796.4	557.8	16.80	372.2	194.9	511.6	725.0	618.3	48.7	304.1	175.6
Mean	630.9	935.1	780.5	236.1	497.3	375.5	735.9	956.1	846.0	238.6	457.9	347.8
F test	ns	ns	ns									
CV, %	24.7	19.5	21.64									

*ns: Non-significant, CA: Conservation agriculture, ConvA: Conventional agriculture

Interaction effect of M-W-MB cropping system and CA with Rajkumar variety resulted in 43.9% higher average B:C ratio (2.26) than the average B:C ratio recorded from the interaction effect of the same cropping system and ConvA with the same variety (1.57). Similarly, the interaction effect of the same cropping system and CA with Arun-2 variety produced 42.9% higher average B:C ratio (1.73) than the average B:C ratio resulting from the interaction effect of the same cropping system and ConvA with the same variety (1.21) whereas the interaction effect of M-L-MB cropping system and CA

with Rajkumar variety recorded 43.3% higher average B:C ratio (2.35) compared with the average B:C ratio indicated from the interaction effect of the same cropping system and ConvA with the same variety (1.64). Similarly, interaction effect of the same cropping system and CA with Arun-2 variety recorded 43.7% higher average B:C ratio (1.71) than the average B:C ratio (1.19) resulting from the interaction effect of the same cropping system and ConvA with Arun-2 variety (Table 15).

Table 15. Interaction effect of cropping system, cultural practices and varieties on benefit - cost ratio of maize crop in conservation agriculture experiment, 2014-2015

Cultural practices	Cropping system											
	Maize-wheat-mungbean						Maize-lentil-mungbean					
	Benefit - cost ratio (B:C)											
	Rajkumar			Arun-2			Rajkumar			Arun-2		
	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean
CA	2.18	2.35	2.26	1.62	1.85	1.73	2.21	2.49	2.35	1.58	1.83	1.71
ConvA	1.33	1.82	1.57	1.02	1.41	1.21	1.53	1.75	1.64	1.05	1.33	1.19
Mean	1.75	2.08	1.91	1.32	1.63	1.47	1.87	2.12	1.99	1.31	1.58	1.45
F test	ns	ns	ns									
CV, %	8.2	9.1	8.8									

*ns: Non-significant, CA: Conservation agriculture, ConvA: Conventional agriculture

Soil moisture. Soil moisture of the CA experimental plots were recorded from 30 to 90 days after seeding in 7 days' interval. The average soil moisture of the experimental plots under maize-wheat-mungbean was found slightly higher (10.91%) than the experimental plots of maize-lentil-mungbean cropping system (10.87%). The average soil moisture recorded from the CA experimental plots were found 9.4% higher (11.41%) than the average soil moisture recorded from the experimental plots of ConvA (10.43%). The difference in soil

moisture between CA and ConvA agriculture was found significant ($p < 0.05$ - $p < 0.01$) in all readings except the readings of 90 days after seeding. Although the difference in soil moisture between their two varieties was not found statistically significant, the average soil moisture of the Rajkumar variety seeded experimental plots were found 2.5% higher (11.02%) than Arun-2 variety seeded experimental plots (10.75%) (Table 16).

Table 16. Individual effects of cropping systems, cultural practices and varieties on soil moisture of maize crop in conservation agriculture experiment, 2015

Cropping system	Soil moisture from 30 to 90 days after seeding, %					Mean
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	
M-W-MB	10.89	10.45	11.37	12.00	9.85	10.91
M-L-MB	10.26	10.66	11.76	11.57	10.08	10.87
Mean	10.57	10.55	11.56	11.78	9.96	10.89
F test	ns	ns	ns	ns	ns	
CV, %	4.6	3.1	6.2	7.8	5.4	
Cultural practices						
CA	11.06	11.10	12.11	12.61	10.17	11.41
ConvA	10.08	10.01	11.01	10.96	9.97	10.43
Mean	10.57	10.55	11.56	11.78	10.07	10.92
F test	*	**	**	*	ns	
LSD (0.05)	0.79	0.64	0.44	1.20		
Varieties						
Rajkumar	10.90	10.88	11.66	11.73	9.93	11.02
Arun-2	10.24	10.23	11.46	11.84	10.00	10.75
Mean	10.57	10.55	11.56	11.78	9.96	10.88
F test	ns	ns	ns	ns	ns	

