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Adoption of Resource Conservation Technologies and Its Impact on Wheat Cultivation in Haryana

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ABSTRACT

The study was conducted in Kaithal district of Haryana during 2014-15 in nine villages with 120 purposively selected farmers who have adopted either of the three resource conservation technologies *viz;* zero tillage, rotary tillage and laser land leveller or in combination. Majority (68.98 %) of the farmers belonged to middle age group (31-50 years) followed by young (20.33 %) and old (18.69 %). Majority (85 %) of the farmers were literate and agriculture was their main occupation. Farmers were categorised in four groups on land holding basis and 6.5 per cent, 15.46 per cent, 39.02 per cent and 39.02 per cent, in marginal, small, medium and large categories, respectively. In the study area, majority of the farmers preferred Agriculture Development Officers (ADOs) as main source of information. The study on adoption pattern of resource conservation technologies revealed that 69.92 per cent of the farmers had adopted zero tillage, 51.22 per cent rotary tillage, 67.48 per cent laser land leveller, 22.76 per cent zero tillage+rotary tillage, 47.15 per cent zero tillage+laser land leveller, 33.33 per cent rotary tillage+laser land leveller and 13.01 per cent zero tillage+ rotary tillage+ laser land leveller. Majority (84.88 %) of the farmers used zero tillage for timely sowing and 40.70 per cent used for both i.e. timely and late sown conditions. Regarding the impact of zero tillage technology, majority of the farmers (77.91 %) told that there was saving of time under zero tillage sowing as compared to conventional tillage. Majority of the farmers (80.23 %) told that there was an increase in broader leaf weeds under zero tillage and reduction in narrow leaf weed population (80.23 %) and 76.74 per cent of them recorded reduction in overall weed population. All the farmers agreed that there was cost saving under zero tillage technology. Most of them (91.86 %) harvested more yield as compared to conventional tillage. A large number of farmers (61.63 %) observed longer crop duration (4-7 days), increased soil fertility (51.16 %), increased organic carbon in the soil (54.65 %) and increased moisture retention capacity of soil (50 %) and less lodging (87.21 %) as compared to conventional tillage. All the farmers agreed that there was time saving under rotary tillage in wheat sowing. Majority of them (68.25 %) recorded decrease in cost of cultivation, more yield (41.27 %), increased soil fertility (86.96 %), increase in organic carbon content of soil (57.14 %), increase in moisture retention capacity of soil (52.33 %), avoidance of terminal heat (85.71 %) and increase in lodging (46.03 %). Due to adoption of laser land leveller farmers (45.78 %) could save time in field preparation, 2-3 per cent increase in cultivable area, less time required to irrigate the crop, 30-40 per cent water saving, more yield (96.39 %) and less lodging (95.18 %).

Keywords: Resource, conservation, technology, terminal heat, adoption, organic carbon, fertility, zero tillage, rotary tillage, laser land leveller

INTRODUCTION

Due to over exploitation of water resources the underground water level is going down, in some of the areas soil health has been in worst condition due to excessive use of fertilizers and pesticides. This situation has compelled the agricultural scientists and farmers to think and rethink about conservation as an alternative way of farming in years to come. In Indo-Gangetic Plains rice-wheat system in practiced in 10.3 million hectares out of which 2 million hectare is under conservation agriculture and most of it is under zero tillage. In recent years, resource conservation technologies have proved their utility under rice-wheat system in the Indo-Gangetic Plains. There has been a significant increase in area under zero tillage, rotavator and laser land leveler. The adoption of RCTs have ensured better yield and saving of critical inputs, *viz;* labour, time, money, water, and wear and tear of machinery (Singh *et al.,* 2007). It also ensured environmental protection due to burning of straw by the farmers. Kumar *et al* (2006) reported that the farmers can plant wheat crop using zero tillage machine and need not to burn crop residue. Further, zero tillage improves the soil health. In Haryana, the adoption of zero tillage technology had shown an increasing trend in initial years but its adoption was more in rice-wheat crop rotation

