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Effect of Tillage and Nitrogen Scheduling on Nutrients Uptake and Economics of Wheat (*Triticum aestivum* L.) in Central Punjab

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A B S T R A C T

The present research entitled, "Effect of tillage and nitrogen scheduling on yield, nutrients uptake and economics of wheat (*Triticum aestivum* L.) in central Punjab" was carried out at Experimental Research Farm of the Department of Agriculture, Mata Gujri College, Sri Fatehgarh Sahib, Punjab during *Rabi* season of 2016-2017. The soil was alluvial having sandy loam texture with pH 7.3. The study was done in randomized block design with twelve treatments and three replications with HD 3086 wheat variety. The aim of this study was to evaluate the impact of two tillage systems used *viz.*, zero tillage (ZT) and conventional tillage (CT) and three nitrogen application rated (100,125 and 150 kg/ha) on yield components, nutrients uptake by grain and straw and economics of individual plant parameters were recorded from randomly selected plants in each plot. On the basis of results summarized, the application of T_{11} - ZT + N_5 i.e. N@125 kg (4 splits) applied at ¼, ¼, ¼ and ¼ at basal, 4, 6 and 8 WAS gave the best result in terms of crop yield, nutrients uptake by grain and straw and economics which is statistically at par to the application of T_5 - CT + N_5 i.e. N@125 kg (4 splits) applied at ¼, ¼, ¼ and ¼ at basal, 4, 6 and 8 WAS and T_{12} - ZT + N_6 i.e. N@150 kg (4 splits) applied at ¼, ¼, ¼ and ¼ at basal, 4, 6 and 8 WAS.

Introduction

Wheat (*Triticum aestivum* L.) is the second most important cereal crop in India with an average area of 29.7 mha and annual production of 92.5 mt which contribute approximately 12.5% and 12% in world's wheat area and production respectively. In India, Uttar Pradesh stands first in respect of area followed by Madhya Pradesh, Punjab. In production, Uttar Pradesh also stands first followed by Punjab, Haryana, Madhya Pradesh. As regards to the productivity, Punjab stands first with 4531 kg/ha followed by Haryana with 4066 kg/ha (*Anonymous* 2014-2015). The production of wheat can be improved and enhanced by using better inputs, proper production technology and appropriate tillage methods. Tillage and nitrogen can be considered as the most critical management practices as both affect the production potential of wheat. Soil tillage is one of the fundamental agro-technical operations in agriculture because of its influence on soil properties, environment and crop yield. Tillage plays important role in changing initial state of soil which modify whole environment likes bulk density and porosity which affects the infiltration rate of soil. Bhattachariya *et al.,* 2008 reported that change in bulk density depends on the intensity of tillage systems. Different tillage systems produce different results like zero tillage (ZT) promotes soil organic carbon (SOC) sequestration, improves soil aggregates and better pore size allocation while conventional tillage (CT) usually increases available water capacity and infiltration rate and decreases run-off. The continuous adoption of conventional tillage makes the soil more compact and a hardpan is usually developed underneath the plough layer with high bulk density and lower saturated hydraulic conductivity which hinder the movement of water and air, inhibits root growth and reduces crop yield (Huang *et al.,* 2012). Moreover, low precipitation (<200 mm annually) and highly pulverized surface soils caused by repeated tillage increases the wind erosion, energy usage and soil degradation. In order to minimize the degradation of the physical and chemical properties of the soil and increases water availability for crops, conservation tillage could be a key measures. The conservation tillage embraces crop production system involving management of surface residues.

The conservation tillage is helpful in maintaining soil moisture in comparison to intensive tillage operations (Hatfield and Stewart, 1994). Zero tillage improves water and nutrient use efficiencies and increase crop productivity and carbon sequestration, ameliorate soil properties and mitigate green house gasses emission. Zero tillage exhibited highest grain yield (4.8 t/ha) of wheat after rice as compared to conventional till (4.5 t/ha), deep tillage (4.4 t/ha) and reduced tillage (4.3 t/ha) (Imran *et al.,* 2013). Sen *et al.,* 2002 reported significantly higher yield of wheat under zero tillage than under conventional tillage.

