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Research paper

Growth and Productivity of Wheat as Influenced by Tillage Methods, Mulch and Graded Nitrogen Levels in Chitwan, Nepal

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Abstract: A field experiment was carried out to assess the growth and productivity of wheat as influenced by the tillage methods, mulch and graded nitrogen levels at the Agronomy Farm of Agriculture and Forestry University, Rampur during winter season of 2015/2016. The experiment was laid out in strip split plot design comprising tillage methods (zero tillage and conventional tillage) and mulch (mulch and no mulch) as horizontal and vertical factors, respectively and nitrogen levels as sub-sub plot factor (0, 50, 100 and 150 kg N ha^{-1}). The highest grain yield (3.58 t ha^{-1}) was obtained with 100 kg ha^{-1} N followed by 150 kg ha^{-1} N (3.45 t ha^{-1}), 50 kg ha^{-1} N (3.14 t ha^{-1}) kg ha^{-1} N and 0 kg ha^{-1} N (1.91 t ha^{-1}). Grain yield (2.95 t ha^{-1}) under zero tillage was similar to conventional tillage (3.1 t ha^{-1}). Mulched crop (3.11 t ha^{-1}) had slightly higher grain yield than no mulched crop (2.94 t ha^{-1}). Economic analysis indicated that the highest gross net return (NRs. 40,800 ha^{-1}) and BCR (1.733) were observed with the application of nitrogen level of 100 kg ha^{-1}. Higher net return was observed in zero tillage (NRs. 29,000.00 ha^{-1}) than conventional tillage (NRs. 26,500 ha^{-1}). Physical and economical doses of nitrogen were calculated as 100.6 and 94.1 kg ha^{-1} for zero tillage with mulch and 127.4 and 119.4 kg ha^{-1}, respectively for zero tillage without mulch. Similarly, physical and economical doses of nitrogen for conventional tillage with mulch were 101.6 and 96.8 kg ha^{-1} and for conventional without mulch were 128.1 and 121.6 kg ha^{-1}, respectively.
Keywords: Zero tillage, Productivity, Nitrogen use efficiency, Physical and economic maximum dose

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a crop of global significance as it is a staple food for over 10 billion people in as many as 43 countries of the world (Ali *et al*., 2011). Rice-wheat sequence is the world's largest cropping system, occupying 24 million ha in

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the Indo-Gangetic Plain and China (Ladha et al., 2003). In Nepal, more than one-third of the total area planted to rice is followed by wheat (Ranjit *et al*., 2000). It ranks third position after rice and maize in terms of both area and production. The area under wheat crop in Nepal is 735850 hectares with a total production of 1879191 tons and productivity of 2.55 t ha^{-1} (MOAD, 2017).

Sustainability of rice-wheat system is under threat because of declining soil fertility and crop yield (Sah *et al*., 2014). Research results showed that conventional tillage practice had declined soil structure and stability over years due to depletion of soil organic matter (Gupta *et al*., 2003). It has also increased cost and water requirement (Hobbs and Gupta, 2003). Unlike conventional tillage, zero tillage may facilitate wheat planting at optimum time, reduce cost of production, improve water and nutrient use efficiencies, ameliorate soil properties and increase crop productivity.

Nitrogen is the most limiting nutrient in crop production and its efficient use to increase food production is more than any other input (Usman *et al*., 2013). Efficient use of nitrogen is crucial for economic wheat production; however, much use of N may cause plants susceptible to lodging and disease with resulting decreased yields and increased input costs (Alley *et al*., 2009). Moreover, excessive use of nitrogen may cause environmental concerns such as nitrate leaching, eutrophication, and greenhouse gases emissions and reduce crop yield.

Sustaining wheat productivity in RWCS without jeopardizing the quality of soil and environment depends on appropriate tillage in combination with optimum N rate. Looking to the scenario of unsustainable CT and its negative impact on SOM and productivity decline, there is a need to modify current tillage practices while growing wheat after rice. Current N recommendations developed for CT may be inadequate for optimum production of wheat under ZT. No studies have been conducted in Nepal to determine feasibility of tillage methods in combination with mulch and N rates, and their effects on wheat yield. Considering the above facts, the present investigation was carried out to determine the best method of tillage and to explore optimum N rate in wheat sown after rice.