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compared to pearl millet-wheat, cluster bean-wheat and cotton-wheat (Coventry *et al.,* 2015). Kurukshetra and Kaithal are the two major districts to adopt resource conservation technologies the most followed by Faridabad, Yamunanagar and Fatehabad where rice-wheat system is predominant (Coventry *et al.,* 2015). Since beginning, extension agencies have made more efforts to popularize zero tillage machines in the rice-wheat crop rotation. The rotary tillage technology has got a good momentum and is being popularized under food security mission across the country. In recent years, realization about leveling of fields with laser land leveler has been given high priority for efficient water usage. In the realm of increased adoption and popularity of RCTs, the study aims at assessing its impact on farmers' field so that policy makers could be convinced for up scaling the technology at a large scale.

METHODOLOGY

The study was conducted in Kaithal district of Haryana during 2014-15 crop season in purposively selected nine villages namely; Rasina, Sanch, Aahoon, Duhsain, Sangroli, Himmatpur, Kakrala, Habri, Hajwana. A total of 123 farmers were selected purposively from these village farmers who have adopted either of the three resource conservation technologies *viz;* zero tillage, rotary tillage and laser land leveller or in combination.

RESULT S AND DISCUSSION

Socio personal profile

Majority (68.98%) of the farmers belonged to middle age group (31-50 years) followed by young (20.33%) and old (18.69%). It clearly indicated the involvement of youth was less hence they need to be involved in agriculture and allied activities. Majority (85%) of the farmers were literate and only 15 per cent of them were illiterate. Among literates, 28.33 per cent were matric, 20 per cent were intermediate, 13.33 per cent were having education up to matric and graduation each. The main occupation of majority of the farmers was agriculture while dairying was subsidiary occupation of most of the farmers. Some of the farmers were also involved in business and service for additional income.

Table 1: Socio-personal profile of the farmers

Categories	Frequency	Percentage
Age		
Young (<30 years)	25	20.33
Middle (31-50 years)	75	60.98
Old (>51 years)	23	18.69
Education		
Illiterate	13	15.00
Can read and write	2	01.67
Primary	5	07.50
Middle	27	13.33
Matric	27	28.33
Intermediate	22	20.00
Graduate	24	13.33
Post graduate and above	3	00.83
Occupation	**Main**	**Subsidiary**
Agriculture	115	8.00
Dairying	5	86.00
Business	2	4.00
Service	1	

Land holding

Categorization of the farmers was done on the basis of owned and total land holding. It was found that on owned land holding basis 6.5 per cent, 15.46 per cent, 39.02 per cent and 39.02 per cent, farmers were lying under marginal, small, medium and large categories, respectively. But on total land holding (owned+ leased in) basis under the respective categories 4.87 per cent, 11.38 per cent, 33.33 per cent and 50.4 per cent of the farmers were lying. It clearly indicates that taking land on rent or contract is a common practice in Haryana and because of that more number of farmers were in large category on total land holding basis.

Table 2: Categorization of farmers on land holding basis n=123

Category of farmers	Owned (acres)		Total (owned + leased in)	
	Frequency	Percentage	Frequency	Percentage
Marginal (< 2.5 acres)	08	06.50	06	04.87
Small (2.6-5.0 acres)	19	15.46	14	11.38
Medium (5.1-10 acres)	48	39.02	41	33.33
Large (10.1 -25 acres)	48	39.02	62	50.40

Extension contact and communication behaviour

Extension contact is the indicator of different sources of information sought by the farmers to acquire information related to agriculture. In the study area, majority of the farmers preferred ADOs and it was ranked first followed by neighbours/friends/relatives, progressive farmers, experts from research institutes, input dealers at II, III, IV and V rank, respectively.

