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Studies on tillage and green manuring for enhancing productivity of wheat (*Triticum aestivum*)

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ABSTRACT

A field experiment was conducted in 2016–17 and 2017–18 during *kharif* and *rabi* season at agricultural research farm of BHU, Varanasi, to study the effect of different tillage practices and green manuring on productivity and profitability of maize-wheat cropping system. The experiment was laid out in split plot design comprising 20 treatments. The four different tillage practices, viz. T_1 (Conventional tillage maize-Conventional tillage wheat), T_2 (Minimum tillage maize-Minimum tillage wheat), T_3 (Minimum tillage maize-Zero tillage wheat) and T_4 (Zero tillage maize-Zero tillage wheat) were assigned to main plot and five summer green manuring treatments, viz. M_1 (Summer fallowing), M_2 (Dhaincha), M_3 (Sunnhemp), M_4 (Clusterbean) and M_5 (Cowpea) were kept in sub plots. The treatment, T_4 and T_1 were at par with each other and registered higher yield attributing characters, grain (4814.61, 4931.94 and 4754.03, 4840.69 kg/ha during 2016–17 and 2017–18, respectively) and straw yield, quality and B:C ratio. In case of summer green manuring, M_2 (Dhaincha) recorded higher yield attributing characters, grain and straw yield and quality (4846.27, 4957.54 kg/ha during 2016–17 and 2017–18, respectively) over other treatments but it was at par with M_3 (Sunnhemp). It is recommended that ZT wheat and summer green manure Dhaincha residue mulching should be followed to achieve higher yield and profitability.

Keywords: Clusterbean, Conventional tillage, Cowpea, Dhaincha, Green Manure, Sunnhemp, Wheat, Zero Tillage

Maize-wheat is the third most important cropping system after rice-wheat (RW). Conventional tillage RW system causes problems such as development of hardpan, low input use efficiency including water use efficiency, and emergence of insects-pests as well as environmental pollution through emission of greenhouse gases. Furthermore, there is great concern about groundwater depletion in large areas of North-West India where the RW system prevails (Rodell *et al*. 2009). Conservation tillage system improves land productivity by way of improved soil physical properties, reduced soil loss and enhanced soil organic carbon. Besides these advantages, input costs are lowered by eliminating a series of tillage operations (Hobbs 2007). There is a growing interest towards the use of conservation agriculture, such as reduced-tillage, no-tillage, crop residue addition, and improved nutrient management practices in rice and other crops in rotation for sustainably increasing food production in South Asia (Johnston *et al*. 2009). The importance of leguminous green manure crops in improving soil fertility and soil physical properties has received increasing attention in recent times. The improvement in soil physical conditions as a result of build-up of organic matter by incorporation of green manure or crop residue is associated with a decrease in bulk density, increase in total pore space, water stable aggregates and hydraulic conductivity of the soil (Bhatnagar *et al*. 1992). Hence, different conservation tillage methods are adopted as alternative to conventional tillage to overcome problems related to productivity, profitability, water and soil. In view of the difficulties faced in traditional method of growing of these crops, and by considering the several benefits of conservation tillage practices such as economic benefits to labour, a substantial saving in time and cost, erosion protection, soil and water conservation, and increase in soil organic matter, the present experiment was conducted to evaluate the feasibility of different tillage practices with summer green manuring to sustain crop productivity and soil health in maize-wheat cropping sequence under irrigated condition of eastern Uttar Pradesh.

MATERIALS AND METHODS

The field experiment was undertaken at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras

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Hindu University, Varanasi during *kharif* and *rabi* season of 2016–17 and 2017–18. Geographically, Varanasi is situated at 25°18' N latitude, 83°31' E longitude and altitude of 75.7 m msl in the northern Indo-Gangetic alluvial plains and receives average annual rainfall of 1,100 mm. The soil was sandy clay loam, with *p*H 7.72 and electrical conductivity (EC) 0.30 dS/m, low in organic carbon (0.41%), available N (146 kg/ha), and medium in available phosphorus (18.3 kg/ha) and potassium (175 kg/ha). The field experiment was laid-out in split plot design with three replications. The treatment comprised four tillage practices in main plot, viz. T_1 (Conventional tillage maize-Conventional tillage wheat), T_2 (Minimum tillage maize-Minimum tillage wheat), T_3 (Minimum tillage maize-Zero tillage wheat), T_4 (Zero tillage maize-Zero tillage wheat) and five summer green manuring in sub plot, viz. M_1- Summer fallowing, M_2-Dhaincha (*Sesbania aculeata*), M_3-Sunnhemp (*Crotalaria juncea*), M_4-Clusterbean (*Cyamopsis tetragonoloba*), M_5- Cowpea (*Vigna sinensis*) were investigated.

All the summer green manure crops were incorporated or cut at 45 DAS. In T_1, T_2 and T_3 treatments, different green manure crops were incorporated according to main plot tillage practices. In zero tillage wheat (ZTW) plots, the crop was established without any preparatory tillage. In conventional tillage wheat (CTW) and minimum till wheat (MTW), the field was tilled according to main plot treatments in same layout during *rabi* season.