MATERIALS AND METHODS

The experiment was conducted in the Agronomy farm of the Agriculture and Forestry University, Rampur, Chitwan from November to April during the winter season of 2015/16. The climate of the site is subtropical with hot summer and cool winter. The site received total rainfall of 46.9 mm during the experimental period. The maximum temperature was ranged from 17.4 ºC during February to 41.3 ºC during April. Similarly, the minimum temperature was ranged from 3 ºC during December to 32.2 ºC during April. The mean relative humidity ranges from 57.13% in the month of April to 100% in the month of December. The solar radiation was ranged from 13.85MJ/m^2/day in the month of December to24.63 MJ/m^2/day) in the month of April. The soil of experimental site was sandy loam with medium level of total N, available P and soil organic matter but low level of available K.

The experiment was laid out in strip-split plot design with the combinations of 16 treatments comprising tillage methods (zero tillage and conventional tillage) and mulch (mulch and no mulch) as horizontal and vertical factors, respectively and nitrogen levels as sub-sub plot factor (0, 50, 100 and 150 kg N ha^{-1}). The size of the each plot was 7 m x3.5 m (24.5 m^2). Wheat variety "Vijay" was used in the experiment as a test

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crop. In conventional tillage practice, the field was plowed twice by the tractor-drawn cultivator, double-pass each time, 15- 20 cm deep. The land was manipulated manually to bring the soil in to good tilth prior to sowing at the time of final land preparation. Seed and basal fertilizers were separately applied in rows manually. In zero tillage practice, the field was sprayed with glyphosate 47% SL before 10 days of sowing with the rate of 10 ml per liter. Wheat seed and fertilizer were drilled; 3 cm deep, by a tractor- drawn inclined plate zero-till drill. The seed used was120 kg ha^{-1}. Phosphorus (P_2O_5) @ 50 kg ha^{-1}and potassium (K_2O) @ 25 kg ha^{-1}was applied in rows. In zero N, no nitrogen was applied and in remaining nitrogen level treatment, nitrogen was applied according to the treatment. Half dose of N was applied at sowing and remaining half in two equal splits as top dressings. Mulching was applied at 15 days after sowing @ 4 t ha^{-1}. Single irrigation was applied at flowering stage (78 DAS).

The parameters on crop growth and development, yield attributes, yields and economics were observed. N uptake (grain and straw) and nitrogen use efficiencies were calculated by following formulae:

$$\text{N uptake (Kg ha}^{-1}\text{)} = \frac{\text{Nitrogen content (\%)} \times \text{dry matter (kg ha}^{-1}\text{)}}{100}$$

$$\text{Agronomic efficiency (AE)} = \frac{\text{Grain yield in N applied plot (kg ha}^{-1}\text{)} - \text{Grain yield in N control plot (kg ha}^{-1}\text{)}}{\text{N applied (kg ha}^{-1}\text{)}}$$

$$\text{Recovery efficiency (RE)} = \frac{\text{Total N uptake in N applied plot (kg ha}^{-1}\text{)} - \text{Total N uptake in N control plot (kg ha}^{-1}\text{)}}{\text{N applied (kg ha}^{-1}\text{)}}$$

Partial factor productivity (PFP)

$$\text{PFP} = \frac{\text{Grain yield (kg ha}^{-1}\text{)}}{\text{N fertilizer applied (kg ha}^{-1}\text{)}}$$

All the collected data were entered into MS excels and recorded data was processed to fit into GENSTAT and MSTAT-C software. If the null hypothesis was rejected, DMRT a mean separation technique was applied to identify the most efficient treatment. The software programs, Microsoft Word 2007 was used for word processing, and MS excels for tables, graphs and simple statistical analysis.

