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Research Communication

Effect of nitrogen management on yield attributes and nitrogen-use efficiency of late-sown wheat (*Triticum aestivum* L.) in western Uttar Pradesh

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ABSTRACT

A field experiment was conducted during the winter (*rabi*) season 2016–17 at Meerut, Uttar Pradesh, to evaluate the nitrogen management for late-sown wheat (*Triticum aestivum* L.) crop. The experimental field condition was well-drained, sandy loam in texture, alkaline in reaction (*p*H 7.80), low in available nitrogen, medium in available phosphorus and potassium with an electrical conductivity of 0.25dS/m. Eleven treatments comprising control, recommended dose of nitrogen (RDN) for a time as well as late-sown wheat with different application schedules were tested in randomized block design (RBD) with 3 replications. Yield-attributing characters were significantly better in the treatments where the major portion of N was applied during the early growth period. The highest grain yield was recorded in treatment (T_8) where 50% of recommended N in accordance to timely sown wheat was applied at sowing. This treatment was found statistically similar to T_4, T_6 and T_{10} treatment. Growth and yield-attributing characters were comparatively higher in treatment T_8. Nutrient-use efficiency expressed in terms of agronomic efficiency, apparent nitrogen-recovery efficiency and physiological efficiency were also worked out.

Key words : Wheat, Imbalanced fertilizer, Nitrogen availability, Soil health

In India, wheat occupied an area of 31.0 million hectare, with a production of 88.9 million tonnes of grains and productivity of 2872 kg/ha during 2015–16 (Anonymous, 2016). Productivity of wheat is low in the state of Uttar Pradesh (2,850 kg/ha), contributing almost 50 percent share, against 4,360 kg/ha in Punjab. Moreover, there are huge yield gaps in the productivity of front-line demonstrations and farmer's fields across the country.

The delayed sowing further causes supra-optimal thermal stress at the reproductive phase which ends up in forced maturity (Gupta *et al.*, 2002). Hot temperature stress at the reproductive phase of the crop (Sharma *et al.*, 2007) in wheat sowing 20 and 40 days from the conventional sowing delay date (15 November) reduces grain yield by 23 kg/ha/day and 30 kg/ha/day respectively (Kaur and Pannu, 2008). Plant nutrients though present in small concentration, play a decisive role in the growth and development, quality and yield formation of crops. A primary goal of N management is to optimize crop yield by applying sufficient N to the crop. Nitrogen-use efficiency (NUE) is widely used as an index to measure the efficiency of N uptake based on the quantity of N applied. The excessive use of N fertilizer leads to low NUE and economic loss. Therefore, the optimizations of N nutrition for crops as well as the rational use of N fertilizers and soil N are some of the most important tasks of agronomy. Lower utilization efficiency of N occurs when the amount of applied N exceeds the crop requirements, which thereby increases the risk of N loss. High N input coupled with low NUE threatens the sustainability of the agro-ecosystems. Optimal N fertilizer application plays a vital positive role in the growth and productivity of crops. Appropriate N applications rates help improve the profitability of crop production and NUE. In western Uttar Pradesh which is sugarcane-dominated area, most of the wheat is sown as late. The nitrogen application in timely and late-sown wheat is different and a lower level of nitrogen is applied in late-sown condition. Therefore, the question arises that whether this reduced level of N application in present soil-fertility conditions is enough for potential production or it should be increased with change within the N application schedule.

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Nitrogen is applied to wheat in 3 splits, i.e. half basal and the rest half in 2 equal splits–at 1st and 2nd irrigation. There is a need for re-examination of this schedule by changing the proportion of N application rates at these stages of wheat production, hence an experiment was carried out.