To understand the information seeking behaviour of the farmers from mass media, data was analysed at 5 point continuum and total score was calculated and on the basis of total score, the information sources were ranked. Radio was ranked first followed by demonstrations, trainings, magazines/leaflet/folders,kisan mela/ agricultural exhibitions, meetings and group discussions at II, III, IV, V and VI rank, respectively.

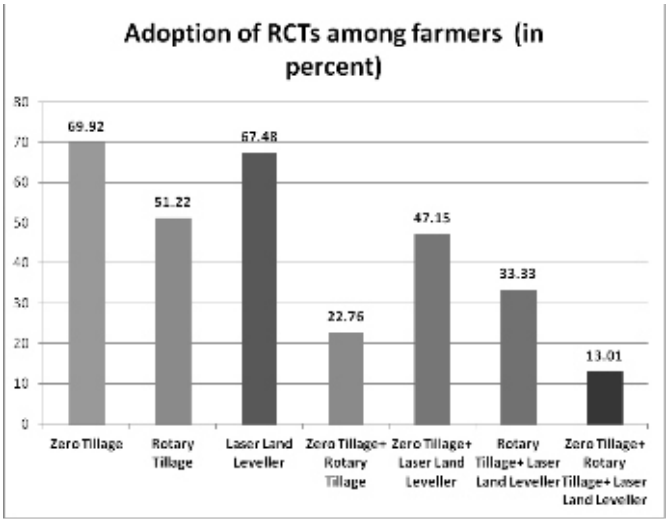
Table 3: Ranking of communication variables

Extension Contact	Frequency						
Sources	**MF**	**F**	**ST**	**R**	**N**	**Total Score**	**Rank**
ADOs/ agriculture officers	46	30	23	22	2	387	I
Experts of research institutes (SAU/ICAR)	2	2	8	3	1	260	IV
Neighbours/friends/relatives	30	14	4	15	58	290	II
Contact/ progressive farmers	23	14	48	39	20	271	III
Input dealers	13	32	35	26	14	242	V
Mass Media Exposure							
Radio	115	1	1	3	3	592	I
Television	11	9	41	46	16	322	VIII
Newspaper	16	6	36	51	14	328	VII
Magazines /leaflets/folders etc.	52	38	21	12	0	489	IV
Kisan mela/agricultural exhibitions	46	32	27	18	0	485	V
Meetings/group discussion	37	23	35	27	1	431	VI
Demonstrations	71	28	21	3	0	536	II
Trainings	71	29	17	6	0	534	III
Internet/SMS	7	13	13	87	3	303	IX

MF = More frequently, F= Frequently, ST= Sometimes, R= Rarely, N= Never

Tube well was the main and only source of irrigation of majority of the farmers (72.36 %) in the study area. The quality of water was normal (52.85 %) to brackish (47.15 %) in the study area. The soil texture varied from heavy to medium and majority of the farmers (79.67 %) had heavy soil followed by medium soil (20.33 %). Fertility status of the soil under the study area varied from high (59.35 %) to medium (40.65 %). None of the farmer's field was reported under low fertility.

The adoption pattern of resource conservation technologies was studied and it was found that 69.92 per cent of the farmers had adopted zero tillage, 51.22 per cent rotary tillage, 67.48 per cent laser land leveller, 22.76 per cent zero tillage+rotary tillage, 47.15 per cent zero tillage+laser land leveller, 33.33 per cent rotary tillage+laser land leveller and 13.01 per cent had adopted all the three viz; zero tillage+ rotary tillage+ laser land leveller at their fields. In a study conducted by Ministry of Agriculture and Farmer Welfare during 2003-04, the total estimated area under zero tillage + reduced tillage was 8,20,000 hectares in Indian IGP. Most of the adoption was concentrated in Haryana (46 %) (MOA, 2004). In 2004-05, the total estimated ZT+RT area was 1.6 million hectares in Indian IGP (Shoran, 2005). The adoption ceiling for ZT+RT has been conservatively estimated at 3.4 million ha or 33 per cent of the wheat area in the rice-wheat systems in the Indo-Gangetic Plains (Pal et el., 2003; Laxmi et al., 2007a,b). The adoption level of ZT was studied at farmers fields by many researchers in different years and they reported different levels of adoption; 34.5 per cent of surveyed households in Haryana (Erenstein et al., 2007b), 12 per cent in Punjab in a study with 759 households in 2003-04 (Joginder Singh, personal communication).



