Indian Journal of Agronomy **56** (2): 116–120 (June 2011)

Effect of tillage and nutrient management on resource conservation and productivity of wheat (*Triticum aestivum*)

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Received: August, 2010

ABSTRACT

A field experiment was conducted from 2003 to 2005 at Jammu Chatha to study the effect of tillage and nutrient management on resource conservation and productivity of wheat [*Triticum aestivum* (L.) Fiori & Paol.] in *basmati* rice (*Oryza sativa* L.) - wheat system. Zero tillage significantly improved the physico-chemical properties of soil *viz.,* available N, P and K with concomitant increase in field capacity storage, permanent wilting point and soil moisture content. Bulk density values in the soil layers of 0-15 and 15-30 cm depth were higher under zero tillage. Conventional tillage though recorded 5.2 and 3.6% more grain yield of wheat than zero tillage. Tillage methods did not influence dry matter accumulation, grain and biological yields of wheat during both the years. Increasing fertility level from 75 to 100% of recommended fertilizer dose (100, 50 and 25 kg/ha of N, P and K) significantly increased the growth and yield of wheat during both the years, whereas further increase in recommended dose to 125% did not show significant impact on growth and yield of wheat.

Key words: Fertility levels, Physico-chemical proparties, Productivity, Rice, Tillage method, Wheat

Indiscriminate use of chemical fertilizers, intensive tillage and other faulty management practices have threatened the sustainability of the rice-wheat cropping system in north-western India. Productivity of this system is declining, both the crops being nutrient exhaustive, deteriorate soil fertility and pose great threat to the natural resources (Prasad, 2005). Therefore, it becomes imperative to sustain the productivity of this cropping system through alternative and efficient technologies such as zero tillage. Zero tillage is emerging as a way of transition to the sustainability of intensive production systems, besides, generating net social gains to society (Bhale and Wanjari, 2009). It permits management of water and soil for agricultural production without excessive disturbance to soil. The sowing with zero-till drill not only facilitates timely sowing of wheat on residual soil moisture but also improves the soil health as the plant stand is influenced by moisture content, tillage and time of sowing. Further, from a study conducted on the fate of soil carbon in the USA, it was reported that when adoption rate of conservation tillage is 76%, zero tillage would contribute to increase carbon deposits into soil by almost 400 m tonnes thus would improve soil fertility (Reicosky, 2005). Moreover, Jammu region is known for its *basmati* rice, where wheat sowing is usually delayed due to long duration of *basmati* rice. Therefore, the study was undertaken to assess the performance of zero and conventional tillage under various fertility levels and time of N application on the growth and yield of wheat besides the moisture conservation and fertility status of the soil.

MATERIALS AND METHODS

A field experiment was conducted at the Research Farm, Chatha of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu during the *kharif* and *rabi* of 2003-04 to 2004-05. The soil of the experimental field was sandy-clay-loam in texture, slightly alkaline (pH 7.8), low in organic C (0.34 %) and available N (214 kg/ha) and medium in available P (13.8 kg/ha) and K (129.8kg/ha). The experimental site was under potato crop for two seasons before sowing of experimental crop.

Basmati rice ('B-370') during *kharif* was followed by wheat ('PBW-343') during *rabi*. Rice crop was raised as a uniform crop under puddled transplanted conditions. On the succeeding wheat crop, 30 treatment combinations comprising of two tillage methods, *viz* zero and conventional and three fertility levels, *viz.,* 75, 100 and 125% of recommended fertilizer dose in main-plots and 5 N-splits *viz.,* N_1-0:50:50, N_2-20:40:40, N_3-33:33:33, N_4-50:25:25