RESULTS

Biometrical and yield attributing characters

Leaf Area index (LAI): Leaf area index for 60 DAS was not influenced by tillage methods and mulch. However, conventional tillage had slightly higher LAI than zero tillage. Similarly, mulched crop had higher LAI than no mulched crop. Nitrogen levels had significant effect on LAI. LAI increased significantly with increase in nitrogen levels

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up to 100 kg ha^{-1} and afterwards not significantly increased at 150 kg ha^{-1} N.

Total dry weight: Tillage methods and mulch had no significant effect on total dry weight for 90 DAS. However, zero tillage had higher total dry weight than conventional tillage. Similarly, mulched crop has higher total dry weight than zero tillage. Total dry weight was significantly influenced by the nitrogen levels and increasing the nitrogen levels from 0 to 100 kg ha^{-1}, total dry weight increased significantly but afterwards not significantly increased at 150 kg ha^{-1} N.

Number of effective tiller m^{-2}: The average number of effective tiller m^{-2} was 221.3. The number of effective tillers m^{-2} was significantly influenced by nitrogen levels but not by tillage methods and mulch (Table 1). Higher number of effective tiller m^{-2} was found under conventional tillage than zero tillage method but they were statistically similar with each other. Similarly, number of effective tiller m^{-2} of mulched crop was relatively higher than non-mulched crop. The number of effective tillers m^{-2} increased with increase in nitrogen levels from 0 to 150 kg ha^{-1}. The highest number of effective tiller m^{-2} was obtained from 150 kg ha^{-1} N application and was statistically at par with 100 kg ha^{-1} N and 50 kg ha^{-1}N application; and they were superior to control N.

Number of grains spike^{-1}: The number of grains spike^{-1} was significantly affected by nitrogen levels but not by tillage methods and mulch. The number of grains spike^{-1} under zero tillage was slightly higher than conventional tillage method. The number of grains spike^{-1} of mulched crop was almost similar with no mulch crop. The number of grains spike^{-1} increased with increase in nitrogen level from 0 to 150 kg ha^{-1} N application. The highest number of grains spike^{-1} was found with 150 kg ha^{-1} N application and was statistically similar with 100 kg ha^{-1} N but significantly higher than 50 kgha^{-1} N and control N. Significantly higher number of grains spike^{-1} was recorded with 100 kg ha^{-1} N than 50 kg ha^{-1} N. Similarly, significantly higher number of grains per spike was found with nitrogen level of 50 kg ha^{-1} than N control. The average number of grains per spike was 31.32 (Table 1).

Thousand grain weight: The average thousand grain weight was 47.05 g (Table 1). Thousand grain weight was significantly affected by nitrogen levels but not by tillage methods and mulch. Thousand grain weight under conventional tillage was slightly higher than zero tillage. Thousand grain weight of mulched crop was relatively higher than non-mulched crop but they were statistically similar to each other. The highest thousand grain weight was found with 50 kg ha^{-1} N application and was statistically at par with N control and 100 kg ha^{-1}N but significantly higher than 150 kg ha^{-1} N. Similarly, significantly higher thousand grain weight was observed with 100 and 0 kg ha^{-1} N than 150 kg ha^{-1} N.

Sterility percentage: The mean sterility of wheat was found to be 36.98 %. The sterility percentage was significantly affected by levels of nitrogen but not by tillage methods and mulch (Table 1). Sterility percentage under conventional tillage was relatively higher than zero tillage but they were statistically at par to each other. Similarly, sterility percentage of mulched crop was relatively higher than no mulched crop. Sterility percentage decreased with increase in nitrogen level from 0 to 100 kg ha^{-1} N application and increased at 150 kg ha^{-1} N. The lowest sterility percentage was obtained with 100 kg ha^{-1} N application and was significantly lower than 50 kg ha^{-1} and 0 kg ha^{-1} N but statistically at par with 150 kg ha^{-1} N. Similarly, sterility percent with the application of 150 kg ha^{-1} was significantly

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lower than 50 kg ha^{-1} and control N. Significantly higher sterility percent was observed with 50 kg ha^{-1} N application than N control.