Although the adoption of RCTs was high in the study area (Coventry *et al,* 2015) but possession of RCT machines such as zero till drill (46.51 %), rotavator (42.86 %) and laser land leveller (6.02 %) was low. Custom hiring of machines used under RCTs is very common in Haryana. The reason put forth for low possession of rotavator was high cost and lottery system of subsidy for rotavator under NFSM and RKVY programmes.Only 6 per cent of the farmers had laser land leveller and the obvious reason for this was high cost of machine. Custom hire service was very common and it was 93.98 per cent for laser land leveller, 57.14 per cent for rotavator and 53.49 per cent for zero tillage. A survey of ZT drill owing farmers has highlighted that 69 per cent of the wheat area planted with each ZT drill was under custom hiring (Punia *et al.,* 2002). Similarly, other surveys found 60-82 per cent of ZT adopters in Haryana have relied on contract ZT services for wheat sowing (Corbishley and Pearce, 2006; Erenstein *et al.,* 2007a). Average rate of custom hiring for zero tillage sowing with zero tillage/turbo happy seeder was ₹ 655/acre and it ranged from ₹ 450-1200. Hiring of ZT was ₹ 715/ha (Punia *et al.,* 2002) and ₹ 875/ha (Lathwal and Banga, 2005) in their study. For rotary tillage, it was ₹ 747/ acre and the range was ₹ 800-1100. In case of laser land leveller, average rate of custom hire was ₹ 505/hour and it ranged from ₹ 500-800/hour in the study area. Majority of the farmers (40 %) told that state department of agriculture is making efforts to popularize resource conservation technologies in the state.

Table 4: Possession of RCT machines among the farmers

Machine	Possessed		Hired	
	Frequency	Percentage	Frequency	Percentage
Zero tillage	40	46.51	46	53.49
Rotary tillage	27	42.86	36	57.14
Laser land leveller	05	06.02	78	93.98

Table 5: Rate of custom hire of RCT machines

Machine	Average rate	Range
Zero tillage/Turbo Happy Seeder	655/acre	₹ 450-1200 /acre
Rotary tillage	447/acre	₹ 700-1200/acre
Laser land leveller	505/hour	₹ 500-800/hour

Adoption of zero tillage technology over time

Average area per farmer under zero tillage was 7.5 acre while under conventional tillage it was 2.8 acres. It means that there is a shift from conventional method of wheat sowing to the zero tillage. Contrary to this, Coventry *et al.* 2011, reported more area/per farmer under conventional tillage as compared to zero tillage. Majority (84.88 %) of the farmers used zero tillage for timely sowing and 40.70 per cent used for both i.e. timely and late sown conditions. Majority of the farmers (96.51 %) were convinced about the benefits of zero tillage and were ready to continue while 3.49 per cent were not convinced and were planning to discontinue. Burning of straw before wheat sowing was also observed and 79.67 per cent farmers were still following, 8.13 per cent of them were incorporating residue while 12.20 per cent of the farmers did not respond this question. About 48.78 per cent of the farmers used reaper before sowing of wheat with zero tillage machine.