*Values are significantly different at 5% level of significance, **highly significantly different at 1% level of significance, ns: Non-significant, DAS: Days after seeding, M-W-MB: Maize-wheat-mungbean, M-L-MB: Maize-lentil-mungbean

Interaction effect of M-W-MB cropping system and CA resulted in 10.8% higher average soil moisture (11.47%) than the average soil moisture recorded from the interaction effect of the same cropping system and ConvA (10.35%). Similarly, the interaction

effect of M-L-MB cropping system and CA produced 9.25% higher average soil moisture (11.34%) than the average soil moisture (10.38%) obtained from the interaction effect of the same cropping system and ConvA (Table 17).

Table 17. Interaction effect of cropping system and cultural practices on soil moisture of maize crop in conservation agriculture experiment, 2015

Cropping system	Soil moisture from 30 to 90 days after seeding, %											
	Conservation agriculture						Conventional agriculture					
	30	45	60	75	90	Mean	30	45	60	75	90	Mean
M-W-MB	11.28	10.89	12.07	13.16	9.97	11.47	10.49	10.02	10.66	10.84	9.74	10.35
M-L-MB	10.84	11.31	12.15	12.06	10.34	11.34	9.67	10.01	11.36	11.08	9.80	10.38
Mean	11.06	11.10	12.11	12.61	10.15	11.40	10.08	10.03	11.01	10.96	9.77	10.36
F test	ns	ns	ns	ns	ns							
CV, %	6.10	5.00	3.10	8.30	4.10							

*ns: Non-significant, M-W-MB: Maize-wheat-mungbean, M-L-MB: Maize-lentil-mungbean

The interaction effect of M-W-MB cropping system and Rajkumar variety indicated slightly higher average soil moisture (10.98%) than the average soil moisture obtained from the interaction of the same cropping system and Arun-2 variety (10.84%) whereas the interaction effect of M-L-MB cropping system

and Rajkumar variety resulted in 3.6% higher average soil moisture (11.06%) than the average soil moisture obtained from the interaction effect of the same cropping system and Arun-2 variety (10.67%) (Table 18).

Table 18. Interaction effect of cropping system and varieties on soil moisture of maize crop in conservation agriculture experiment, 2015

Cropping system	Soil moisture from 30 to 90 days after seeding (%)											
	Rajkumar						Arun-2					
	30	45	60	75	90	Mean	30	45	60	75	90	Mean
M-W-MB	11.15	10.68	11.43	11.74	9.91	10.98	10.62	10.22	11.30	12.25	9.79	10.84
M-L-MB	10.65	11.08	11.90	11.72	9.95	11.06	9.86	10.25	11.62	11.42	10.21	10.67
Mean	10.90	10.88	11.66	11.73	9.93	11.02	10.24	10.23	11.46	11.83	10.00	10.75
F test	ns	ns	ns	ns	ns							

*ns: Non-significant, M-W-MB: Maize-wheat-mungbean, M-L-MB: Maize-lentil-mungbean

Interaction effect of CA and Rajkumar variety indicated 12.3% higher average soil moisture (11.66%) than the average soil moisture obtained from the interaction effect of ConvA and the same variety (10.38%). Similarly, the interaction effect of CA and Arun-2

variety recorded 7.8% higher average soil moisture (11.16%) than the average soil moisture resulting from the interaction effect of ConvA and the same variety (10.35%) (Table 19).

