International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 3 Number 11 (2014) pp. 313-319**
http://www.ijcmas.com

Original Research Article

Evaluation of conservation agriculture practices on rice - wheat system in inner terai of Nepal

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A B S T R A C T

To increase the efficiency of rice-wheat system, farmers are adopting different approaches of Conservation Agriculture (CA) for reducing critical inputs in terai and inner terai of Nepal. The study was carried out to analyze the input used, production and cost efficiency of CA practices in Chitwan district during 2010. Study revealed that farmers had advantages of early sowing, better germination, reduced diseases and pest problems with better response of irrigation and fertilizers applied through adoption of CA practices over conventional practices. Farmers also saved the production cost by 31.98, 33.85 and 34.44% as well as increased benefit-cost ratio by 51.55, 29.19 and 54.11% respectively through the adoption of zero tilled-wheat, reduced tilled-wheat and dry direct seeded rice. Of the total respondents, 95.00, 80.00 and 88.24% are willing to increase area under zero tilled-wheat, reduced tilled-wheat and dry direct seeded rice, respectively in the coming year.

Keywords

Conservation agriculture, DDSR, ZT-wheat

Introduction

The terai and inner terai of Nepal have plentiful natural resources, productive soil, sufficient irrigation water, suitable climatic conditions that permit multiple-cropping. The green revolution technologies, beginning 1970s, have transformed terai and inner terai of Nepal into cereal basket of country. Rice is the most important crop in terai and mid hills as it contributes nearly 50% to the total calorie requirement with the 20% share to agricultural gross domestic products (NARC, 2007). The contribution of rice in supplying per capita dietary energy, protein and fat of the Nepalese people is 38.5, 29.4 and 7.2%, respectively (FAO STAT, 2004). Wheat is important in the western hills in terms of food security. Terai shares 70.59% area and 73.52% production of rice and 57.92% area and 70.68% production of wheat (SINA, 2010). Under rice-wheat cropping system, farmers grow rice in Kharif season followed by wheat in winter season that have the coverage of the rice-wheat system is 0.5 million hectare which accounts 32% of total rice area (1556 thousand hectare) and 42% of total wheat area, 695 thousand hectare (Ladha *et al.*, 2003). The productivity of the rice-wheat system was rapidly increased by the adoption of technological package of improved rice and wheat seeds, chemical fertilizers and irrigation during 1990s.

Several yield reducing and yield limiting factors, together with delayed planting of wheat and transplanting of rice; infestation of *Phalaris minor* and its resistance to isoproturon; and crop residue burning have contributed to the stagnating or declining area, production and productivity and sustainability of the rice-wheat system. Season wet and dry crop cycles over a long term; increased use of and reliance on inorganic fertilizers; asymmetry of planting schedules; and greater uniformity in crop varieties cultivated and hence their susceptibility to the same pests is the resultant outcomes of rice-wheat system (Gupta *et al.,* 2002). The most common consequences of rice-wheat system are: water logging and salinity build up; depletion and pollution of water resources specially ground water; hard pan formation; toxicities or deficiencies of nutrients in the soil; and pests build up along with developing resistance and pest related yield losses for the both crop in a system (Pingali and Shah, 1999). The input use efficiency of the system is low. The soil organic matter content has reduced. Hence, from the above facts, productivity has stagnated (Kataki *et al.,* 2001 and Prasad, 2005), and a complimentary set of new agricultural technologies must be identified and adopted to cope up the constraints and boost productivity of the system.