The experiment was conducted during the winter (*rabi*) season 2016–17 at the crop research centre of the Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, the nitrogen management for late-sown wheat crop to evaluate. (29° 40' N 77° 42' E and 237 m above mean sea-level), Uttar Pradesh. The soil was well-drained, sandy loam, alkaline (*p*H 7.80), low in available nitrogen, medium in available phosphorus and potassium with an electrical conductivity of 0.25dS/m. Eleven treatments [T_1, Control (without nitrogen); T_2, recommended dose of nitrogen fertilizer (RDNF) for timely sown wheat (150 kg N) in 3 splits, i.e. 50% N as basal, 25% at crown-root initiation (CRI) and 25% at tillering; T_3, RDNF for late-sown wheat (80 kg N) in 3 splits, i.e. 50% N as basal, 25% at CRI and 25% at tillering; T_4, RDNF for timely sown wheat (150 kg N) in 2 splits, i.e. 50% N as basal and 50% at CRI; T_5, RDNF for late-sown wheat (80 kg N) in 2 splits, i.e. 50% N as basal and 50% at CRI; T_6, RDNF for timely sown wheat (150 kg N) in 3 splits, i.e. 60% N as basal, 30% at CRI and 10% at tillering; T_7, RDNF for late-sown wheat (80 kg N) in 3 splits, i.e. 60% N as basal, 30% at CRI and 10% at tillering; T_8, RDNF for timely sown wheat (150 kg N) in 3 splits, i.e. 50% N as basal, 44% at CRI and 2% urea spray at tillering and (rest of 4% N was deducted at the time of Tillering; T_9, RDNF for late-sown wheat (80 kg N) in 3 splits, i.e. 50% N as basal, 44% at CRI and 2% urea spray at tillering and (rest of 4% N was deducted at the time of tillering; T_{10}, RDNF for timely sown wheat (150 kg N) in 3 splits, i.e. 60% N as basal, 34% at CRI and 2% urea spray at tillering and (rest of 4% N was deducted at the time of tillering; T_{11}, RDNF for late-sown wheat (80 kg N) in 3 splits, i.e. 60% N as basal, 34% at CRI and 2% urea spray at tillering and (rest of 4% N was deducted at the time of tillering, were tested in randomized block design with 3 replications. Phosphorus and potassium @ 40 kg/ha were applied in each treatments uniformly in all the treatments in accordance to late-sown recommendation. Nutrient-use efficiency expressed in terms of agronomic efficiency, apparent nitrogen-recovery efficiency and physiological efficiency which were worked out as:

$$\text{Agronomic efficiency} = \frac{\text{Grain yield F} - \text{Grain Yield C}}{\text{Fertilizer applied}}$$

$$\text{N-Apparent efficiency} = \frac{\text{N uptake F} - \text{N uptake C}}{\text{Fertilizer applied}} \times 100\%$$

$$\text{Physiological efficiency N} = \frac{\text{Grain yield F} - \text{Grain yield C}}{\text{N uptake F} - \text{N uptake C}}$$

Where, C, Control plot; F, fertilize plot; N, nitrogen; grain yield and fertilizer rate are in kg/ha and N Uptake (grain + straw is in kg/ha).

In general, treatments receiving a major portion of nitrogen at an early stage accumulated more biomass on Spike length, spikelet/spike, grains/spike and 1,000-grain weight were significantly affected by different nitrogen-management treatments (Table 1). The data regarding spike length of wheat as influenced by different nitrogen treatments (Table 1) showed that, spike lengths differed from 7.2 to 9.8 cm. A maximum spike length of 9.8 cm was found in treatment T_{10}, it was lowest in the control T_1 (7.20 cm). The other treatments showed spike lengths in the range of 9.5 to 9.1 cm respectively. Lower spike length was noted with

Table 1. Effect of different nitrogen management on spike length, spikelet/spike, grains/spike and 1,000-grain weight of wheatTreatment

		Length of spike (cm)	Spikelet/ spike	Grain/ spike	Testweight (g)
T_1	Control	7.2	18	29	35.2
T_2,	RDN for timely sown wheat (50 : 25 : 25)	9.6	22	33	39.3
T_3,	RDN for late-sown wheat (50 : 25 : 25)	9.5	21	29	37.0
T_4,	RDN for timely sown wheat (50 : 50 : 0)	9.7	25	35	42.3
T_5,	RDN for late-sown wheat (50 : 50 : 0)	9.5	22	32	39.6
T_6,	RDN for timely sown wheat (60 : 30 : 10)	9.7	25	37	43.0
T_7,	RDN for late-sown wheat (60 : 30 : 10)	9.6	22	32	38.3
T_8,	RDN for timely sown wheat (50 : 44 : 2% urea sprays.)	9.7	24	37	43.6
T_9,	RDN for late-sown wheat (50 : 44 : 2% urea spray.)	9.6	22	32	40.6
T_{10},	RDN for timely sown wheat (60 : 34 : 2% urea sprays.)	9.8	24	36	42.0
T_{11},	RDN for late-sown wheat (60 : 34 : 2% urea sprays.)	9.6	22	32	39.6
	SEm±	0.05	0.82	0.53	0.27
	CD (P=0.05)	0.15	2.42	1.59	0.82

RDN, Recommended dose of nitrogen

the application of lower N level at the application schedule.