Nitrogen is the most essential fertilizer element playing vital role in yield improvement of wheat. Nitrogen often affects amino acid composition of protein and in turns its nutritional quality (Joshi *et al.,* 2014). The application of nitrogen fertilizers increases nitrogen content of leaves in addition to chlorophyll and carotenoids as a consequence leaf and photosynthesis is increased and thus increases dry matter production. Nitrogen is frequently reported as deficient in agricultural soils of India (Islam, 1990). Intensive farming system of high yielding varieties (HYV) of cereal crops and the removal of crop residue including the roots causing considerable decline in both organic matter and nitrogen content in agricultural soils of India.

Nitrogen deficiency generally results in stunted growth and chlorotic leaves caused by poor assimilate formation that leads to pre-mature flowering and shortening of the growth cycle while the presence of nitrogen in excess promotes development of above ground organs with abundant dark green (high chlorophyll-II) tissues of soft consistency and relatively poor root growth. This enhances the risk of lodging and reduces the plants resistance to brash climatic condition and foliar diseases (Mohammadin *et al.,* 2011). Nitrogen use and demand is continuously increasing day by day (Abd El-Lattief, 2011). Since it is highly mobile, it is subjected to greater losses from the soil-plant system. Even under the best management practices, 30-50% of applied nitrogen is lost through different agencies and hence the farmers compelled to apply more than the actual need of crop to compensate the losses. The loss of nitrogen not only troubles the farmers but it has also hazardous impacts on the environment. Many strategies have been developed to mitigate nutrients leaching and improve the nutrients use efficiency (NUE). The timing of fertilizer application is one of the low cost strategy to reduce nutrient leaching so that the nutrients supply is synchronized with plant demand (Gehl *et al.*, 2005). The split application of nitrogen reported as beneficial rather than basal application of all nitrogenous fertilizers. The split application of nitrogen is one of the methods to improve nitrogen use by the crop while reducing the nutrients loss through leaching and volatilization (Tadesse *et al.*, 2013). Mishra *et al.*, 2006 showed that split application of nitrogenous fertilizer to 4 doses i.e. first at sowing, second at crown root initiation stage, third at tillering and fourth at jointing stage was found superior than other nitrogen scheduling treatments in terms of increased wheat yield and nitrogen use efficiency. Usman *et al.*, 2012 found that the highest grain yield and number of spikes/m of wheat was obtained with the application of N@200 kg/ha applied in three splits and zero tillage. The two-third of nitrogen fertilizer applied as basal during final land preparation and rest one-third applied as top dressing at crown root initiation (CRI) stage reported as most efficient in improving grain yield of wheat (Singh *et al.*, 2013).

Materials and Methods

Experimental site

The experiment was conducted at the student's research farm of Mata Gujri College, Sri Fatehgarh Sahib during *Rabi* season of year 2016-2017. The experimental site falls in the sub-tropical plains of Punjab at the elevation of 247 meters above the mean sea level. The site represents 30^0 - 27^0 and 30^0- 46^0 N latitude and 76^0 – 04^0 and 76^0 – 38^0 E longitude.

Experimental design and treatments

The experiment was laid out in randomized block design with twelve treatments and three replications. The whole plot was divided into 36 sub-plots and dimension of each plot was 4.0 m X 3.0 m.

Crop management

The experimental field was thoroughly ploughed with the help of tractors and followed by planking two days prior to actual date of sowing. The stones and pebbles were removed from the field. The sowing of wheat variety "HD 3086" was sown in the experimental field on 25^{th} November 2016. The wheat crop was sown using seed rate 100 kg/ha at row to row spacing of 22.5 cm by zero tillage. The seed was placed at about 4-5 cm deep.

The organic manures such as Farm Yard Manure (FYM) @ 5-6 t/ha was applied on dry weight basis three weeks prior to sowing and thoroughly mixed with soil in the field. The recommended dose of fertilizer of P and K for wheat is 52 and 30 kg/ha respectively applied at the time of sowing. The amount of nitrogen was applied at per treatment wise. Nitrogen, phosphorus and potassium were applied through urea, diammonium phosphate and murate of potash respectively.

Soil sampling and statistical analysis

The undisturbed soil cores (15 cm high and 6-7 cm diameter) were obtained from 0-15 cm soil depths from each plot. Soil parameters such as soil pH, organic carbon, electrical conductivity, available nitrogen, phosphorus and potassium were determined.