Furthermore, the major costs in wheat production were land preparation (33%) and harvesting and threshing (32%), with the balance going to inputs and weeding. For rice production, preparing land (36%), raising and transplanting seedlings (21%), and harvesting and threshing (23%) were the major costs (Hobbs *et al.,* 1996). Net returns were sometimes negative for wheat because of the low yield and low returns reflect the subsistence nature of this crop. However, in this context, farmers in the Indo-Gangetic Plains are rapidly adopting conservation agriculture (CA) practices mainly dry direct seeded rice (DDSR) in rice in rainy season, zero-tillage and reduced tillage sowing wheat after rice. In Nepal these important components of CA were initiated during 1996–97. Because of the benefits from DDSR, zero and reduced tillage i.e. not significant reduction in yield, cost effectiveness, significant saving in water, soil quality and inputs, these conservation agriculture technologies are gaining more popularity in the Indo-Gangetic Plains of Nepal.

Materials and Methods

The present study comprised two components: a household survey and focus-group discussions. For these Chitwan districts of Nepal and its four village development committees (VDCs) namely Patihani, Phoolbari, Saradanagar and Sivanagar, ware purposively selected. Zero and reduced tillage wheat growers and dry direct seeded rice (DDSR) adopted farmers constituted the research population. Sample size of DDSR was 51 and that of Zero tillage (ZT) – wheat and reduced tillage (RT) – wheat were 60 and 45, respectively (Table 1). Similarly for the comparison of these technologies with conventional farming, 60 conventional rice growers and 60 conventional wheat growers were included in the study.

A comprehensive questionnaire was developed for the collection of data regarding the production technology of wheat crop in the study area. The main focus of the current paper was to evaluate the impact of Conservation Agriculture Technology especially Dry direct seeded rice, Zero tillage and reduced tillage –wheat as against the conventional methods of transplanting and/or sowing. Total costs, gross margins, crop yield and benefit-cost analysis were calculated both for CA practices and conventional methods of sowing.

Results and Discussion

Advantage and problems associated with Conservation Agriculture (CA) practices

Wheat was a winter season crop in the study area and generally grows in the residual soil moisture after rice harvest. Most of the wheat growing area has generally more amount of soil moisture which when plough it takes about three weeks to sowing the seed. Most of the farmers experienced the advantage of optimizing sowing time, better seed germination, reduced weed and increased irrigation efficiency in both rice and wheat due to practices of CA (Table 2). Slightly more numbers of farmers observed better seed germination in RT-wheat (66.67%) as compared to ZT-wheat (61.66%). Possibly due to application of herbicides farmers observed less weed. Reduction of weed was greatly observed in DDSR (76.47%) followed by RT-wheat (71.11%) and by ZT-wheat (63.33%) as compared to the conventional practices. RT-wheat and DDSR were greatly effective for increasing fertilizer efficiency. Fewer numbers of farmers (33.33% ZT-wheat, 40.00% RT-wheat and 45.09% DDSR farmers) observed reduction in disease infection. Large numbers of farmers observed that CA practices increased yield. About 70.59% DDSR, 66.67% RT-wheat and 65.00% ZT-wheat farmers harvest better yield in this year.

Due to the new technology and lack of technical knowledge, farmers experience some problems. Poor crop stand, weed problems and difficulty in fertility management were observed with ZT- wheat, RT-wheat and DDSR (Table 3). The use of FYM and compost was the most difficult task in practicing the CA. Few farmers (5.00%) observed more seed requirement in the ZT-wheat as compared to conventional practices.

Major inputs used in conservation agriculture practices

Farmers used 14.24 kg more seeds in DDSR as compared to the normal conventional practices (40 kg/ha) (Table 4). Nitrogen application to the DDSR (49.87Kg/ha) was almost half than the recommended level (100 kg/ha) while P_2O_5 and K_2O were comparable to national recommended dose. Farmers used low seed rate in ZT-wheat (71.76 kg/kg) and RT-wheat (69.00 kg/ha) as compared to the recommended rate of 120 kg/ha. Similarly nitrogen application in both ZT and RT-wheat was far lower than the recommended dose while P_2O_5 and K_2O were comparable to national recommended dose.