RESULTS AND DISCUSSION

The tillage treatments, T_4 (ZTM – ZTW) and T_1 (CTM – CTW) exhibited significantly higher values of dry matter. Overall the effect of tillage practices on wheat dry matter accumulation at harvest were in the order T_4> T_1> T_2> T_3. Among summer green manuring treatments, M_2 (dhaincha) recorded significantly higher dry matter accumulation at all the growth stages of crop as compared to other green manuring treatments but it was at par with M_3 (sunnhemp). This might be due to better soil health and micro-environment created by continuous adoption of zero till based practices. Tillage showed significant effect on seed germination, number of tillers, dry matter and crop yield of wheat (Dhirubhai *et al*. 2016). Singh *et al.* (2013) reported that growth parameters of wheat crop were significantly influenced by ZT sowing method compared to CT, whereas non-significant difference in growth parameters and yield between MT and CT treatment were observed. Yadav *et al.* (2005) also reported better growth and yield attributes of the wheat crop under zero till treatments as compared to intensive and minimum tillage practices.

Tillage practices exhibited marked improvement in the yield and yield attributes of wheat i.e. number of spikes/m, grains/spike and spike length (cm). Among the tillage practices, treatment T_4 (ZTM-ZTW) and T_1 (CTM-CTW) exhibited higher values but were statistically at par with each other. Whereas both of these tillage treatments were significantly superior over the other tillage treatments. Overall the effect of tillage practices on crop yield and yield attributing characters were in the order of T_4> T_1> T_2> T_3. However, test weight (g) and harvest index (%) did not meet the level of significance during both the years and protein content in second year of experimentation. Summer green manuring also had a significant effect on yield and yield attributes of wheat. M_2 (dhaincha) recorded significantly higher yield and yield attributing characters which was at par with M_3 (sunnhemp) . Test weight and harvest index were not influenced significantly due to different green manuring

Table 1 Effect of different tillage practices and green manuring on yield attributes of wheat

Treatment	Dry matter (g/m)		No. of spikes/m		No. of grains/spike		Spike length (cm)		Test weight (g)	
	2016–17	2017–18	2016–17	2017–18	2016–17	2017–18	2016–17	2017–18	2016–17	2017–18
Tillage practices										
T_1: CTM-CTW	231.95	234.81	74.27	74.63	39.97	41.14	12.16	13.25	41.93	42.23
T_2: MTM-MTW	220.39	222.86	70.14	70.60	37.99	39.22	11.77	12.75	41.77	41.93
T_3: MTM-ZTW	214.38	213.14	69.10	68.76	34.95	34.57	11.75	12.59	41.66	41.63
T_4: ZTM-ZTW	234.48	237.68	75.99	76.57	40.37	41.56	12.60	13.73	42.06	42.38
SEm ±	3.91	4.10	1.34	1.38	0.61	0.63	0.17	0.21	0.30	0.30
CD (P=0.05)	13.52	14.18	4.63	4.78	2.11	2.18	0.60	0.71	NS	NS
Summer green manuring										
M_1: Summer fallowing	210.37	210.36	67.31	65.91	35.42	35.32	11.38	12.06	41.46	41.57
M_2: Dhaincha	238.34	241.28	77.85	78.64	40.35	41.47	12.77	13.92	42.17	42.46
M_3: Sunnhemp	231.82	234.06	75.90	76.48	39.59	40.67	12.51	13.61	42.06	42.33
M_4: Clusterbean	223.85	225.86	71.80	72.49	38.45	39.49	11.93	12.99	41.83	41.96
M_5: Cowpea	222.11	224.04	69.02	69.70	37.78	38.67	11.76	12.82	41.76	41.88
SEm ±	3.82	3.77	1.11	1.14	0.65	0.65	0.19	0.20	0.27	0.26
CD (P=0.05)	11.02	10.86	3.20	3.28	1.86	1.88	0.55	0.57	NS	NS
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2 Effect of different tillage practices and green manuring on yield and quality of wheat