Table 1: Leaf area index, total dry weight, no. of effective tillers m^{-2}, no. of grains spike^{-1}, thousand grain weight and sterility % as influenced by tillage, mulch and levels of N application at AFU, Rampur, Chitwan during 2015/16

Treatments	Leaf area index (60 DAS)	Total dry weight (90 DAS)	No. effective tillers m^{-2}	No. of grains spike^{-1}	TGW(g)	Sterlity (%)
Tillage methods						
ZT	2.29	7332	215.6	31.43	46.79	36.63
CT	2.36	7101	226.6	31.21	47.30	37.32
SEm (±)	0.06	544.2	11.23	0.872	0.418	1.054
LSD (=0.05)	ns	ns	ns	ns	ns	ns
Mulch						
No mulch	2.23	6362	207.1	31.31	47.54	36.62
Mulch	2.42	8071	235.0	31.33	46.55	37.33
SEm (±)	0.21	728.3	7.2	0.47	0.92	0.76
LSD (=0.05)	ns	ns	ns	ns	ns	ns
Nitrogen levels						
N_0	1.48^c	4556^c	195.8^b	22.38^c	47.65^a	44.03^a
N_{50}	2.21^b	6708^b	222.0^a	31.60^b	48.35^a	36.04^b
N_{100}	2.79^a	8337^a	231.1^a	35.19^a	47.49^a	33.84^c
N_{150}	2.84^a	9266^a	235.5^a	36.11^a	44.69^b	34.00^c
SEm (±)	0.15	422.6	6.79	0.75	0.60	0.65
LSD (=0.05)	0.41	1233.6	19.83	2.2	1.769	1.921
CV%	22.9	20.3	10.6	8.3	4.5	6.2
Grand Mean	2.33	7217	221.1	31.32	47.05	36.98

Note: ZT, Zero tillage; CT, Conventional tillage; ns, non-significance. Treatments means followed by common letter (s) are not significantly different among each other based on DMRT at 5 % level of significance.

Grain and straw yield and harvest index

Grain yield: The mean grain yield was found to be 3.02 t ha^{-1}. The grain yield was significantly influenced by nitrogen levels but not by tillage methods and mulch (Table 2). The grain under zero tillage method was slightly higher than zero tillage. Similarly, grain yield of mulched plot was higher than non mulched plot but they were statistically similar with each other. Increasing N levels from 0 to 100 kg ha^{-1} increased the grain yield and declined at 150 kg ha^{-1}. The highest grain yield was observed at 100 kg N ha^{-1} and was statistically similar with 150 kg ha^{-1} N application but superior to 50 kg ha^{-1} N and control N. Similarly, grain yield with nitrogen level of 150 kg ha^{-1} was significantly higher than 50 and 0 kg ha^{-1} N. Significantly higher grain yield was observed with 50 kg ha^{-1} N than N control.

Straw yield: Straw yield was significantly influenced by the tillage methods and nitrogen levels but not by mulch. Straw yield under conventional tillage was

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significantly higher than zero tillage. Straw yield of mulched crop was higher than non mulched crop. Straw yield among 150 kg ha^{-1} N, 100 kg ha^{-1} N and 50 kg ha^{-1} N application were statistically similar to each other and they were significantly higher than N control. The mean straw yield was found to be 4.35 t ha^{-1} (Table 2).

Harvest index: Harvest index was not significantly influenced by tillage methods and mulch but by nitrogen levels (Table 2). Harvest index under zero tillage was relatively higher than conventional tillage. Higher harvest index was recorded in no mulched crop than mulched crop. Harvest index increased with increased in nitrogen level from 0 to 100 kg ha^{-1}N application and decreased at 150 kg ha^{-1} N. It was highest with 100 kg ha^{-1}N application and was statistically at par with 150 kg ha^{-1} N and 50 kg ha^{-1} N but significantly higher than N control. Harvest index among nitrogen levels of 150, 50 and 0 kg ha^{-1} were statistically at par. The mean harvest index was found to be 40.44%.