Table 6: Information on adoption of zero tillage technology

Technology	Average area (acres/farmer)	
Zero tillage	7.5	
Conventional tillage	2.8	
Continued adoption of zero tillage	**Frequency**	**Percentage**
Yes	95	96.51
No	06	3.49
Sowing Conditions		
Timely sown	73	84.88
Both (Timely and late sown)	35	40.70
Burning of straw		
Yes	98	79.67
No	10	08.13
Can't say	15	12.20
Use of reaper		
Yes	60	48.78
No	48	39.02
Can't say	15	12.20

Regarding the impact of adoption of zero tillage on wheat cultivation it was found that majority of the farmers (77.91%) recorded less time while 13.95 per cent observed same time as compared to conventional tillage in sowing of wheat. Many studies reported time saving under ZT in comparision to conventional method especially on tractor operations ranging from 6-12 hours/ha *i.e.* on an average 81 per cent in Punjab Haryana and Eastern UP (Laxmi *et al.,* 2007a). Most of the farmers (79.07 %) used same quantity of seed as compared to conventional method but 17.44 per cent of the farmers used 5 kg less seed and only 3.49 per cent used more seed rate. About 39.53 per cent of the farmers found more germination under zero tillage while 1.16 per cent observed less and 59.30 per cent did not find any difference. Majority the farmers (82.56%) used recommended dose of fertilizer under zero tillage sown wheat and it was similar to conventional tillage. Majority of the farmers (80.23 %) told that there was an increase in broad leaf weeds under zero tillage while 80.23 per cent farmers reported reduction in narrow leaf weed population. Yadav *et al.* (2002a) reported 30-40 per cent reduction in Phalari minor population in zero tillage fields as compared to CT fileds. Majority of the farmers (76.74 %) observed reduction in overall weed population but 10.46 per cent of the farmers observed increase and 12.79 per cent found no change in weed population as compared to conventional tillage. On similar line many researchers have reported in their field studies; with the adoption of ZT in rice-wheat systems in the IGP comparatively less weeds were found in the wheat crop (Malik et al., 1998, 2002a; Sen *et al.*, 2002; Prasad *et al.,* 2002; Singh *et al.,* 2002a,b; Franke *et al.,* 2007).

The long term trials and farmer surveys revealed change in weed spectrum in ZT fields, particularly in increase in the population of broad leaved weeds. (Malik *et al.,* 1998; Yadav *et al.,* 2002b, Singh et al., 2009). Laxmi *et al.* (2003) reported that 51 per cent of farmers in Haryana and 85 per cent of farmers in Bihar perceived that weed infestation has decreased due to adoption of ZT in wheat. Focus groups also perceived decrease in P. Minor and increase in broad leaf weeds (Laxmi *et al.,* 2007b). It was further observed that majority of the farmers (52.32 %) applied less water under zero tillage crop. It is well supported by the many researchers; ZT saves 20-35 per cent water as compared to conventional tillage (Mehla *et al.,* 2000; Gupta *et al.,* 2002; Hobbs and Gupta 2003). A study from Haryana reported a smaller but water saving of 13 per cent with ZT (Erenstein *et al.,* 2007b), 10-27 per cent (Chandra *et al.,* 2007).

The saving of water could be because of saving of pre sowing irrigation, less evapo-transpiration due to surface cover and less water requirement of untilled land as compared to tilled one. Kumar *et al.* (2005a) reported similar findings on the line of present study that 51 per cent of farmers reported no change in water requirement he further reported that in water scarce areas where farmers were dependent on diesel tube wells 56 per cent reported water savings.

Table 6: Impact of zero tillage technology on wheat cultivation n=86

Parameters	Impact		
	Increased	Same	Decreased
Time taken in sowing	07 (8.14)	12 (13.95)	67 (77.91)
Seed rate	03 (03.49)	68 (79.07)	15 (17.44)
Germination percentage	34 (39.53)	51 (59.30)	01 (01.16)
Fertilizer requirement	01 (01.16)	71 (82.56)	14 (16.28)
Population of broad leaf weeds	69 (80.23)	17 (19.77)	02 (02.33)
Population of narrow leaf weeds	08 (09.30)	09 (10.47)	69 (80.23)
Overall population of weeds	09 (10.46)	11 (12.79)	66 (76.74)
Water Requirement	03 (03.49)	38 (44.18)	45 (52.32)
Cost of cultivation	03 (03.49)	25 (29.07)	58 (67.44)
Yield	79 (91.86)	07 (08.14)	00 (00. 00)
Duration of crop (sowing to harvesting)	53 (61.63)	33 (38.37)	00 (00.00)
Fertility of soil	44 (51.16)	42 (48.83)	00 (00.00)
Organic carbon content of soil	47 (54.65)	39 (45. 19)	00 (00.00)
Moisture retention capacity of the soil	43 (50.00)	43 (50.00)	00 (00.00)
Lodging	00 (00.00)	11 (12.79)	75 (87.21)
Avoidance of terminal heat	22 (25.58)	66 (76.74)	00 (00.00)