Treatment	Grain yield (kg/ha)		Straw yield (kg/ha)		Biological yield (kg/ha)		Harvest index (per cent)		Protein content (per cent)	
	2016–17	2017–18	2016–17	2017–18	2016–17	2017–18	2016–17	2017–18	2016–17	2017–18
Tillage practices										
T_1: CTM-CTW	4754.03	4840.69	6782.86	6790.53	11536.89	11631.22	41.20	41.61	11.08	11.44
T_2: MTM-MTW	4517.11	4597.11	6449.52	6464.86	10966.64	11061.97	41.19	41.56	11.01	11.35
T_3: MTM-ZTW	4212.39	4200.82	6070.17	6045.75	10282.56	10246.56	40.95	40.98	11.00	10.91
T_4: ZTM-ZTW	4814.61	4931.94	6850.16	6864.16	11664.77	11796.10	41.28	41.83	11.08	11.70
SEm ±	84.01	85.00	115.57	114.34	188.17	169.38	0.23	0.35	0.17	0.14
CD (P=0.05)	290.71	294.16	399.92	395.68	651.16	586.15	NS	NS	NS	0.47
Summer green manuring										
M_1: Summer fallowing	4265.67	4273.64	6123.79	6126.18	10389.46	10399.82	41.05	41.08	11.01	10.97
M_2: Dhaincha	4846.27	4957.54	6911.68	6916.20	11757.96	11873.74	41.25	41.78	11.06	11.66
M_3: Sunnhemp	4715.10	4793.03	6722.07	6719.09	11437.17	11512.12	41.19	41.61	11.06	11.62
M_4: Clusterbean	4547.56	4616.33	6493.99	6491.01	11041.55	11107.34	41.16	41.54	11.05	11.26
M_5: Cowpea	4498.07	4572.67	6439.37	6454.14	10937.43	11026.81	41.11	41.47	11.02	11.24
SEm ±	82.01	79.85	107.12	107.36	193.00	187.76	0.19	0.29	0.10	0.13
CD (P=0.05)	236.25	230.01	308.57	309.27	555.97	540.89	NS	NS	NS	0.39
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

treatments during both the years and protein content in first year of experimentation. Overall the yield obtained from different green manuring treatments were in the order of M_2> M_3> M_4> M_5> M_1.

Grain, straw and biological yield and harvest index during 2017–18 cropping season resulted in higher values of these parameters irrespective of treatments. Higher yield of wheat was due to longer and favorable period, tillers and ear formation resulting in more spikelet development and greater chances of producing long ears containing a large number of grains. Moreover, less favorable climatic conditions and short term effect of tillage and summer green manures resulted in lower productivity during 2016–17.

Higher yield and yield attributing characters in zero till wheat (ZMT-ZTW) might be because of residue retention of summer green manures and continuous effect of zero tillage, which ultimately improved the soil moisture conservation and fertility status of soil. Zero tillage had higher values of plant growth, yield parameters, grain yield and straw yield as compared to conventional tillage (Ali *et al.* 2016).

However, applying summer green manure residue under zero tillage treatments produced higher values of yield attributes in wheat than residue incorporation in conventional and minimum tillage treatments. This might be due to good and favorable soil moisture, moderate soil temperature, and improved soil fertility due to constant supply of nutrients through slower mineralization of summer green manure residues. Mulching significantly increased maize and wheat yields in the experimental field under irrigated conditions (Huang *et al*. 2012 and Liu *et al*. 2018). The results of higher wheat productivity under ZT are in agreement with earlier studies (Ram *et al*. 2010 and Gathala *et al*. 2011).

The treatment T_4 (ZTM-ZTW) recorded higher gross return (□105638/ha and □107601/ha), net return (□71262/ha and □73268/ha), and benefit:cost ratio (2.08 and 2.13) as compared to other tillage practices during both the years of study. Zero till wheat (ZTM-ZTW) recorded lower cost of cultivation and higher gross return, net return, benefit:cost ratio as compared to CTM-CTW, MTM-MTW and MTM-

Table 3 Effect of different tillage practices and green manuring on economics of wheat

Treatment	Cost of cultivation (□/ha)		Gross return (□/ha)		Net returns (□/ha)		B:C ratio	
	2016–17	2017–18	2016–17	2017–18	2016–17	2017–18	2016–17	2017–18
Tillage practices								
T_1: CTM-CTW	41932	41932	104384	105823	62453	63892	1.49	1.52
T_2: MTM-MTW	36532	36532	99201	100563	62669	64031	1.72	1.75
T_3: MTM-ZTW	34333	34333	92732	92446	61854	61557	1.80	1.79
T_4: ZTM-ZTW	34333	34333	105638	107601	71262	73268	2.08	2.13

ZTW. Lower cost of production under ZT than CT practice was due to no-tillage operations, except planting of crops, saving of money in weed control practices due to herbicide application, which were less costly than manual weeding and labor cost involved in various cultural operations. The cost saving towards irrigation, land preparation for sowing and weed control makes zero tillage profitable and is the main driver behind its spread. More number of tillage operations contribute greatly to cost of cultivation in any crop production system resulting in lower economic returns (Labios *et al*. 1997). The higher cost of production under CTW practices was due to more number of tillage operations, which diminished the net return during both the years of investigation. The lowest net income and benefit:cost ratio with CT was due to the highest cost of cultivation and low yield as compared to ZT of wheat crop. The ZT sowing technique saved cost of production and gave higher yield of wheat in comparison to CT and MT. The results are in close agreement with Erenstein *et al*. (2008) and Singh *et al*. (2013).

Study concluded that summer green manure dhaincha residue mulching in zero tilled maize (ZTM) and wheat (ZTW) produced higher grain yield and net return than conventional tillage due to higher biomass accumulation, carbon sequestration and cost saving. Long term experimentation is suggested to evaluate the effect of green manuring under different tillage practices in maize and wheat cropping system.

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