Table 2: Grain Yield, straw yield and harvest index as influenced by tillage methods, mulch and levels of N application at AFU, Rampur, Chitwan during 2015/16

Treatments	**Grain Yield (t ha^{-1})**	**Straw Yield (t ha^{-1})**	**Harvest Index (%)**
Tillage methods			
ZT	2.95	4.25^{b}	40.74
CT	3.10	4.48^{a}	40.13
SEm (±)	0.04	0.02	0.49
LSD (=0.05)	ns	0.1437	ns
Mulch			
No mulch	2.94	4.11	41.28
Mulch	3.11	4.62	39.6
SEm (±)	0.09	0.11	1.26
LSD (=0.05)	ns	ns	ns
Nitrogen levels			
N_0	1.91^{c}	2.79^{b}	38.71^{b}
N_{50}	3.14^{b}	4.66^{a}	40.24^{ab}
N_{100}	3.58^{a}	4.91^{a}	42.11^{a}
N_{150}	3.45^{a}	5.08^{a}	40.70^{ab}
SEm (±)	0.10	0.15	0.8
LSD (=0.05)	0.27	0.44	2.33
CV%	10.9	12.2	10.7
Grand Mean	3.02	4.36	40.44

Note: ZT, Zero tillage; CT, Conventional tillage; ns, non-significance. Treatments means followed by common letter (s) are not significantly different among each other based on DMRT at 5 % level of significance.

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Nitrogen Use Efficiency

Agronomic efficiency of nitrogen (AEN)

Tillage methods and mulch had no significant effect on agronomic efficiency of nitrogen (AEN). AEN under conventional tillage was relatively higher than zero tillage method. Similarly, higher AEN was observed in no mulched crop than mulched crop. Nitrogen had significant effect on AEN. With increased in nitrogen level, there was decreased in AEN. The highest AEN was observed with 50 kg ha^{-1} N and was significantly higher than 100 kg ha^{-1} N and 150 kg ha^{-1}N. AEN with 100 kg ha^{-1} N was also significantly higher than 150 kg ha^{-1} N.

Recovery efficiency of nitrogen (REN): The average recovery efficiency of nitrogen (REN) was 44.86% (Table 3).

Table 3: Nitrogen use efficiency on wheat as influenced by tillage methods, mulch and levels of N application at AFU, Rampur, Chitwan, Nepal during 2015/2016

Treatments	Nitrogen use efficiency		
	AEN (Kg grain Increased Kg^{-1} N applied)	REN % (Kg N uptake increased Kg^{-1} N applied)	PFPN (Kg grain Kg^{-1} N applied)
Tillage methods			
ZT	14.11	41.57	38.75
CT	20.30	48.14	42.40
SEm(±)	2.72	3.52	0.75
LSD (=0.05)	ns	ns	ns
Mulch			
No mulch	18.59	46.56	39.39
Mulch	15.82	43.15	41.77
SEm (±)	1.87	1.274	0.41
LSD(=0.05)	ns	ns	ns
Nitrogen levels			
N_0	-	-	-
N_{50}	24.56^{a}	59.82^{a}	62.81^{a}
N_{100}	16.75^{b}	41.63^{b}	35.87^{b}
N_{150}	10.31^{c}	33.12^{c}	23.17^{c}
SEm (±)	1.017	1.64	0.74
LSD (=0.05)	3.05	4.92	2.24
CV (%)	20.5	12.7	6.4
Grand Mean	17.21	44.86	40.58

Note: ZT, Zero tillage; CT, Conventional tillage; ns, non-significance. Treatments means followed by common letter (s) are not significantly different among each other based on DMRT at 5 % level of significance.

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Tillage methods and mulch had no influenced on REN. However, conventional tillage had higher REN than zero tillage. It was higher in no mulch than with mulch.Nitrogen had significant effect on REN. There was significant decreased in REN with increased in nitrogen rate. The highest REN was observed with 50 kg ha^{-1} N which was followed by 100 kg ha^{-1} N and 150 kg ha^{-1} N.

Partial factor productivity of nitrogen (PFPN): Partial factor productivity of nitrogen (PFPN) was not influenced by tillage methods and mulch. However, higher PFPN was observed under conventional tillage than zero tillage. Mulched crop had higher PFPN than no mulch. PFPN was significantly affected by nitrogen level. With increase in nitrogen level, PFPN decreased significantly. The highest PFPN was observed with 50 kg ha^{-1} N and followed by 100 kg ha^{-1} N and 150 kg ha^{-1} N. The average PFPN was found to be 40.58 Kg grain Kg^{-1} N.

