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Effect of nitrogen scheduling on wheat (*Triticum aestivum*) productivity and quality under alternate tillage practices

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ABSTRACT

Field experiments were conducted during 2004–07 to study the effect of nitrogen scheduling on growth, yield and quality on bread wheat (*Triticum aestivum* L. emend. Fiori & Paol.) under alternate tillage systems on sandy clay loam soil having low to medium soil fertility. A total of 9 nitrogen scheduling treatments including absolute control, full basal, 2, 3 and 4 splits at different stages were undertaken with recommended dose of nitrogen under zero and rotary tillage. Results showed that both the tillage options gave statistically similar plant height, tillers/m^2 and 1000 grain weight in all N schedules. Nitrogen splitting at 2 or 3 or 4 times gave almost similar plant height, tillers/m^2 and 1 000 grain weight but greater than the single dose application either at basal or tillering. Grain and straw yield were statistically similar under rotary and zero tillage. The grain and straw yield were higher under 3 splits of nitrogen scheduling either 1/3 basal+1/3 at tillering+1/3 at floral formation or 1/4 basal+1/2 at tillering+1/4 at floral formation and 2 splits 1/3 basal + 2/3 at first node compared to the other treatments. Full N as basal or full at tillering gave significantly less yield as compared to other treatments. Three and four splits of nitrogen were significantly better in total protein yield as compared to two splits or single N application. Agronomic efficiency was also found to be higher under split application treatments (1/3 basal+1/3 at tillering+1/3 at floral formation or 1/4 basal+1/2 at tillering+1/4 at floral formation and 2 splits 1/3 basal+2/3 at first node).

Key words: Agronomic efficiency, Grain protein, Nitrogen scheduling, Tillage options, Wheat, Yield

The continuous cropping without adequate restorative practices may pose threats to the sustainability of rice (*Oryza sativa* L.)–wheat (*Triticum aestivum* L. emend. Fiori & Paol.) system. In recent years, the emphasis has been made on new tillage practices for achieving higher crop productivity with reduced cost of production. Profitable responses to minimum tillage and farmyard manure in wheat and maize (*Zea mays* L.) can be obtained on long-term cultivated silt clay loam soil (Khan *et al.* 2008). Number of researchers have reported enhancement of nutrients in the upper part of soil surface with zero tillage practice (Dou and Hons 2006, Pendell *et al.* 2007) and rotary tillage mixed the upper 5 cm soil and prepares fine tilth which facilitates good germination. Furthermore, role of nitrogenous fertilizers is pivotal among the factors contributing to wheat productivity. Nitrogen scheduling plays an important role in growth, productivity and quality of wheat as well as on its use efficiency. The nitrogen scheduling verified for higher productivity in conventional tillage may be different for alternate tillage situations. It has been estimated that only 33% of total N applied for cereal production in the world is actually removed in the grain and 67% lost due to various reasons. Technological advances are needed to reduce excess nutrient applications by improving use efficiencies and reducing losses (Bellido and Bellido 2001). Keeping above facts in view, the present experiment was conducted with varied nitrogen scheduling in wheat under zero and rotary tillage to find out the most appropriate nitrogen application schedule for wheat in different tillage options.

MATERIALS AND METHODS

A field experiment was conducted at research farm of Directorate of Wheat Research, Karnal during winter *(rabi)* season of 2004–07. The experimental soil was sandy clay loam in texture (56% sand, 22% silt and clay each), low in organic carbon (0.36%) and available N (139 kg/ha), medium in available P (17.6 kg/ha) and K (151 kg/ha) content. Electrical conductivity and *p*H were 0.273 dS/m and 7.8 respectively. Two tillage systems, viz zero and rotary tillage and 9 nitrogen schedulings, viz full basal (T_1), 1/3 basal+1/3 at tillering+1/3 at floral initiation (T_2), 1/3 basal+2/3 at 1st

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node (T_3), ¼ basal+1/2 at tillring+1/4 at floral initiation (T_4), ½ basal +1/2 at tillering (T_5), 6. ¼ basal+1/4 at tillering+1/4 at floral initiatian+1/4 at grain filling (T6), 0+ ½ at tillering+1/2 at floral initiation (T_7), full at tillering (T_8) and absolute control (T_9), were allocated in a split-plot design with 3 replications. Recommended doses of fertilizers (nitrogen, phosphorus and potash @150: 60: 40 kg/ha) were applied to all treatments but schedule of N application varied, according to the treatment. Irrigation was applied on the basis of critical physiological stages of wheat. Under zero tillage condition, wheat was sown by zero till drill directly after harvesting of transplanted rice without any tillage, whereas under rotary tillage sowing was done by rotavator in one pass. 'PBW 343' wheat was sown in the experiment. The observations on important characters, like plant height, tillers/m^2, 1 000 grain weight, biomass and grain yield were recorded. Protein and nitrogen were determined as per methods described under AOAC. Apparent recovery was estimated by change in N uptake compared to control multiplied by 100 and divide by the rate of N applied. Agronomic efficiency was determined by difference in grain yield between treatment and control divide by N applied.