Productivity in conservation agriculture and conventional agriculture

On an average, the RT-wheat had lower productivity as compared to the ZT and conventional wheat (Table 5). ZT-wheat produced 2.47% more while RT-wheat had 14.84% lower grain yield compared to the conventional wheat. ZT-wheat had 20.33% more yield as compared to the RT-wheat. Rice yield in DDSR was lower than the conventional rice farming. On an average, yield of DDSR was 2.92 t/ha and which was only 2.01% lower than the conventional practice. The yield difference between the DDSR and conventional practices was huge in Saradanagar (0.36 t/ha) and Patihani (0.31 t/ha) while more yield of DDSR as compared to conventional in Sivanagar (0.63 t/ha).

Cost of cultivation: On an average, conventional system of crop farming required more cost to cultivate as compared to CA (Table 6). Conventional wheat farming required NRs. 33195.25 per hectare which is 47.03 % more than in ZT - wheat and 51.18 % more than in RT - wheat. Comparatively higher cost of production observed in ZT-wheat than RT-wheat due to high cost for herbicides and irrigation. Similarly in rice cultivation, cost of cultivation for DDSR was NRs. 22021.75 which was 57.34% lower than the conventional rice farming.

Returns of crop production: In wheat return per hectare was slightly higher in ZT –wheat which was 2.52% more than the conventional farming system while return in RT - wheat was lower (14.88%) than conventional practices (Table 6). Similarly return per hectare was higher in conventional rice farming (NRs. 50636.30/ha) than DDSR (NRs. 49654.38/ha) which was 1.93% lower in DDSR.

B:C ratio: In average B:C ratio was higher in the CA technologies as compared to the conventional in both crop rice and wheat (Table 6). The B:C ratio of ZT-wheat was highest (2.44) and it was 51.55% higher than conventional and 17.30% higher than RT-wheat. Similarly RT-wheat had 29.19% more B:C ratio as compared to conventional wheat. Similarly B:C ratio of DDSR (2.25) was 54.11% more than conventional rice (1.46).

Adoption pattern of CA practices and Willingness to adopt in next year

The results show area of all CA technologies is increased during recent years. The correlation between area and years was significant for all CA technologies (Table 7). Area of zero tillage wheat was increased and this variation (91.81%) was observed due to the year changed. Similarly for reduced tillage wheat this value was 94.54%, and for DDSR 90.74 and total of CA technologies was 93.49%. Area increased in each year was mostly determined by positive impact of these technologies on crop production, mainly increased the yield and reduced the cost of cultivations. Most of the farmers are interested in the CA practices and will adopt in next year. Comparatively more farmers (95.00%) continued ZT-wheat followed by DDSR (88.24%) and RT-wheat (80.00%).

Table.1 Sample household of the field survey in four different VDCs of Chitwan district, Nepal in 2010

Cultivation practices s	Study VDCs of Chitwan district				
	Patihani	Phoolbari	Sradanagar	Sivanagar	Total
Dry Direct seeded rice (DDSR)	15	21	6	9	51
Conventional rice	15	24	9	12	60
Zero tillage wheat (ZT-wheat)	15	24	9	12	60
Reduced tillage wheat (RT – wheat)	9	15	9	12	45
Conventional wheat	15	24	9	12	60

Table.2 Advantages experienced with CA practices of sampled households of the field survey in Chitwan district, Nepal in 2010

SN	Factors	ZT-wheat	RT-wheat	DDSR
1	Optimized sowing time	57 (95.00)	43 (95.55)	49 (96.07)
2	Increased seed germination	37 (61.66)	30 (66.67)	34 (66.66)
3	Reduced weed infestation	38 (63.33)	32 (71.11)	39 (76.47)
4	Increased irrigation efficiency	60 (100.00)	45 (100.00)	51 (100.00)
5	Increased fertilizer efficiency	20 (33.33)	34 (75.55)	32 (62.74)
6	Reduced disease infection	20 (33.33)	18 (40.00)	23 (45.09)
7	Increased yield	39 (65.00)	30 (66.67)	36 (70.59)

Figure in the parenthesis indicated the percentage of the respective frequency, ZT = Zero Tillage, RT = Reduce Tillage and DDSR = Dry Direct Seeded Rice.