Response of Nitrogen: The effect of nitrogen levels on grain yield of wheat was significant and polynomial regression equation was obtained. Nitrogen response equation, physical maximum dose (PMD) and economic maximum dose (EMD) of nitrogen for wheat for zero tillage with mulch and without mulch and conventional tillage with mulch and without much along with their regression equation and grain yield are as shown in Table 4.

PMD and EMD for zero tillage with mulch were lower than zero tillage without mulch. Similarly PMD and EMD for conventional tillage with mulch used were lower than without mulch. Higher PMD and EMD were found on conventional tillage than zero tillage on both mulched and no mulched condition.

Economic analysis

Cost of cultivation

The mean cost of cultivation was found NRs. 53,930.00 ha^{-1} (Table 5). The cost of cultivation was higher under conventional than zero tillage. The cost of cultivation slightly was slightly higher with mulch used compare to no mulch. The cost of cultivation progressively increased with the increased in application of nitrogen level.

Gross return

The mean gross return was NRs. 81,710.00 ha^{-1} (Table 5). Gross return was not influenced by tillage methods and mulch. Higher gross return was observed under conventional tillage than zero tillage. Application of mulch also improved gross return but not significantly. Nitrogen levels had significant effect on gross return. The highest gross return was observed with 100 kg ha^{-1} N application and was statistically similar with 150 kg ha^{-1} N but significantly higher than 50 kg ha^{-1} N and N control.

Net return

The mean net return was found to be NRs. 27,700.00 per hectare (Table 5). Tillage methods and mulch treatments had no significant effect on net return. Net return was significantly affected by nitrogen levels. The highest net return was recorded with the nitrogen dose of 100 kg ha^{-1} and remained at par with 150 kg ha^{-1} N but significantly higher than 50 kg ha^{-1} N and 0 kg ha^{-1} N.

Benefit cost ratio (BCR)

Benefit cost ratio (BCR) was significantly influenced by nitrogen levels but not by tillage methods and mulch (Table 5). The highest BCR was recorded with 100 kg ha^{-1}N application; followed by 50 kg ha^{-1} N, 150 kg ha^{-1} N and 0 kg ha^{-1} N . BCR among nitrogen levels of 50, 100 and 150 kg ha^{-1} were statistically at par but these were

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significantly higher than N control. The mean BCR was 1.503.

Table 5: Total cost of production, gross return, net return and BC ratio of wheat as influenced by tillage, mulch and N application at AFU, Rampur, Chitwan, Nepal during 2015/16

Treatments	Total cost of cultivation (NRs. 000ha^{-1})	Gross return (NRs.000 ha^{-1})	Net return (NRs.000 ha^{-1})	B:C ratio
Tillage methods				
ZT	50.56	79.6	29	1.50
CT	57.29	83.8	26.5	1.44
SEm(±)		1.15	1.15	0.02
LSD (=0.05)		ns	ns	ns
Mulch				
No mulch	52.81	79.3	26.5	1.48
Mulch	55.04	84	28.9	1.52
SEm (±)		2.45	2.45	0.04
LSD(=0.05)		ns	ns	ns
Nitrogen levels				
N_0	48.61	51.6^c	3.0^c	1.07^b
N_{50}	52.64	84.8^b	32.3^b	1.61^a
N_{100}	56.03	96.9^a	40.8^a	1.73^a
N_{150}	58.42	93.4^a	34.9^{ab}	1.60^a
SEm (±)		2.74	2.57	0.04
LSD (=0.05)		7.5	7.5	0.13
CV (%)		10.9	32.1	10.9
Grand Mean	53.93	81.7	27.7	1.503

Note: ZT, Zero tillage; CT, Conventional tillage; ns, non-significance. Treatments means followed by common letter (s) are not significantly different among each other based on DMRT at 5 % level of significance.