RESULTS AND DISCUSSION

Crop growth and yield attributes

Both the tillage options zero and rotary tillage produced statistically similar plant height across all N schedules and thus tillage options have no significant effect on plant height (Table 1). However, a group of researchers thought that soil compaction due to movement of machinery significantly affected the root and shoot growth and biomass of different wheat varieties. Nitrogen splitting either at 2 or 3 or 4 times gave almost similar plant height, which was more than the full, basal and without basal. There was no definite trend in 1000 grain weight and tillers/m^2, but values of both the characters were less where no basal nitrogen was applied. Tillers/m^2 were also less under full basal N application. This may be ascribed to the fact that nitrogen is required throughout the grand growth period and hence adequate and regular N supply is must during this period. Dou and Hons (2006) reported similar crop growth under different tillage systems.

Crop yield

Pooled data presented in Table 2 showed that grain and straw yields were statistically similar under rotary and zero tillage although numerically higher yields were produced under rotary tillage as compared to zero tillage. Thomas *et al.* (2007) reported that mean grain yield and gross margin of wheat were similar under conventional and zero tillage, however, Parihar (2004) reported higher grain and straw yields of wheat under rotary tillage compared to zero tillage. It may be due to the reason that sowing with zero till drill does not create favourable tilth and roots of crop plants in zero tillage remain shallow than rotary or conventional tillage and they may not be able to extract nutrients and moisture from deeper layers of soil (Kumar 2000). The straw and grain yields were higher under 3 splits of nitrogen scheduling either 1/3 basal+1/3 at tillering+1/3 at floral formation or 1/4 basal+1/2 at tillering+1/4 at floral formation and 2 splits 1/3 basal + 2/3 at first node compared to the other treatments. Full N as basal and at full tillering gave significantly less

Table 1 Effect of tillage and nitrogen scheduling on plant height and yield attributes of wheat

Treatment	Plant height (cm)				Tilers/m^2				1 000 grain weight (g)			
	2004–05	2005–06	2006–07	Pooled	2004–05	2005–06	2006–07	Pooled	2004–05	2005–06	2006–07	Pooled
Tillage												
Zero	83.5	84.5	85.8	84.6	335	339	341	338	42.8	43.0	43.4	43.1
Rotary	85.3	86.6	87.6	86.3	339	354	344	346	42.6	42.9	45.4	43.6
CD (*P*=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	1.60	NS
N scheduling												
T_1	81.7	81.7	83.2	82.2	321	334	318	323	43.3	44.0	46.3	44.5
T_2	86.2	88.6	89.0	88.0	343	356	326	341	42.7	43.3	44.2	43.5
T_3	86.5	88.0	88.4	87.6	337	353	357	350	42.5	43.2	44.4	43.4
T_4	86.3	88.6	88.7	87.8	346	362	381	363	42.9	42.8	43.6	43.3
T_5	85.7	88.0	89.0	87.5	339	358	352	349	42.6	43.2	46.1	44.0
T_6	84.9	86.2	86.3	85.8	349	363	370	361	43.4	43.5	45.4	44.1
T_7	83.2	83.7	84.7	83.9	344	343	338	342	41.7	41.7	42.3	41.9
T_8	80.5	83.5	84.6	82.9	319	308	298	308	42.3	42.0	42.1	42.1
T_9	73.5	74.1	74.2	73.9	218	230	215	221	36.6	36.8	37.4	36.9
CD (*P*=0.05)	NS	4.50	4.18	NS	NS	38.7	40.6	NS	NS	1.54	1.90	NS

T_1–Full basal, T_2–1/3 basal+1/3 tillering+1/3 floral initiation, T_3–1/3 basal+2/31st node, T_4–¼ basal+1/2 tillring+1/4 floral initiation, T_5–½ basal +1/2 tillering, T_6–¼ basal+1/4 tillering+1/4 floral initiatian+1/4 grain filling, T_7–0+ 1/2tillering+1/2 floral initiation, T_8–full at tillering, T_9–absolute control yield compared to other treatments. Although full basal application of N did well under rotary tillage compared to the zero tillage but not to the extent of treatment like 1/3 basal+1/3 at tillering+1/3 at floral initiation, 1/3 basal+2/3 at first node and ¼ basal+1/2 at tillring+1/4 at floral initiation. Harvest index was at par in all N schedules either it is zero or rotary tillage and the values varied from 41.4 to 44.8.