The grains/spike varied significantly from 29 to 37 under different treatments. The maximum number of grains/spike (37) was in the treatments T_6 and T_8, while the other treatments like T_4 and T_{10} have shown at par results to T_6 and T_8. The lower level of N application within the same split application recorded significantly lower number of grain/spike. The number of spikelets/spike, as influenced by different nitrogen management treatments, differed significantly from each other and ranged from 18 to 25. The maximum number of spikelets/spike was recorded in T_4 and T_6, i.e. 25, while the minimum under the control i.e. 18. The number of spikelets/spike were higher than T_1, T_2, T_3, T_5, T_7, T_9 and T_{11} treatments. Significantly lower spikelet/spike was noted with lower N levels at the same application schedule. Test weight [1,000-grains weight (g)] differed significantly in different N treatments and ranged from 35.0 to 43.6 g. Maximum test weight of 43.6 g was statistically at par to T_4 and significantly higher than the remaining treatments was found in T_8 while the minimum (35.0 g) in the control (T_1). Test weight was significantly affected by the level of N application while similar N application, schedule and test weight was lower with reduced N application.

In general, these character parameters were better in the treatments receiving maximum N at early growth stages. This could be ascribed to a better vegetative growth that might have resulted in more photosynthesis with a possible higher leaf-area index. Singh *et al.* (2017) reported that, ears/m row length, ear length, grains/year, grain weight/ear

Table 2. Effect of different nitrogen management treatments on plant N uptake (kg/ha) at different stages of wheat crop

Treatment	Crown-root initiation	Tillering	At harvestin		
			Straw	Grain	Total
Control	3.5	15.4	13.1	33.7	46.9
RDN for timely sown wheat (50 : 25 : 25)	7.8	38.7	27.3	61.5	88.8
RDN for late-sown wheat (50 : 25 : 25)	6.0	28.6	18.7	47.3	66.0
RDN for timely sown wheat (50 : 50 : 0)	8.1	43.8	29.6	63.7	93.4
RDN for late-sown wheat (50 : 50 : 0)	6.4	29.3	19.7	46.2	65.9
RDN for timely sown wheat (60 : 30 : 10)	8.4	43.8	27.0	71.6	98.6
RDN for late-sown wheat (60 : 30 : 10)	6.3	29.1	20.1	48.6	68.8
RDN for timely sown wheat (50 : 44 : 2% urea spr.)	7.9	42.9	26.5	71.7	98.3
RDN for late-sown wheat (50 : 44 : 2% urea spr.)	6.0	28.6	21.9	47.4	69.3
RDN for timely sown wheat (60 : 34 : 2% urea spr.)	8.5	44.3	31.2	70.4	101.6
RDN for late-sown wheat (60 : 34 : 2% urea spr.)	6.3	28.9	21.1	49.3	71.5
SEm±	0.186	0.794	0.745	1.743	5.83
CD (P=0.05)	0.554	2.360	2.214	5.177	16.81

RDN, Recommended dose of nitrogen

Table 3. Effect of different nitrogen-management treatments on nitrogen-use efficiency in wheat

Treatment	Agronomic efficiency (kg grain/kg N applied)	Apparent N efficiency (%)	Physiological efficiency	Grain (t/ha)	Straw (t/ha)
T_1, Control	-	-	-	2.34	3.66
T_2, RDN for timely sown wheat (50 : 25 : 25)	10.0	27.9	35.8	3.84	5.25
T_3, RDN for late sown wheat (50 : 25 : 25)	08.7	23.9	36.6	3.04	3.90
T_4, RDN for timely sown wheat (50 : 50 : 0)	10.9	31.0	35.2	3.98	5.62
T_5, RDN for late sown wheat (50 : 50 : 0)	08.2	23.8	34.6	3.00	4.20
T_6, RDN for timely sown wheat (60 : 30 : 10)	12.2	34.5	35.3	4.17	5.43
T_7, RDN for late sown wheat (60 : 30 : 10)	09.4	27.3	34.3	3.09	4.19
T_8, RDN for timely sown wheat (50 : 44 : 2% urea sprays.)	12.2	34.2	35.8	4.18	5.40
T_9, RDN for late sown wheat (50 : 44 : 2% urea sprays.)	09.7	28.0	34.8	3.12	4.36
T_{10}, RDN for timely sown wheat (60 : 34 : 2% urea sprays.)	11.5	36.5	31.5	4.07	5.79
T_{11}, RDN for late sown wheat (60 : 34 : 2% urea spr.)	08.6	30.7	28.0	3.03	4.40
SEm±	0.330	1.062	1.187	0.80	4.52
CD (P=0.05)	0.989	3.18	3.55	2.38	1.52