Table 19. Interaction effect of cultural practices and varieties on soil moisture of maize crop in conservation agriculture experiment, 2015

Cultural practices	Soil moisture (%) at 15 days interval from 30 to 90 days after seeding											
	Rajkumar						Arun-2					
	30	45	60	75	90	Mean	30	45	60	75	90	Mean
CA	11.59	11.40	12.33	12.78	10.20	11.66	10.53	10.80	11.89	12.44	10.13	11.16
ConvA	10.21	10.36	11.00	10.68	9.66	10.38	9.94	9.67	11.03	11.24	9.88	10.35
Mean	10.9	10.9	11.7	11.7	9.93	11.02	10.23	10.23	11.46	11.84	10.00	10.75
F test	ns	ns	ns	ns	ns							

*ns: Non-significant, CA: Conservation agriculture, ConvA: Conventional agriculture

Regarding the interaction effect of cropping system, cultural practices and variety, interaction of M-W-MB cropping system and CA with Rajkumar variety recorded 9% higher average soil moisture (11.46%) than the average soil moisture obtained from the interaction of the same cropping system and ConvA with the same variety (10.51%) whereas the interaction of the same cropping system and CA with Arun-2 variety recorded 12.28% higher average soil moisture (11.43%) compared with the average soil moisture resulting from the interaction effect of the same cropping system and ConvA with the same variety (10.18%). Similarly, the interaction

effect of M-L-MB cropping system and CA with Rajkumar variety recorded 9.7% higher average soil moisture (11.87%) than the average soil moisture recorded from the interaction of the same cropping system and ConvA and the same variety (10.25%) whereas the interaction of the same cropping system and CA with Arun-2 variety indicated 2.8% higher average soil moisture (10.82%) compared with the average soil moisture (10.52%) resulting from the interaction effect of the same cropping system and ConvA with the same variety (Table 20).

Table 20. Interaction effect of cultural practices, cropping system and varieties on soil moisture of maize crop in conservation agriculture experiment, 2015

Cropping system	Soil moisture (%) at 15 days interval from 30 to 90 days after seeding											
	Conservation agriculture					Cultural practices						
	30	45	60	75	90	Mean	30	45	60	75	90	Mean
M-W-MB						Rajkumar						
	11.66	10.94	11.91	12.78	10.00	11.46	10.64	10.42	10.95	10.70	9.83	10.51
						Arun-2						
	10.90	10.83	12.23	13.54	9.64	11.43	10.33	9.61	10.37	10.97	9.64	10.18
M-L-MB						Rajkumar						
	11.52	11.85	12.76	12.79	10.41	11.87	9.78	10.30	11.04	10.65	9.49	10.25
						Arun-2						
	10.16	10.77	11.55	11.33	10.31	10.82	9.56	9.72	11.69	11.51	10.11	10.52
F test	ns	ns	ns	ns	ns							
CV, %	10.50	8.00	10.90	8.00	9.0							

*ns: Non-significant, M-W-MB: Maize-wheat-mungbean, M-L-MB: Maize-lentil-mungbean

Discussion

The average productivity of maize under M-L-MB cropping system was found 1.6% higher (5.75 t/ha) than M-W-MB cropping system (5.66 t/ha). The average grain yield of maize under CA was found 16.7 higher (6.15 t/ha) than ConvA (5.27 t/ha). Similarly, interaction effect of both cropping systems and CA recorded 16% higher average grain yield than ConvA. Variety Rajkumar produced 43.5% higher average grain yield (6.73 t/ha) than Arun-2 variety (4.69 t/ha). The interaction of M-W-MB cropping system and Rajkumar variety recorded 41.9% higher average grain yield (6.60 t/ha) than Arun-2 (4.65 t/ha) whereas the interaction of M-L-MB cropping system and Rajkumar variety produced 45% higher average grain yield (6.85 t/ha) than Arun-2 (4.72 t/ha). The interaction effect of CA and Rajkumar variety recorded 17.6% higher average grain yield (7.27 t/ha) than from the interaction of ConvA and the same variety (6.18 t/ha) whereas the interaction effect of CA and Arun-2 variety resulted in 15% higher average grain yield (5.02 t/ha) than from the interaction of ConvA and the same variety (4.35 t/ha).