The grain yield of each plot was recorded and converted in hectares. The statistical analysis was done as per the procedures given by Gomez and Gomez (1984). The interpretation of results is based on 'F' test. The critical difference (CD) was worked out for significant treatments.

Results and Discussion

Effect on crop yield

The result of the present study indicated that the yield is the result of co-ordinate interplay of various growth characters. Grain yield (q/ha), Straw yield (q/ha), Biological yield (q/ha) and Harvest index (%) were significantly influenced by different treatments. The application of T_{11} - ZT + N_5 i.e. N@125 kg (4 splits) applied at ¼, ¼, ¼ and ¼ at basal, 4, 6 and 8 WAS recorded higher grain yield which was at par with T_5 - CT + N_5 i.e. N@125 kg (4 splits) applied at ¼, ¼, ¼ and ¼ at basal, 4, 6 and 8 WAS & T_{12} - ZT + N_6 i.e. N@150 kg (4 splits) applied at ¼, ¼, ¼ and ¼ at basal, 4, 6 and 8 WAS and it recorded significantly superior over rest of treatments. However in case of biological yield, the highest value was recorded with the application of ZT + N_5 i.e. N@125 kg (4 splits) applied at ¼, ¼, ¼ and ¼ at basal, 4, 6 and 8 WAS and found at par with T_5 - CT + N_5 i.e. N@125 kg (4 splits) applied at ¼, ¼, ¼ and ¼ at basal, 4, 6 and 8 WAS which was significantly superior over rest of treatments. This result was attributed due to adequate availability of nutrient thus marked improvement in dry matter accumulation and better nutrient uptake. The treatments which had higher growth attributing characters produced higher crop yield. Further seed and yield of wheat enhanced significantly at higher levels of NPK and integrated with organic residue and inorganic fertilizers. Application of organic residue increased grain and straw yield of wheat. The highest yields were recorded under the treatment of integration of NPK with crop residue. There was positive correlation between grain yield and yield components like number of effective tillers and grain spike which were increased in nutrient availability and high nutrient uptake due to higher nutrient availability to crop. Similar results were reported by Fisher *et al.*, (2003), Kumar *et al.*, (2005) and Subedy *et al.*, (2007).

Effect on nutrient uptake by crop plants

The maximum uptake of N,$P_2O_5$and K_2O by crop with the application ofT_{11} - ZT + N_5 i.e. N@125 kg (4 splits) applied at ¼, ¼, ¼ and ¼ at basal, 4, 6 and 8 WAS which was followed by of T_5 - CT + N_5 i.e. N@125 kg (4 splits) applied at ¼, ¼, ¼ and ¼ at basal, 4, 6 and 8 WAS which was found significantly superior over rest of the treatments. But the minimum uptake of N, P and K was in T_1 - control treatments. Interaction of tillage and nitrogen schedule on crop also was significant on N P K uptake by plant (Table 1–7).

Table.1 Initial fertility of soil

Particular	Value obtained	Method employed
Texture	Sandy loam	International pipette method (Piper, 1966)
Soil pH	7.3	1: 2 soil: water suspensions with the help of digital pH meter (Jackson, 1973)
Soil Organic	0.42	Walkey and Black method (1934)
Soil EC (dSm^{-1})	0.50	With the help of digital conductivity meter.
Available N (kg/ha)	215.5	Alkaline potassium permanganate method of Subbiah and Asija (1956)
Available P_2O_5 (kg/ha)	24.4	Olsen *et al.*, (1954)
Available K_2O (kg/ha)	122.30	Ammonium acetate method of Merwin and Peech (1951)

Table.2 Experimental detail

Variety	**HD 3086**
Date of Sowing	Timely sown (*Rabi* season)
Number of treatments	12
Number of replication	3
Total number of treatments	36
Design	Randomized Block Design
Replication border	1.0 m
Gross plot size	4.0 m x 3.0 m
Net plot size	3.77 m x 2.77 m
Spacing row to row	22.5 cm