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and N_5-50:50:0 in sub-plots, were imposed. The experiment was arranged in split plot design with 3 replications. The wheat was sown at 20 cm row spacing under both conventional and no-till method with a seed rate of 100 kg/ha. In conventional tillage, the field was ploughed twice with disc harrow to get fine seed bed and sowing was done on 26 and 21 November; whereas sowing in zero-tilled plots was taken directly after harvest of *basmati* rice on 18 and 14 November in 2003-04 and 2004-05, respectively, on residual soil moisture. The recommended dose of N: P: K fertilizer for rice crop was 30:20:10 kg/ha, whereas wheat crop was fertilized with N: P : K @ 100:50:25 kg/ha respectively, using urea, diammonium phosphate and muriate of potash as source of fertilizers. Full dose of P and K along with half of N were applied as basal in both the crops and remaining N was applied in 2 splits at 30 and 60 days after transplanting in *basmati* rice, and as per treatment in wheat at crown root initiation (CRI) and ear initiation (EI) stages of the crop during both the years of experimentation. Data on growth, yield attributes, grain and biological yield of wheat were calculated as per the standard procedures. Both the crops were irrigated as and when required. The rainfall received during 2003-04 crop season was slightly higher than received during 2004-05.

Soil water content was measured gravimetrically at 0-15, 15-30, 30-60 and 60-90 cm depths before sowing (Table 1) and at harvest (Table 5) of wheat crop. Depth-wise bulk density values were determined using soil core sampler at sowing and at harvest for each treatment. Water content at each depth were averaged and converted to a volume basis using a pre determined value of bulk density for respective treatment, time and depth.

Table 1. Initial physical characteristics of soil profile

Soil depth (cm)	Field capacity		PWP		Available water content (cm)	Bulk density (Mg/m^3)
	% w/w	cm	% w/w	cm		
0-15	13.24	3.01	5.35	1.22	1.79	1.52
15-30	12.65	2.84	5.52	1.24	1.60	1.50
30-60	13.72	6.46	5.90	2.78	3.68	1.57
60-90	14.01	6.64	6.10	2.89	3.75	1.58
Total		18.95		8.13	10.82	

RESULTS AND DISCUSSION

Growth and yield of wheat

Dry matter production (Table 2) of wheat increased with advancement in crop age up to 90 DAS and thereafter increased gradually with decreasing rate up to harvest stage. Tillage systems did not result in significant variation in dry matter production at various growth stages, though conventional tillage gave higher dry matter production

Table 2. Effect of tillage and fertilizer treatments on wheat dry matter production (t/ha) at various growth stages

Treatment	Days after sowing									
	30		60		90		120		At harvest	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
Tillage										
Zero	0.38	0.39	2.03	2.10	4.62	4.65	6.83	7.01	7.85	8.05
Conventional	0.40	0.40	2.16	2.16	4.73	4.84	6.88	7.12	8.11	8.27
SEm±	0.06	0.04	0.40	0.27	0.35	0.64	0.20	0.43	0.88	0.72
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fertility level (RDF)										
75%	0.38	0.38	1.97	2.02	4.54	4.55	6.70	6.89	7.60	7.76
100%	0.39	0.40	2.14	2.16	4.72	4.75	6.88	7.12	8.00	8.18
125%	0.40	0.40	2.17	2.21	4.77	4.93	6.98	7.17	8.34	8.54
SEm±	0.09	0.07	0.05	0.04	0.06	0.07	0.05	0.02	0.12	0.14
CD (P=0.05)	NS	NS	0.16	0.14	0.16	0.20	0.16	0.08	0.34	0.39
N-splits										
0:50:50	0.35	0.36	1.72	1.80	4.35	4.38	6.49	6.67	7.60	7.83
20:40:40	0.38	0.38	1.94	1.99	4.77	4.83	6.97	7.18	8.01	8.28
33:33:33	0.39	0.41	2.21	2.25	5.06	5.06	7.10	7.36	8.25	8.43
50:25:25	0.40	0.41	2.58	2.29	4.80	4.94	7.02	7.25	8.17	8.29
50:50:0	0.42	0.42	2.34	2.31	4.47	4.51	6.68	6.85	7.86	7.97
SEm±	0.01	0.01	0.07	0.06	0. 08	0.11	0.06	0.07	0.12	0.14
CD (P=0.05)	0.03	0.02	0.18	0.17	0.23	0.34	0.18	0.18	0.35	0.41