The average net benefit of the maize crop studied under M-L-MB cropping system was found 4% higher (US\$ 597.33/ha) than M-W-MB cropping system (US\$ 573.89/ha). Similarly, the average net benefit of the maize crop studied under CA was found 102% higher (US\$ 783.67/ha) than ConvA (US\$ 386.79/ha). Rajkumar variety recorded 127% higher average net benefit (US\$ 813.49/ha) than Arun-2 (US\$ 357.81/ha). The interaction effect of M-W-MB and

Rajkumar variety resulted in 112% higher average net benefit (US\$ 780.5/ha) than Arun-2 (US\$ 367.1/ha) whereas the interaction effect of M-L-MB cropping system and Rajkumar variety indicated 140% higher average net benefit (US\$ 846.0/ha) than Arun-2 (US\$ 348.6/ha). The interaction effect of CA and Rajkumar variety recorded 77% higher average net benefit (US\$ 1041.7/ha) than from the interaction effect of ConvA with the same variety (US\$ 588.1/ha) whereas the interaction effect of CA and Arun-2 variety recorded 185% higher average net benefit (US\$ 530.1/ha) than the net benefit obtained from the interaction of ConvA with the same variety (US\$ 185.7/ha).

The average benefit-cost (B:C) ratio of the maize crop studied under M-L-MB cropping system was found slightly higher (1.72) than the average B:C ratio of the M-W-MB cropping system (1.70). The average B:C ratio of the maize crop seeded under CA was found 42% higher (2.01) than ConvA (1.41). The average B:C ratio recorded from the interaction effect of both cropping systems and CA was found 43% higher than ConvA. The average B:C ratio of Rajkumar variety was found 33% higher (1.95) than Arun-2 (1.46). The interaction effect of the M-W-MB cropping system and Rajkumar variety recorded 30% higher average B:C ratio (1.92) than Arun-2 (1.47) whereas the interaction of the M-L-MB cropping system and Rajkumar variety resulted in 37% higher B:C ratio (1.99) than Arun 2 (1.45). Similarly, the interaction effect of CA and Rajkumar variety recorded 43% higher average B:C ratio (2.30) than the B:C ratio obtained from the interaction of ConvA and the same variety (1.60) whereas the interaction of CA and Arun-2 variety recorded 43%

higher average B:C ratio (1.72) than the B:C ratio recorded from the interaction of ConvA and the same variety (1.20).

The soil moisture recorded from the experimental plots of the M-W-MB cropping system was found slightly higher (10.91%) than the M-L-MB cropping system (10.87%). The average soil moisture of CA experimental plots was found 9.4% higher (11.47%) than ConvA (10.43%). The average soil moisture of Rajkumar variety studied experimental plots was found 2.5% higher (11.02%) than Arun-2 (10.75%). The interaction effect of M-W-MB cropping system and CA recorded 10.8% higher average soil moisture than ConvA, whereas the interaction effect of the M-L-MB cropping system and CA resulted in 9% higher soil moisture than ConvA. Similarly, the interaction effect of CA and Rajkumar variety resulted in 12% higher average soil moisture (11.66%) than ConvA (10.38%) whereas the interaction effect of CA and Arun-2 variety recorded 7.8% higher average soil moisture (11.16%) than ConvA (10.35%).

Various researchers have also reported similar findings. CA practices produced higher maize yield in rain-fed central highland of Mexico than the maize yield of conventional practices (Lumpkin and Sayre, 2009). Mazvimavi et al. (2012) established 39% higher grain yield of maize in CA than in ConvA. McNair et al. (2012) reported CA farmers of Angonia became able to sell more maize grain than non-CA farmers indicating increase in maize yield. Kassam et al. (2009) and Derpsch et al. (2010) found 201-120% higher yield in CA than in ConvA. FAO (2010b) reported better availability of water throughout the cropping period is the clue of better yield in CA practices. Wang et al. (2011) reported higher crop yield in no till plot with straw retention than conventionally tilled plot. Karki et al. (2014) revealed higher grain yield of maize under CA practices (5.21 t/ha) than ConvA (4.75 t/ha) in the western hills of Nepal.