Table.3 Detail of treatments

Treatments	Treatment Combination
T_1	CT + N_1 i.e. Control
T_2	CT + N_2 i.e. N@100 kg (2 splits) applied ½ at basal and ½ at 4 WAS
T_3	CT + N_3 i.e. N@100 kg (3 splits) applied ½ at basal, ¼ at 4 WAS and ¼ at 8 WAS
T_4	CT + N_4 i.e. N@125 kg (2 splits) applied ½ at basal and ½ at 4 WAS
T_5	CT + N_5 i.e. N@125 kg (4 splits) applied at ¼, ¼, ¼ and ¼ at basal, 4, 6 and 8 WAS
T_6	CT + N_6 i.e. N@150 kg (4 splits) applied at ¼, ¼, ¼ and ¼ at basal, 4, 6 and 8 WAS
T_7	ZT + N_1 i.e. Control
T_8	ZT + N_2 i.e. N@100 kg (2 splits) applied ½ at basal and ½ at 4 WAS
T_9	ZT + N_3 i.e. N@100 kg (3 splits) applied ½ at basal, ¼ at 4 WAS and ¼ at 8 WAS
T_{10}	ZT + N_4 i.e. N@125 kg (2 splits) applied ½ at basal and ½ at 4 WAS
T_{11}	ZT + N_5 i.e. N@125 kg (4 splits) applied at ¼, ¼, ¼ and ¼ at basal, 4, 6 and 8 WAS
T_{12}	ZT + N_6 i.e. N@150 kg (4 splits) applied at ¼, ¼, ¼ and ¼ at basal, 4, 6 and 8 WAS

CT- Conventional Tillage and ZT- Zero Tillage

Table.4 Effect of tillage and nitrogen scheduling on crop yield (q/ha) and harvest Index (%)

Treatment	Grain Yield (q/ha)	Straw Yield (q/ha)	Biological Yield (q/ha)	Harvest Index (%)
T_1 –CT+N_1	28.27	52.34	80.61	35.07
T_2 –CT + N_2	34.55	55.09	89.94	38.54
T_3 – CT + N_3	40.46	58.94	99.40	40.70
T_4 – CT + N_4	43.71	59.45	103.16	42.37
T_5– CT + N_5	51.92	64.81	116.73	44.47
T_6– CT + N_6	46.38	62.63	109.01	42.54
T_7– ZT + N_1	30.04	53.57	83.61	35.92
T_8 - ZT + N_2	35.59	56.18	91.77	38.78
T_9 - ZT + N_3	42.13	59.21	101.34	41.57
T_{10} - ZT + N_4	44.51	61.93	106.44	41.81
T_{11} - ZT + N_5	52.96	66.09	119.05	44.49
T_{12}- ZT + N_6	49.60	63.72	113.32	43.76
SEm ±	1.32	1.35	1.36	1.40
CD at 5%	3.87	3.96	4.00	4.10

Table.5 Effect of tillage and nitrogen scheduling on nutrient content (%) in grain and straw

Treatments	Grain			Straw		
	N	P	K	N	P	K
T_1 –CT+N_1	1.54	0.24	0.17	0.76	0.04	1.29
T_2 –CT + N_2	1.59	0.29	0.22	0.79	0.05	1.34
T_3 – CT + N_3	1.66	0.34	0.28	0.84	0.06	1.39
T_4 – CT + N_4	1.73	0.39	0.31	0.88	0.08	1.44
T_5– CT + N_5	1.86	0.47	0.41	0.95	0.10	1.54
T_6– CT + N_6	1.81	0.42	0.35	0.92	0.09	1.49
T_7– ZT + N_1	1.57	0.26	0.20	0.78	0.04	1.32
T_8 - ZT + N_2	1.62	0.31	0.26	0.81	0.06	1.37
T_9 - ZT + N_3	1.70	0.36	0.30	0.85	0.07	1.42
T_{10} - ZT + N_4	1.77	0.40	0.33	0.90	0.08	1.47
T_{11} - ZT + N_5	1.89	0.48	0.44	0.97	0.11	1.57
T_{12}- ZT + N_6	1.79	0.45	0.39	0.93	0.10	1.52
SEm ±	0.02	0.01	0.01	0.01	0.01	0.01
CD at 5%	NS	NS	NS	NS	NS	NS

Table.6 Effect of tillage and nitrogen scheduling on nutrient uptake (kg/ha) in grain and straw