DISCUSSION

Leaf area index (LAI) is the main physiological determinant of crop yield. It describes the surface growth and light use during crop period. Nitrogen is an integral part of chlorophyll and adequate supply of nitrogen is associated with higher photosynthetic activity and higher leaf area that ultimately increased the LAI. Moreover, in crops with limited nitrogen level, leaf senescence tends to be rapid because of the demand for nitrogen by young rapidly growing organs (Biscoe and Willington, 1982) resulting lower LAI in crops with lower nitrogen level application. Ullah *et al*. (2013) also reported that increasing nitrogen rates (60, 90, 120, 150, 180 and 210 kg ha^{-1} N) gradually increased the leaf area index having the highest value at 210 kg ha^{-1}N.

Tiller buds appear to be little affected by environmental factors but the growth of tiller buds is affected by nutrient availability and plant population (Kirby and Applleyard, 1982). There might be complete growth of tiller buds with higher dose of nitrogen so higher number of tillers was observed at higher nitrogen levels. But in N control and lower dose of nitrogen, there might be

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senescence of tiller buds due to inadequate nitrogen availability and resulted less number of effective tillers m^{-2}. Similar trends of increase in number of effective tillers m^{-2} with the increased in nitrogen level was also reported by Mitra *et al*. (2014). Higher number of effective tillers m^{-2} in mulched crop was probably due to soil moisture conservation, weed suppression and organic matter addition in the soil. Similar finding was also reported by Ranjit *et al*. (2009).

Number of grains per spike is one of the most crucial yield determining components and has directly related to the grain yield of wheat. More grains $spike^{-1}$ at higher N was due to more availability of nitrogen as it plays a very vital role in the process of grain filling. The number of spikelet depends on the nitrogen status of plant between the double ridge and floret initiation (Kirby and Applleyard, 1982). Thus, lower number of spikelet was observed in N control and 50 kg ha^{-1} N application due to inadequate availability of nitrogen resulting reduced number of grains per spike. Gul *et al*. (2012) also reported that with increase in nitrogen levels (0, 100, 130 and 160 kg ha^{-1}), number of grains per spike increased linearly (39.67, 43.68, 45.06 and 49.92) in the field experiments conducted at the New Developmental Farm of Agricultural University, Peshawar, Pakistan.

Decreased in thousand grain weight at nitrogen level of 150 kg ha^{-1} was due to lodging that caused shrivelled grain and smaller grain size. When too much nitrogen is applied, excessive vegetative growth occurs, cells of the plants and stem become enlarged but relatively weak and plants are more prone to lodging with heavy rain and wind (Brady and Well, 2012). Moreover, higher dose of nitrogen caused higher number of effective tillers and number of grains per spike which ultimately resulted in mutual competition of photosynthates in grains and decrease grain size and weight. Iqbal *et al*. (2012) also observed significantly lower thousand grain weight at 150 kg ha^{-1} N (47.19 g) compared to 125 (50.81 g) in the experiment conducted at Faisalabad, Pakistan.

The grain yield increased significantly with increase in nitrogen. The higher grain yield with increasing N levels from 0 to 100 kg ha^{-1} N application was because N plays role in synthesis of chlorophyll and enzymes which increases vegetative and reproductive growth (Lawlor et al., 1988). Moreover, significantly higher grain yield with higher nitrogen dose was attributed to more LAI, more total dry matter, more number of effective tillers m^{-2} and more number of grains per spike. Mahato *et al*. (2015) found increasing trend of grain yield with increase in N level attaining maximum yield (4.97 t ha^{-1}) and decreased at 180 kg ha^{-1} N (4.71 t ha^{-1}) in the field experiment conducted at Torikhet, Chitwan during 2009/10.

CONCLUSION

Zero tillage method had comparable grain yield to the conventional tillage method but net return and BCR was relatively higher in zero tillage method than conventional tillage, so zero tillage is better. Adoption of zero tillage method with mulch at nitrogen dose of 100 kg ha^{-1} could improve the productivity, net return and benefit cost ratio of wheat under the agro-climatic condition of Rampur, Chitwan, Nepal

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