Y_1- Year 2003-04; Y_2- Year 2004-05, N-splits: Basal, CRI, Ear initiation stage, RDF – 100:50:25

over the zero tillage. Yield attributes *viz.,* number of spikes/ 2, number of grains per spike, spike weight and 1,000-grain weight as well as grain and biological yield (Table 3) did not differ significantly under two tillage methods. Zero tillage advanced the sowing date and resulted in proper placement of seed, early emergence of wheat seedlings and availability of higher nutrient and moisture content, which might have helped the crop to compete with the crop sown under conventional tillage. Results corroborate to the findings given by Kumar and Yadav (2005).

Increasing fertilizer dose from 75 to 100% of recommended dose significantly increased dry matter production, yield attributes and grain and biological yield of wheat (Table 3). However, further increase in fertilizer dose to 125% of recommended dose didn't increase the dry matter production, yield attributes and grain and biological yield significantly. This may be due to optimal supply of nutrients to the wheat crop upon use of recommended dose of fertilizers, thereby resulting in better growth and development of the crop.

Interaction of tillage system with fertility levels revealed that zero-tilled wheat responded up to 125% of recommended fertilizer dose. Dry matter production and grain yield of wheat was found to be significantly the highest at 125% fertility level than 100 and 75% fertility levels (Table 4). In turn, under same tillage system, 100% fertility level also produced significantly higher dry matter and grain yield than 75% fertility level. However, under conventional tillage system these increased significantly only up to 100% fertility level and it remained at par with 125% fertility level. This may be due to additional requirement of nitrogen for proper decomposition of paddy (preceding crop) stubbles under zero tilled conditions which after mineralization may have supplied available nutrients to the crop and also had solubilizing effect on fixed forms of other nutrients. The results corroborate to the results of Singh *et al.* (2001).

Application of N in three equal splits N_3 (33:33:33) as basal dose, crown root initiation and ear initiation stage resulted in significantly higher dry matter (Table 2), yield attributes and grain and biological yield (Table 3) than N_1 (0:50:50) and N_5 (50:50:0) splits but were at par with N_4 (50:25:25) and N_2 (20:40:40) treatments. The increase in grain and biological yield may be due to the availability of nitrogen at various critical crop growth stages in optimal amount which might have increased the yield attributes of wheat thus resulting in the increased grain and biological yield. This is in conformity to the results of Kumar and Yadav (2005).

Economics

Zero tillage method recorded 5.2 and 6.8% higher net returns over conventional tillage (Table 3) from 2003-04 to 2004-05 respectively. Higher net returns may be on account of savings on operational cost, diesel and time under zero tillage. Net returns increased with increase in fertilizer

Table 3. Effect of tillage and fertilizer management on yield attributes, yield and economics of wheat