All the farmers agreed that there was cost saving under zero tillage technology (Sharma *et al.,* 2005). Corbishley and Pearce (2006) reported net gain of ₹ 430/ha in ZT, Rs. 1691/ha in Eastern UP, Yadav *et al.,* (2002b), ₹ 1865/ha for IGP: Dhiman *et al.* (2003), ₹ 2320/ha in Bihar, Singh *et al.* (2002b); ₹ 2500/ha, Hobbs (2002). The focus groups in Punjab and Haryana reported cost savings of ₹ 2000-2500/ha and an overall net benefit of ₹ 4400-5000/ha for ZT.

In Eastern UP the reported cost savings were relatively high but overall the focus groups confirm the significant cost savings and increase in profitability attributable to ZT (Laxmi *et al.,* 2007b). Hobbs *et al.* (1997), Nagarajan *et al.,* 2002; Erenstein *et al.,* 2007b, reported cost savings of Rs. 2300/ha of 6-7 per cent particularly tillage savings. Majority (91.86%) of the farmers got more yield as compared to conventional tillage under zero tillage. Hobbs *et al.,* 1997 reported substantial yield gain of 5-7per cent, and in Uttarakhand 16 per cent (Thakur *et al.,* 2004).

The yield gain of 15.4 per cent in on-farm trials in Haryana, on station trials across Indian IGP reported yield gain from 1-12 per cent with an average gain of 240kg/ha or 6.4 per cent across IGP studies. The highest yield gain (62.5%) was reported in Eastern UP (Sen *et al.,* 2002), Dhiman *et al.,* 2003, reported average yield gain of 110kg/ha in Punjab, 172kg/ha in Haryana, 273kg/ha in Uttarakhand, 345kg/ha in Eastion UP and 490kg/ha in Bihar. Long term monitoring of six sets of farmers fields over 8 years in Haryana has shown that ZT had consistently higher or similar yields to CT (Yadav *et al.,* 2005). The survey data from Haryana consistently highlighted higher yields with ZT with an average gain of 210kg/ha or 5 per cent across IGP. About half (52%) of 180 zero tillage farmers in another survey in Haryana reported ZT wheat yields to be higher, with 44per cent reporting similar yields and 4per cent lower yields (Kumar et al., 2005a). A survey in Bihar reported that 60per cent of the farmers achieved an average ZT yield increase of at least 200kg/ha (Kumar et al., 2005b). Focus groups confirmed reported yield gain of 500kg/ha in Punjab and Haryana, 325 kg in Eastern UP i.e. an approximate 10per cent yield gain at each site (Laxmi et al., 2007b). The yield advantage and economic benefits under zero tillage could be attributed to savings on tillage operations, savings on herbicides application, early planting of wheat particularly in basmati rice fields and savings on water and labour.

Majority of the farmers (61.63%) observed longer crop duration (4-7 days) as compared to conventional tillage. Majority of the farmers observed increased soil fertility (51.16%), increased organic carbon in the soil (54.65%) and increased moisture retention capacity of soil (50%) and less lodging (87.21%). On similar line, Kumar et al 2005b, reported less lodging in ZT fields by 97per cent of the respondents. When farmers were asked that is there any advantage of zero tillage technology to avoid terminal heat then most for the farmers (76.74%) were unable to answer it properly but 25.58per cent of them found it helpful in mitigating terminal heat as moisture remains for a longer duration in root zone. ZT improves soil quality in various dimensions, including soil structure, soil fertility, and soil biological properties (Chauhan *et al.,* 2002; Mohanty *et al.,* 2007). ZT can enhance organic carbon content in the surface layers and result in high stability of soil aggregates (Chauhan *et al.,* 2002). ₹ 2320/ha in Bihar, Singh *et al.* (2002b); ₹ 2500/ha, Hobbs (2002).