Treatments	Grain			Straw			Crop		
	N	P	K	N	P	K	N	P	K
T_1-CT+N_1	43.54	6.79	4.81	39.78	2.10	67.52	83.32	8.89	72.33
T_2-CT+N_2	54.93	10.02	7.60	43.52	2.75	73.83	98.45	12.77	81.43
T_3 -CT+N_3	67.17	13.76	11.33	49.51	3.54	81.93	116.68	17.30	93.26
T_4 -CT+N_4	75.62	17.05	13.56	52.32	4.76	85.61	127.94	21.81	99.17
T_5-CT+N_5	96.58	24.41	21.29	61.57	6.49	99.80	159.48	30.90	121.88
T_6-CT+N_6	83.95	19.48	16.23	57.62	5.64	93.32	141.57	25.12	109.55
T_7-ZT+N_1	47.16	7.82	6.01	41.79	2.15	70.72	88.95	9.97	76.73
T_8-ZT+N_2	57.65	11.04	9.26	45.50	3.38	76.97	103.15	14.42	86.23
T_9-ZT+N_3	71.62	15.17	12.64	50.33	4.15	84.08	121.95	19.32	96.72
T_{10}-ZT+N_4	78.79	17.81	14.66	55.74	4.96	91.04	134.53	22.77	105.70
T_{11}-ZT+N_5	100.10	25.43	23.31	64.11	7.27	103.77	162.88	32.70	125.75
T_{12}-ZT+N_6	88.79	22.32	19.35	59.26	6.38	96.86	149.38	28.70	116.21
SEm ±	1.40	1.11	0.92	1.34	0.36	1.37	1.54	0.80	1.41
CD at 5%	4.12	3.25	2.71	3.92	1.07	4.02	4.52	2.36	4.13

Table.7 Effect of tillage and nitrogen scheduling on economics of crop

Treatments	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C Ratio
T_1 –CT+N_1	41590.16	69491.75	27901.59	0.67
T_2 –CT + N_2	43790.16	80934.25	37144.09	0.84
T_3 – CT + N_3	45290.16	92270.5	46980.34	1.03
T_4 – CT + N_4	47190.16	97781.25	50591.09	1.07
T_5– CT + N_5	51390.16	113534.5	62144.34	1.20
T_6– CT + N_6	49390.16	103551	54160.84	1.09
T_7– ZT + N_1	41590.16	72921.5	31331.34	0.75
T_8 - ZT + N_2	44390.16	83114.75	38724.59	0.87
T_9 - ZT + N_3	46090.16	95105.75	49015.59	1.06
T_{10} - ZT + N_4	48190.16	100197.25	52007.09	1.07
T_{11} - ZT + N_5	52290.16	115800.5	63510.34	1.21
T_{12}- ZT + N_6	50490.16	109274	58783.84	1.16

Nutrients uptake increased due to application of integration of NPK with crop residue and FYM. In this treatment, nutrient availability higher and also helps in solubilizing the nutrients. Similar results were reported by Gangwar *et al.*, (2004), Kumar and Yadav (2005), Tripathi *et al.*, (2010) and Kaushal *et al.*, (2012).

Effect on economics of crop

The gross return showed considerable differences in various treatments. The highest net return and B:C ratio was computed with the application of T_{11} - ZT + N_5 i.e. N@125 kg (4 splits) applied at ¼, ¼, ¼ and ¼ at basal, 4, 6 and 8 WAS which was followed by of T_5 - CT + N_5 i.e. N@125 kg (4 splits) applied at ¼, ¼, ¼ and ¼ at basal, 4, 6 and 8 WAS. Minimum net return and B: C ratio was observed under T_1 - control treatments. This was possible due to higher number of tillers grains in per spikelets, test weight ultimately higher total production of wheat which in turns increased the net returns compared to other treatments. Higher B: C was obtained in these treatments due to higher grain yield which in turn increased the net returns. These findings are closely in confirmation to the finding of Pal and Bhatnagar *et al.*, (2008), Usman *et al.*, (2012) and Singh *et al.*, (2013).

In conclusion on the basis of results summarized above, it can be concluded that application of T_{11} - ZT + N_5 i.e. N@125 kg (4 splits) applied at ¼, ¼, ¼ and ¼ at basal, 4, 6 and 8 WAS gave best results of respect to all the crop yield, total nutrients uptake by grain and straw and economics of crop and second best treatment is T_5 - CT + N_5 i.e. N@125 kg (4 splits) applied at ¼, ¼, ¼ and ¼ at basal, 4, 6 and 8 WAS. The lowest net income overall was in T_1 – CT + N_1 i.e. control treatment.

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