Tshuma et al. (2010) reported high gross margin from CA than ConvA. Less labor requirement and high production are the reason of earning more profit from CA than conventional (Ito et al., 2007; Mazvimavi, 2011; Haggblade et al., 2011). Higher annual return was found in CA (US\$ 104/ha) than ConvA practices in Zambia (FAO, 2010a). Higher annual return (US\$ 213/ha) was found in CA than ConvA (US\$ 61/ha) in Zimbabwe and this high profit from CA was possible due to high yield in low cost (Shetto and Owenya, 2007; FAO, 2008; Derpsch et al., 2010).

Residues contribute to minimize soil water evaporation by lowering surface soil temperature and wind effect (Klocke et al., 2009; van Donke et al., 2010; Singh et al., 2011). Klocke et al. (2009) reported that annual irrigation was saved by 10-13% due to no tillage cultural practices and the same author reported full surface residue coverage of corn stover contributed to reduce evaporation loss by 50%. Lumpkin and Sayre (2009) established that CA practices saved 16% water requirement in maize compared with irrigation water requirement by conventional practices. Sauer et al. (1996) found that retention of residues on the soil surface reduces soil water evaporation by 34 to 50%. Azooz and Arshad (1995) reported high moisture content under zero tillage soil than tilled soil. Govaerts et al. (2009a) indicated high soil moisture in no till residue retention plot than tilled and residue removed plots.

Conclusion

The study concluded that grain yields of maize and economic returns were significantly higher in conservation agriculture practices as compared to that of conventional practices. Planting of hybrid maize was found to be an important factor for increasing yield

and return under CA system. Adopting cropping pattern namely maize-lentil-mungbean increased grain yield and return under CA. The conservation agriculture had the potential to increase grain yields and returns.

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References

- ABPSD (Agro-Business Promotion and Statistics Division)**, 2013, 2014. Statistical Information on Nepalese Agriculture. Ministry of Agriculture Development, Singhdurbar, Kathmandu, Nepal. <http://moad.gov.np/public/uploads/1009021694-YearBook%202013.pdf>
- Azooz RH and Arshad MA**, 1995. Tillage effect of thermal conductivity of soils in Northern British-Columbia. *Soil Science Society of America Journal*, 59, 1413-1423.
- Balasubramaniyan P and Palaniappan SP**, 2014. Principles and practices of Agronomy, Second edition. Published by Agrobios, India.
- BK SB and Shrestha J**, 2014. Effect of conservation agriculture on growth and productivity of maize (*Zea mays* L.) in Terai Region of Nepal. *World Journal of Agricultural Research*, 2, 168-175.
- Baral BR, Adhikari P and Shrestha J**, 2016. Productivity and economics of hybrid maize (*Zea mays* L.) in the Inner Terai Region of Nepal. *Journal of AgriSearch*, 3, 13-16.
- Carangal VR, Ali SM, Koble AF, Rinke EH and Sentz JC**, 1971. Comparison of S1 with testcross evaluation for recurrent selection in maize. *Crop Science*, 11, 658-661. <http://dx.doi.org/10.2135/cropsci1971.0011183X001100050016x>
- Derpsch R, Friedrich T, Kassam A and Hongwen L**, 2010. Current status of no till farming in the world and some of its main effects. *International Journal of Agricultural and Biological Engineering*, 3, 1-25. <http://dx.doi.org/10.3965/j.issn.1934-6344.2010.01.0-0>.
- FAO**, 2008. Investing in sustainable crop intensification: the case of improving soil health. *International Technical Working*, July 22-24, 2008, FAO, Rome.
- FAO**, 2010a. Farming for the future of Southern Africa: An introduction to conservation agriculture. FAO Regional Engineering Office for South Africa. Technical Brief, No. 1. Office for South Africa. Technical Brief, No. 1.
- FAO**, 2010b. Cultivating sustainable livelihoods: Socio economic impacts of conservation agriculture in South Africa. FAO Regional Emergency Office for South Africa. Technical Brief, No. 2.
- Friedrich T, Derpsch R and Kassam A**, 2011. Global overview of the spread of conservation agriculture. Presentation at the 5th World Congress on Conservation Agriculture, Brisbane, 26-29 September, 2011.
- FSED (Food Security and Environment Division)**, 2012/13. National Food Balance Sheet of Nepal. Ministry of Agriculture Development, Singhdarbar, Kathmandu.