Protein content, uptake and agronomic efficiency

Protein content in grain increased with increased number of N splits at either zero or rotary tillage. Three and four splits of nitrogen were significantly higher in total protein yield as compared to 2 splits or single application. Total grain protein yield was the lowest under full N application in single dose either as basal or at tillering stage (Table 3). Uptake of nitrogen in wheat was the highest when N was scheduled as 1/3 basal+ 2/3 at 1st node under zero and in 1/3 basal+1/3 at tillering+1/3 at floral initiation under rotary tillage and the lowest was at full N application either at tillering or as basal. Ishaq *et al*. (2001) reported that tillage systems did not significantly affect the plant tissue elemental contents of wheat (at tillering). However, the increasing rates of N, P and K caused a corresponding increase in tissue contents of N, P and K of wheat plant. Tillage and fertilizer treatments had a positive effect on nutrient uptake by wheat. They also reported increase of N, P and K uptake under deep and conventional tillage compared to minimum tillage treatment. Nitrogen-use efficiency was also found to be higher under N

Table 2 Effect of tillage and nitrogen scheduling on wheat productivity

Treatment	Grain yield (tonnes/ha)				Straw yield (tonnes/ha)				Harvest Index (%)			
	2004–05	2005–06	2006–07	Pooled	2004–05	2005–06	2006–07	Pooled	2004–05	2005–06	2006–07	Pooled
Tillage												
Zero	3.79	4.28	3.55	3.99	4.96	5.58	5.13	5.23	44.3	45.1	42.7	44.0
Rotary	3.82	4.60	4.04	4.14	5.06	5.86	5.67	5.81	44.0	43.9	41.8	43.2
CD (*P*=0.05)	NS	0.23	0.11	NS	NS	NS	0.35	NS	NS	NS	NS	NS
N scheduling												
T_1	3.77	4.54	3.77	4.03	4.98	5.79	5.75	5.51	43.1	44.0	39.7	42.3
T_2	4.14	5.06	4.38	4.52	5.34	6.19	6.18	5.90	43.6	44.9	41.5	43.5
T_3	3.81	5.23	3.96	4.36	5.11	6.19	5.90	5.79	43.2	45.8	40.7	43.3
T_4	4.05	4.89	4.39	4.44	5.16	5.93	5.84	5.64	44.0	45.2	42.9	44.1
T_5	3.77	4.68	3.90	4.12	4.82	6.10	6.00	5.64	43.9	43.4	39.5	43.8
T_6	4.31	4.35	3.90	4.19	5.03	5.57	5.41	5.34	46.1	43.9	41.9	44.0
T_7	4.10	4.41	4.10	4.21	4.98	5.61	5.59	5.39	45.1	44.0	42.3	43.9
T_8	3.83	4.47	3.52	3.94	4.82	5.52	4.74	5.03	44.3	44.7	42.5	43.9
T_9	2.25	2.40	2.31	2.32	4.86	5.12	5.00	4.99	31.3	32.4	31.6	31.8
CD (*P*=0.05)	0.31	0.37	0.24	0.45	NS	NS	0.29	NS	NS	NS	NS	NS

Table 3 Effect of tillage and nitrogen scheduling on grain protein and N uptake (mean of 3 years)

Treatment	Grain protein (%)	Protein yield (kg/ha)	N Uptake (grain+straw) (kg/ha)	Apparent recovery kg uptake*100/kg N applied (%)	Agronomic efficiency (kg grain added/ kg N applied)
Tillage					
Zero	11.4	468	96.5	33.1	11.1
Rotary	11.1	481	101.2	36.3	12.1
CD (*P*=0.05)	NS	NS	4.77	2.73	NS
N scheduling					
T_1	10.41	419	85.9	26.1	11.3
T_2	11.80	534	105.5	39.1	14.6
T_3	10.67	463	105.0	38.8	13.5
T_4	11.38	505	103.0	37.5	14.1
T_5	10.68	440	98.0	34.1	11.9
T_6	12.59	527	99.0	34.8	12.4
T_7	11.82	497	95.0	32.1	12.5
T_8	10.48	413	93.0	30.8	10.7
T_9	12.5	291	46.8		
CD (*P*=0.05)	0.74	98.4	6.90	4.18	1.82

schedules viz. 1/3 basal+1/3 at tillering+1/3 at floral initiation, 1/3 basal+2/3 at 1st node and ¼ basal+1/2 at tillring+1/4 at floral initiation where yield, N uptake were also higher than other treatments. McAdrew (2002) also reported that different nitrogen application methods significantly affected the fertilizer nitrogen efficiency under different tillage systems (zero and conventional).

It can be concluded that nitrogen scheduling in 2 splits (1/3 basal+2/3 at 1st node) or 3 splits (1/3 basal+1/3 at tillering+1/3 at floral initiation or ¼ basal +1/2 at tillring+1/4 at floral initiation) were found better in both zero and rotary tillage conditions. Nitrogen-use efficiency was also better under these treatments. Grain quality was better under 3 or 4 splits of nitrogen application. The results of crop growth, productivity and nitrogen-use efficiency could not found to be better under full N application at basal or skipping off basal N application.

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