Treatment	Spikes/m^2		Grains/spike		1000-grain weight (g)		Grain yield (t/ha)		Biological yield (t/ha)		Net returns (Rs/ha)	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
Tillage												
Zero	240.5	248.5	40.1	40.1	39.5	39.7	3.48	3.63	7.86	8.05	17,683	20,073
Conventional	246.1	256.0	42.3	42.5	41.2	41.4	3.66	3.76	8.10	8.27	16,696	18,800
SEm±	2.01	2.55	0.76	0.81	0.62	0.53	0.04	0.05	0.28	0.05		
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS		
Fertility level (RDF)												
75%	233.1	241.9	40.1	40.0	39.4	39.5	3.23	3.43	7.59	7.76	13,562	16,762
100%	244.6	254.0	41.4	41.6	40.7	41.0	3.64	3.74	8.00	8.18	16,480	19,038
125%	251.3	269.8	42.2	42.2	41.0	41.2	3.85	3.94	8.33	8.54	17,929	20,402
SEm±	2.68	3.31	0.33	0.29	0.19	0.18	0.08	0.07	0.14	0.17		
CD (P=0.05)	8.2	10.7	1.1	1.0	0.67	0.62	0.27	0.20	0.34	0.39		
N-splits												
0:50:50	236.1	237.6	40.0	40.2	40.9	41.2	3.36	3.50	7.59	7.83	14,154	17,053
20:40:40	244.6	255.2	41.7	41.5	40.7	40.8	3.63	3.72	8.01	8.28	16,464	18,970
33:33:33	248.7	263.2	42.2	42.4	40.5	40.6	3.80	3.92	8.25	8.43	17,706	20,516
50:25:25	245.8	259.4	41.7	41.9	40.0	40.3	3.66	3.79	8.16	8.29	16,648	19,408
50:50:0	241.2	245.9	40.4	40.4	39.8	40.0	3.43	3.57	7.86	7.97	15,051	17,855
SEm±	2.74	3.59	0.25	0.64	0.16	0.20	0.08	0.07	0.17	0.16		
CD (P=0.05)	8.4	11.1	NS	NS	0.51	0.63	0.27	0.22	0.35	0.41		

Y_1, 2003-04 year; Y_2, 2004-05 year.

dose and maximum net returns were observed at 125% of recommended fertilizer dose during both the years of study. Among N-splits, the treatments receiving three splits recorded more net returns than those receiving two splits of nitrogen (N). The impact of treatments on grain yield might have helped in getting higher profit.

Soil water content

Zero-tilled plots recorded higher values for available soil moisture storage in the soil profile (0-90 cm depth) than conventional tillage. This may be due to improvement in soil structure under zero tillage due to retention of rice stubbles, which resulted in increased organic matter content thereby increasing the water holding capacity between field capacity and permanent wilting point (PWP) (Table 5). Furthermore, undisturbed soil surface along with the crop residues may have helped to reduce evaporation losses by acting as mulch. The results are in conformity to those given by Prasad (2005). However, soil moisture content remained unaffected under different fertility levels and nitrogen splits.

Bulk density

Zero-tillage resulted in higher bulk density in the 0-15 and 15-30 cm depth, whereas bulk density under conventional tillage reduced from initial value of 1.52 to 1.50 Mg/m^3 (Table 5). In the lower depths 30-60 and 60-90 cm there was not much change in bulk density. Fertility levels and N-splits did not register any variation in the bulk density. Under conventional tillage the ploughing and pulverization may be the cause for lower bulk density values. Similar results were reported by Kumar and Yadav (2005) and Chitale *et al*., (2007).

Table 4. Interaction effect of tillage and fertility levels on grain yield of wheat (t/ha)

Fertility levels (RDF)	2003-04		2004-05	
	ZT	CT	ZT	CT
75%	3.11	3.36	3.37	3.5
100%	3.52	3.75	3.62	3.85
125%	3.82	3.90	3.92	3.95
SEm±	0.08		0.07	
CD (P=0.05)	0.27		0.29	

Soil fertility status

Available N, P and K content of the soil at wheat harvest was not affected significantly due to two tillage methods. Contrarily, zero-tilled plots (Table 6) recorded numerically higher content of available nutrients which may be attributed to retention of previous crop residues and less leaching losses under zero-tillage. Rice stubbles might have increased available P content by solublization action of certain acids and displacement of phosphate organic anions formed during decomposition of organic residues (Sharma, 2001). Similarly, available K content was also higher under zero-tilled plots than conventional tilled plots. This is in confirmation to the findings of Chitale *et al*. (2007).