- Govaerts B, Sayre KD, Goudeseune B, De Corte P, Lichter K, Dendooven L and Deckers J**, 2009. Conservation agriculture as a sustainable option for the central Mexican Highlands. *Soil Till. Res.*, 103,222-230.
<https://repository.cimmyt.org/xmlui/handle/10883/1518>
- Gupta RK and Seth A**, 2007. A review of resource conserving technologies for sustainable management of the rice-wheat cropping system of the Indo-Gangetic Plains. *Crop production*, 26, 436-447. <http://dx.doi.org/10.1016/j.cropro.2006.04.030>
- Gupta R and Sayre K**, 2007. Conservation agriculture in South Asia. *Journal of Agricultural Science*, 145-207.
- Hagblade S, Kabwe S and Plerhopies C**, 2011. Productivity impact of conservation farming on small holders cotton farmers in Zambia. In: Food security research project working paper, No. 47, Lusaka, Zambia.
- Hobbs PR and Gupta RK**, 2000. Sustainable resource management in intensively cultivated irrigated rice-wheat cropping system of the Indo Gangetic Plain of South Asia: Strategic and Options. In: Proceedings of International Conference on Managing Natural Resources for Sustainable Production in 25th Century, 14-18 February, 2000, pp. 584-592.
- Ito M, Matsumoto T and Quinones MA**, 2007. Conservation tillage practices in Sub Sahara Africa: The experience of Sabakawa Global. *Crop Protection*, 26, 417-423.
<http://dx.doi.org/10.1016/j.cropro.2006.04.030>
- Jat ML, Singh RG, Saharawat YS, Gathala MK, Kumar V, Sindhu HS and Gupta R**, 2009. Innovations through conservation agriculture: progress prospects and participatory approach in the Indo-Gangetic Plains. In: Proceedings of the 4th World Congress on Conservation Agriculture, 4-7 February, 2009, pp. 60-64.
- Jat RA, Wani SP and Sahrawat KL**, 2012. Conservation agriculture in semi-arid tropics: prospects and problems. *Advances in Agronomy*, 117, 191-273.
- Kandel M, Ghimire SK, Ojha BR and Shrestha J**, 2018. Genetic diversity for heat tolerant related traits in maize inbred lines. *Agriculture*, 105, 23-34.
- Karki TB and Shrestha J**, 2014a. Conservation agriculture: significance, challenges and opportunities in Nepal Agricultural Research Council, 1, 186-188. <http://dx.doi.org/10.12691/wjar-2-6A-3>
- Karki TB and Shrestha J**, 2014b. Maize production under no-tillage system in Nepal. *World Journal of Agricultural Research*, 2, 13-17. <http://dx.doi.org/10.12691/wjar-2-6A-3>
- Karki TB, Gadal N and Shrestha J**, 2014. Studies on the conservation agriculture based practices under maize (*Zea mays* L.) based system in the hills of Nepal. *International Journal of Applied Sciences and Biotechnology*, 2, 185-192.
<http://dx.doi.org/10.3126/ijasbt.v2i2.10353>
- Kasam A, Friedrich T, Shaxson F and Pretty J**, 2009. The spread of conservation agriculture: justification, sustainability and uptake. *Intern. Journal of Agriculture and Sustainability*, 7, 292-320.
<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.911.9636&rep=rep1&type=pdf>
- Klocke NL, Currie RS and Aiken RM**, 2009. Soil water evaporation and crop residues. *Transactions of the ASABE*, 52, 103-110.
- Lumpkin A, Thomas and Sayre K**, 2009. Enhancing resource productivity and efficiency through conservation agriculture. In: Proceedings of 4th World Congress on Conservation Agriculture, February 4-7, 2009, pp. 3-9.