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Rotary Tillage

Majority of the farmers (80.92%) opined that State Department of Agriculture, Haryana putting efforts to popularize this technology but some farmers were not satisfied with lottery system of subsidy on rotavator. They told that it should be open to all the farmers based on their needs. Majority of the farmers (60.87%) told that machine is available in abundance but 39.13 per cent of farmers faced scarcity when they needed it for sowing.

Table 7: Information on adoption of rotary tillage technology

Technology	Average area (acres/farmer)	
Rotary Tillage	7.10	
Conventional Tillage	0.90	
Efforts made by State Department of Agriculture	**Frequency**	**Percentage**
Yes	51	80.92
No	11	19.08
Availability of machine		
Abundance	59	93.65
Scarce	04	06.35
Continued adoption of rotary tillage		
Yes	34	53.97
No	29	46.03

The average area per farmer was 7.38 acres under rotavator as compared to conventional tillage which was 2.9 acres. Most of the farmers (95.65 %) were willing to continue rotavator for sowing of wheat where as 4.35 per cent of them expressed to give up this technology.

Impact of rotary tillage on wheat cultivation

All the farmers agreed that there was time saving under rotary tillage in wheat sowing. It ranged from 45 minutes to 90 minutes for one acre of area. But majority (80.43 %) told that it takes one hour for one acre area. This was one of the reasons of popularity of rotary tillage technology among farmers. It was also recorded that most of the small farmers in the study area opted this technology for wheat sowing. Majority the farmers (73.02 %) used similar quantity of wheat seed under rotary tillage as compared to conventional tillage. Most of them (98.41 %) observed similar germination under rotary tillage as in conventional tillage. About 80 per cent of the farmers applied same quantity of fertilizer and also observed similar type of weed flora (82.54 %) and less water requirement (57.14 %) in rotary tillage as compared to conventional tillage. Majority of the farmers (68.25 %) observed decrease in cost of cultivation and 41.27 per cent got more yield under rotary tillage while 57.14 per cent recorded similar yield as compared to conventional tillage.

There was no effect of rotary tillage on crop duration as reported by 77.78 per cent farmers. There was positive impact of rotary tillage on fertility of soil (86.96) and organic carbon content of soil (57.14 %). About moisture retention capacity of soil 52.33 per cent responded that there was an increase while 39.68 per cent of them did not find any difference. About 46.03 per cent of the farmers observed more lodging of crop under rotary tillage while same number of farmers observed no change on this front as compared to conventional tillage. Majority of the farmers (85.71 %) agreed that this technology helps in avoidance of terminal heat in wheat crop.

Table 8: Impact of rotary tillage on wheat cultivation n=63

Parameters	Impact		
	Increased	Same	Decreased
Time taken in seeding	06 (09.52)	09 (14.29)	48 (76.19)
Seed rate if increased	00 (00.00)	46 (73.02)	17 (26.98)
Germination	00 (00.00)	62 (98.41)	01 (01.59)
Fertilizer requirement	00 (00.00)	49 (77.78)	14 (22.22)
Population of broad leaf weeds	03 (04.76)	40 (63.49)	20 (31.74)
Population of narrow leaf weeds	03 (04.76)	41 (65.08)	19 (30.16)
Overall weed population	03 (04.76)	52 (82.54)	08 (12.70)
Water requirement	05 (07.93)	22 (34.92)	36 (57.14)
Cost of cultivation	07 (11.11)	13 (20.63)	43 (68.25)
Yield	26 (41.27)	36 (57.14)	01 (01.59)
Duration of crop (from sowing to harvesting)	14 (22.22)	49 (77.78)	00 (00.00)
Fertility of soil	36 (57.14)	26 (41.27)	01 (01.59)
Organic carbon content of soil	33 (52.38)	29 (46.03)	01 (01.59)
Moisture retention capacity of the soil	33 (52.33)	25 (39.68)	05 (07.94)
Lodging	29 (46.03)	29 (46.03)	05 (07.94)
Avoidance of terminal heat	54 (85.71)	09 (14.29)	00 (00.00)