Table.3 Problem observed with CA practices of sampled households of the field survey in Chitwan district, Nepal in 2010

SN	Factors	ZT-wheat	RT-wheat	DDSR
1	More seed required per unit area	3 (5.00)	0 (0.00)	0 (0.00)
2	Increased weed infestation	22 (36.66)	10 (22.22)	9 (17.64)
3	Difficult to fertility management	33 (55.00)	28(62.22)	47 (92.15)
4	Difficulty in use of FYM and compost	57 (95.00)	39 (86.67)	50 (98.03)

Figure in the parenthesis indicated the percentage of the respective frequency, ZT = Zero Tillage, RT = Reduce Tillage and DDSR = Dry Direct Seeded Rice.

Table.4 Seeds, fertilizers (kg/ha) and irrigation (no.) used in ZT- wheat, RT-wheat and DDSR of sampled households in Chitwan districts, Nepal in 2010

Inputs	ZT-wheat	RT-wheat	DDSR
Seed (kg/ha)	71.76 ± 0.23	69.00 ± 0.18	54.24 ± 0.13
Urea (kg/ha)	61.11 ± 0.19	57.99 ± 0.18	68.37 ± 0.21
DAP (kg/ha)	82.59 ± 0.28	81.42 ± 0.27	102.36 ± 0.22
MOP (kg/ha)	37.44 ± 0.13	36.00 ± 0.14	45.69 ± 0.20
N (kg/ha)	42.977	41.331	49.875
P_2O_5 (kg/ha)	37.991	37.453	47.086
K_2O (kg/ha)	22.464	21.600	27.414

ZT = Zero Tillage, RT = Reduce Tillage, DDSR = Dry Direct Seeded Rice, DAP = Diammonium Phosphate and MOP = Murate of Potash.

Table.5 Productivity (t/ha) of CA practices and conventional farming across the sample VDCs of sampled households in Chitwan district, Nepal in 2010

VDC	Conventional rice	Conventional wheat	ZT-wheat	RT-wheat	DDSR
Patihani	3.33	3.20	3.49	2.57	3.02
Phoolbari	2.97	2.69	2.72	2.66	2.78
Sharadanagar	3.17	2.70	2.62	2.07	2.81
Shivanagar	2.45	2.73	2.79	2.33	3.08
Total	2.98	2.83	2.90	2.41	2.92

ZT = Zero Tillage, RT = Reduce Tillage and DDSR = Dry Direct Seeded Rice

Table.6 Production cost per hectare (NRs./ha), Returns per hectare (NRs./ha) and B:C ratio of CA technologies and conventional farming of sampled households in Chitwan district, Nepal in 2010

Technologies	Cost of production (NRs/ha)	Return (NRs/ha)	B:C ratio
ZT –wheat	22577.00	55141.38	2.44 ± 0.23
RT - wheat	21957.25	45754.13	2.08 ± 0.37
DDSR	22021.75	49654.38	2.25 ± 0.47
Conventional wheat	33195.25	53750.95	1.61 ± 0.92
Conventional rice	34649.50	50636.30	1.46 ± 0.13

ZT = Zero Tillage, RT = Reduce Tillage and DDSR = Dry Direct Seeded Rice.

Table.7 Simple regression line for CA practices and willingness to adopted in coming years among sampled households in Chitwan district, Nepal in 2010

CA Practices	Equation (Area = Slop x Year + Interception)	r	R^2	Willingness to adopt
ZT-wheat	y = 13.175x - 16.5	0.958*	0.9181	57 (95.00)
RT-Wheat	y = 4.395x - 4.175	0.972*	0.9454	36 (80.00)
DDSR	y = 10.28x - 14.25	0.953*	0.9074	45 (88.24)
Total	y = 27.85x - 34.925	0.967*	0.9349	138 (88.46)

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