- Mazvimavi K, Parick VN, Henry A and Murendo C**, 2012. Productivity and efficiency analysis of maize under conservation agriculture in Zimbabwe. In: Selected paper prepared for presentation at the International Association of Agriculture Economist, Triennial Conference, Foz do Iguacu, Brazil, 18-24 August 2014.
- Mazvimavi K**, 2011. Socio economic analysis of conservation agriculture in southern Africa. Second ed., FAO-REOSA, Johannesburg.
- McNair W, LaMbart D, Willox M, Eash N and Theirfielder C**, 2012. A first look of maize market and demographics among conservation agriculture adaptors and non-adaptors in Mozambique. Poster presented to SANREM-CRSP Meeting, October 2012.
- NARC (Nepal Agricultural Research Council)**, 2018. National Maize Research Program, Rampur, Chitwan, Nepal.
<http://nmrp.gov.np/technology/variety/>
- Prasai HK, Sharma S, Kushwaha UJS, Joshi BP and Shrestha J**, 2016. Evaluation of grain legumes for yield and agronomic traits in far western hills of Nepal. *Journal of Global Agriculture and Ecology*, 4, 21-26.
- Saur TJ, Hatfield JL and Prueger JH**, 1996. Corn residue edge and placement effects on evaporation and soil thermal regime. *Soil Science Society of America Journal*, 60, 1558-1564.
- Sharma PK and Datta SK**, 1985. Effect of puddling on soil physical properties and process. In: *Soil Physics and Rice*. Manila, Intern. Rice Research Institute, pp. 217-234.
- Sharma PK, Ladha JK and Bhusan L**, 2003. Soil physical effects of puddling in rice-wheat cropping system. In: *Improving the productivity and sustainability of rice-wheat systems: Issues and Impacts* (ed. J.K. Ladha). ASA Spec. Publ, 65, ASA and SSSA, Madison, WI, pp. 97-113.
- Shetto R and Owenya M**, 2007. Conservation agriculture as practices in Tanzania: Three case studies. *African Conservation Tillage Network*, FAO, Paris.
- Shrestha J, Yadav DN, Amgain LP and Sharma JP**, 2018. Effects of nitrogen and plant density on maize (*Zea mays* L.) phenology and grain yield. *Current Agriculture Research Journal*, 6. <http://dx.doi.org/10.12944/CARJ.6.2.06>
- Shrestha J**, 2015. Growth and productivity of winter Maize (*Zea mays* L.) under different levels of nitrogen and plant population. Thesis for PhD, Boca Raton, USA.
- Singh PN, Mitchell JP and Wallender WW**, 2011. Parameter optimizing for predicting soil water movement under crop residue cover. *Transactions of the ASABE*, 54, 2029-2035. <http://dx.doi.org/10.13031/2013.40661>
- Tshuma PS, Mazvimavi K, Murando C and Kunzekweguta E**, 2010. Assessment of labor requirement in conservation agriculture in Zimbabwe. In: Abstract of paper presented for CA regional symposium, Johannesburg.
- Van Donk SJ, Martin DL and Irmak S**, 2010. Crop residues cover effects on evaporation, soil water content and yield of deficit-irrigated corn in west central Nebraska, 53, 1787-1797. <http://dx.doi.org/10.13031/2013.35805>
- Wang XB, Dai KA, Zhang DC, Zhang XM, Wang Y, Zhao QS, Cai DX and Hoogm O**, 2011. Dry land maize yield and water use efficiency in response to tillage/crop stubble and nutrient management practices in China. *Field Crops Research*, 120, 47-57.
- Williams LJ and Abdi H**, 2010. Fisher's Least Significant Difference (LSD) Test. In: *Encyclopedia of Research Design*. Thousand Oaks (ed. N. Salkind), CA: Sage Publication.

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