Chronology of adoption of laser land leveller technology revealed that there was a regular increase in number of farmers adopted this technology since 2009. The maximum adoption was achieved during 2013.

Impact of laser land leveller on wheat cultivation

The average area levelled per farmer was 10.9 acres and the remaining area was 2.85 acres. It means most of the areas in the sampled villages have been levelled. All the farmers were very keen to talk about this technology and were willing to adopt continuously whenever required.

Table 9: Information on laser land leveller

Avg. area levelled per farmer (in acres)	Remaining area	Complete levelling (frequency)
11.20	1.6	71(85.54%)
Would you like to continue laser land leveller	**Frequency**	**Percentage**
Yes	123	100
Time taken to level the field		
Time taken (hours/acre)	**Range**	
1.90	1-3.5	

Majority of the farmers (45.78 %) felt that there was decrease in time required for field preparation when they adopt laser land leveller but 33.73 per cent felt that there was an increase in time. The average time for levelling of one acre of land was 1.90 hours but it ranged from 1 hour to 3.5 hours depending on topography of land. All the farmers observed that there was an increase in area by 2-3 per cent under cultivation when they adopted laser land leveller. All the farmers observed that there was reduction in time taken to irrigate the crop to a tune of one third to half in laser levelled fields due to even distribution of irrigation water. All the farmers recorded water saving to a tune of 30-40 per cent percent after adoption of laser land leveller in wheat and rice crop. Majority (48.11 %) felt that cost of cultivation was same in adoption of laser land leveller but 43.4 per cent felt that during first year it increases. Most of the farmers (96.39 %) recorded more (5-10 %) yield after levelling the field. Most of them (95.18 %) observed less lodging of wheat crop in laser levelled fields. This technology is proved to be a boon in rice-wheat system for water saving and better yield

Table 10: Impact of laser land leveller on wheat cultivation n=63

Parameters	Impact		
	Increased	Same	Decreased
Time taken in field preparation	28 (33.73)	17 (20.48)	38 (45.78)
Area brought under cultivation after levelling	43 (51.81)	30 (36.14)	10 (12.05)
Time taken to irrigate the crop (hrs./ha)	00 (00.00)	04 (04.76)	80 (95.24)
Water requirement	00 (00.00)	07 (08.43)	76 (91.57)
Cost of cultivation	10 (12.05)	15 (18.07)	58 (69.88)
Yield	80 (96.39)	03 (03.61)	00 (00.00)
Crop duration (from sowing to harvesting)	06 (07.23)	76 (91.57)	01 (01.20)
Lodging	02 (02.41)	02 (02.41)	79 (95.18)

CONCLUSION

The study highlighted the adoption and impact of resource conservation technologies on wheat cultivation in Haryana. With the adoption of zero tillage, rotary tillage and laser land leveller farmers could save their valuable resources such as water, time, energy and money. Due to adoption of these resource conservation technologies at farmers' field, there was an increase in fertility status, organic carbon and water retention capacity of soil *i.e.,* overall soil health improvement. The effort of state department in popularization of these technologies was highly impactful in the study area. To stop residue burning in the state, these technologies have to be up scaled in other areas and other cropping systems by organizing demonstrations on relay moong in wheat, relay wheat in cotton, zero tillage moong, zero tillage green manuring *etc.* There is a need to out scale RCTs in other states to harness the potential benefits of these technologies.

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