RDN, Recommended dose of nitrogen (Figures in parentheses indicate % show of applied N at different stage of wheat crop) of 'PBW 373' were significantly higher with 150 kg N/ha. Dahiya *et al.* (2008) reported that application of 120 kg N/ha in 2 equal splits–as basal and at CRI-resulted in higher spike length, grains spikes, grain weight/spike. However, grain and straw yields also differed significantly. The nitrogen uptake by wheat crop given in Table 2, showed that N uptake by wheat crop differed significantly at CRI, tillering and harvesting under different treatments. The total nitrogen removal by wheat crop at harvesting ranged from 46.90 to 101.68 kg/ha under different treatments. Removal of nitrogen by wheat straw was lower than grain. Nitrogen removed by straw ranged from 13.18 to 31.27 kg/ha. Maximum N uptake (31.37 kg/ha) statistically at par with T_4 and significantly higher than the remaining treatments, was found in T_{10}, while the minimum (13.18 kg/ha) was significantly lower than the remaining treatments in the control (T_1). Treatments of similar N applications scheduled with variable N level differed significantly and higher level accumulated more nitrogen. Nitrogen uptake by grain varied from 33.73 to 71.77 kg/ha under different treatments. Maximum uptake of 71.77 kg/ha statistically at par with T_6, T_{10} and significantly higher than the remaining treatments was found in T_8 treatment, while the minimum N uptake (33.73 kg/ha) was found significantly in control lower than the remaining treatments. Level of N application reflected its impact on N uptake and at particular N application schedule significantly higher N uptake was observed with the application of higher N level.

At tillering, N uptake in wheat crop ranged from 15.46 to 44.34 under different treatments. Maximum N uptake (44.34 kg/ha) being statistically at par with T_4, T_6, T_8 and significantly higher than the remaining treatments, was found in T_{10} treatment. While and the minimum uptake of 15.46 kg/ha was in the control, being significantly lower than the remaining treatments. At this stage, N accumulation was 32.96 to 46.90% of total N accumulated during entire growth period. Minimum per cent accumulation was found in the control, while the maximum in T_4 treatment. Nitrogen uptake varied significantly among the treatments receiving variable level of N at similar N application schedule.

Assimilation of nitrogen by wheat crop at CRI differed significantly and varied from 3.57 to 8.55 kg/ha under different treatments. Maximum N accumulation (8.50 kg/ha) statistically at par with T_2, T_4, T_6, T_8 treatment and significantly higher than the remaining treatments was found in T_{10} where 60% of recommended dose of N in accordance to timely sown condition was applied as basal. The N uptake declined significantly with the application of N in accordance to late-sown wheat. By this stage, N accumulation ranged from 7.6 to 9.7% of the total N accumulation during the entire growth season under different treatments. Level of N application with similar application schedule exhibited a significant effect on grain and straw efficiency 36.69 was found in T_8, T_{10} and T_3 respectively (Table 3). Maximum grain yield of 4,180 kg/ha, being statistically at par with T_6, T_{10} and T_4 was found in T_8 (Table 3). In all these treatments major portion of N in accordance to timely sown wheat was applied at early growth period. Higher grain in these treatments may be owing to higher yield-attributing characters because of to better vegetative growth. Common N application schedule (50 : 25 : 25) yielded significantly lower than these treatments. Yield attributing characters (Table 1) were lower in this treatment. About 9.0% yield increment in T_8 as compared to T_2 was observed at HAU, Hisar found that the number of tillers, all yield attributes, grain and biological yields were significantly higher with the application of N up 150 kg/ha in case of late-sown wheat earlier growth stages.

It may be concluded that the nitrogen recommendation of 80 kg/ha for late-sown wheat is not sufficient for higher productivity in the present soil condition. The maximum yield of wheat was obtained with the application of nitrogen in accordance to timely sown wheat in a rice–wheat system that is 150 kg N/ha. For late-sown wheat, application of a major portion of recommended nitrogen in accordance to timely sown wheat at early growth seems better; however, this effect was not noticed in the case of late-sown recommendation. The result is based on a one-year study it will require further investigation to find out the optimum dose of nitrogen for late-sown wheat and the appropriate N application schedule.

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