Available nutrient content was statistically highest at 125% of recommended dose of fertilizer followed by 100 and 75% of recommended dose of fertilizer. It may be due to more availability of nutrients at higher fertility levels and also neutral pH of soil may have not impaired the nutrient availability by way of fixing of nutrients especially in case of phosphorus. Chandra *et al.* (2001) observed similar results. All the five N-splits recorded similar content of available N, P and K. Though available N content

Table 5. Influence of tillage and nutrient management on available moisture storage (cm) and bulk density (Mg/m^3) in various soil depths at the termination of study

Treatment	FC				PWP				Bulk density			
	0-15 cm	15-30 cm	30-60 cm	60-90 cm	0-15 cm	15-30 cm	30-60 cm	60-90 cm	0-15 cm	15-30 cm	30-60 cm	60-90 cm
Tillage method												
Zero	3.21	2.90	6.28	7.94	1.28	1.53	2.88	3.20	1.53	1.60	1.48	1.50
Conventional	2.70	2.55	5.89	7.78	1.24	1.49	2.82	3.16	1.50	1.59	1.48	1.49
Fertiliy levels (% RDF)												
75%	2.80	2.87	6.07	6.99	1.24	1.48	2.84	3.18	1.51	1.60	1.49	1.50
100%	3.07	2.45	6.55	7.75	1.29	1.59	2.86	3.15	1.51	1.60	1.47	1.50
125%	2.98	2.89	5.62	6.95	1.27	1.49	2.82	3.21	1.53	1.60	1.49	1.48
N-splits												
0:50:50	2.95	2.71	6.19	7.88	1.28	1.48	2.80	3.17	1.53	1.61	1.46	1.47
20:40:40	3.01	2.66	6.59	7.02	1.27	1.49	2.84	3.26	1.53	1.60	1.51	1.51
33:33:33	2.90	2.57	6.33	8.12	1.28	1.58	2.86	3.20	1.49	1.58	1.49	1.50
50:25:25	2.77	2.76	5.85	6.97	1.27	1.51	2.87	3.16	1.51	1.60	1.47	1.50
50:50:0	3.07	2.91	5.44	6.33	1.23	1.56	2.88	3.11	1.51	1.61	1.48	1.49

FC, Field capacity; PWP, Permanent wilting point

Table 6. Effect of tillage and nutrient management on soil fertility status at the end of study

Treatment	Available nutrients (kg/ha)					
	2003-04			2004-05		
	N	P	K	N	P	K
Tillage method						
Zero	213.5	13.3	129.1	215.8	13.7	130.0
Conventional	211.5	12.7	128.0	214.3	13.5	129.2
SE m±	0.63	0.24	0.40	0.58	0.05	0.33
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Fertility levels (RDF)						
75%	210.5	12.3	125.9	212.8	12.9	128.2
100%	212.5	13.0	128.9	215.6	13.5	129.5
125%	214.6	13.8	130.8	216.7	14.5	131.1
SEm±	0.94	0.19	0.63	0.84	0.18	0.37
CD (P=0.05)	3.05	0.66	1.84	2.44	0.61	1.04
N-splits						
0:50:50	213.7	12.7	125.0	216.0	13.5	128.6
20:40:40	212.3	12.9	128.7	215.3	13.7	128.7
33:33:33	213.6	13.3	130.4	215.1	13.5	130.0
50:25:25	213.0	13.4	129.2	214.6	13.5	130.9
50:50:0	211.7	12.8	129.3	214.3	13.9	129.8
SEm±	0.71	0.27	1.55	0.51	0.17	0.82
CD (P=0.05)	NS	NS	NS	NS	NS	NS

RDF – 100:50:25

in soil was higher in treatments receiving more N splits, which may be due to reduction in N losses and continuous availability.

Thus it can be concluded that conventional-tilled wheat recorded grain and biological yield statistically similar to zero-tilled wheat. Zero-tilled plots showed gradual improvement in conservation of resources, soil physical properties and soil moisture content. Under zero tillage wheat grain yield responded significantly up to 125% of the recommended fertilizer dose.

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