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Effect of different nitrogen fertilizer doses on critical stages of late-sown wheat (*Triticum aestivum* L.)

Babu Lal Gurjar and NB Misal

Abstract
A field experiment is conducted in randomized block design with three replications at the Agricultural Research Farm of Lovely Professional University, Phagwara, Punjab. The experiment comprising, ten different treatments *viz.* T0(control), T1-75% RDN (50% N at Basal + 50% N at CRI stage, T2- 100% RDN (50% N at Basal + 25% N at CRI + 25% N at Tillering stage, T3-125% RDN (50% N at Basal + 25% N at CRI + 25% N at Tillering stage, T4-75% RDN (50% N at Basal + 25% N at CRI + 25% N at Tillering stage, T5-100% RDN (25% N at Basal + 25% N at CRI + 50% N at Tillering stage, T6-125% RDN (25% N at Basal + 25% N at CRI + 50% N at Tillering + 3% Urea solution spray at Late Jointing stage, T7-75% RDN (25% N at Basal + 25% N at CRI + 50% N at Tillering stage, T8-100% RDN (25% N at Basal + 50% N at CRI + 25% N at Tillering stage+ 3% Urea solution spray at Jointing stage, T9-125% RDN(50% N at Basal +50% N at CRI stage + 4% urea solution spray at Flowering stage. The application of 125% RND (25% N at Basal + 25% N at CRI + 50% N at Tillering+ 3% Urea solution spray at Late Jointing stage) recorded significant growth and yield parameters *viz.* plant height, leaf area index, days to 75% flowering, number of tillers, spike per meter square, length of spike, number of grain per spike, test weight, grain yield (47.7 q/ha) and straw yield (70 q/ha).

Keywords: Nitrogen fertilizer, wheat, nutrient uptake

Introduction
Wheat (*Triticum aestivum* L.) is a crop that is often grown in South Western Asia. It is the world's most widely cultivated cereal crop. It is accounts first rank in world as cereal crop and it belongs to the genus *Triticum* and the poaceae family. India is the second largest (99.7 million metric tonnes in year of 2018) wheat producing country after China (131.4 million metric tonnes in the year of 2018). In India wheat crop cultivation area is about 30 million hectares (14% of global area) to give the highest production of 99.70 million tonnes (13.64% of worldwide wheat production) with 3372 kg/ha record average wheat productivity. Uttar Pradesh is the country's largest wheat producer, with an output of about 28 million tonnes, or roughly 30% of total production. Traditional wheat-growing regions such as Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Bihar and Rajasthan provided 85 million tonnes (90%) of India's total wheat production.

Nitrogen has been identified as a critical nutrient for wheat crop production. It is an essential constituent of all living cells and plays a major role in the plant growth. It is also constituent of proteins, enzymes and chlorophyll and take part in metabolic activities. Nitrogen generally occurs in mostly small quantities in soils in the available forms and is utilized in more quantities. Nitrogen is mostly considered as the single important mineral nutrient limiting crop production factor. It is constitutes 1-4% of the plant dry matter. Nitrogen provides about 20% of the total food calories for human. Low yield reduced profit due to insufficient availability of nitrogen to wheat crop. Nitrogen use efficiency (NUE) is generally 30 to 40% of total of N –fertilizer applied. The remaining of applied N is lost due to leaching and run-off in soil. Thus, the application of optimum rate of N fertilizer is considered to primary means of increasing wheat grain yield and improving N uptake. Split application of nitrogen is one of most important method to improve or increase nitrogen use by wheat crop and reducing leaching, denitrification, runoff and volatization losses.

Materials and Methods
The field experiment was conducted with ten treatments and three replications during the *rabi* season of 2019-20 with randomized block design at the Agricultural Research Farm of Lovely Professional University, Phagwara, Punjab which was located at 31°14'43.8"N and 75°41'44.1"E.

The average annual temperature at this location is 23.9°C. The treatments were as T0(control), T1-75% RDN (50% N at Basal + 50% N at CRI stage, T2- 100% RDN (50% N at Basal + 25% N at CRI + 25% N at Tillering stage, T3-125% RDN (50% N at Basal + 25% N at CRI + 25% N at Tillering stage, T4-75% RDN (50% N at Basal + 25% N at CRI + 25% N at Tillering stage, T5-100% RDN (25% N at Basal + 25% N at CRI + 50% N at Tillering stage, T6-125% RDN (25% N at Basal + 25% N at CRI + 50% N at Tillering + 3% Urea solution spray at Late Jointing stage, T7-75% RDN (25% N at Basal + 25% N at CRI + 50% N at Tillering stage, T8-100% RDN (25% N at Basal + 50% N at CRI + 25% N at Tillering stage+ 3% Urea solution spray at Jointing stage, T9-125% RDN (50% N at Basal +50% N at CRI stage + 4% urea solution spray at Flowering stage

The wheat seeds of the variety "Unnat PBW-550'' were treated with fungicide, *i.e.* bavistin@2g/kg of seed, to protect the seeds from disease causing pathogens in the soil and on the seed. Fertilizers were placed at a depth of about 5 cm below the seed furrow, as prescribed (120 kg N + 60 kg P + 40 kg K/ ha). Fertilizers sources are DAP and Urea. Using a precision plot planter, a seed rate of 110 kg/ha was maintained, with a row spacing of 22.5 cm. The crop was manually harvested from the net plot area. The data collected for the five plants were used to calculate a mean for all of the parameters, which was then used in statistical analysis for various characters as growth and yield attributes. Initial status of physiochemical properties of surface soil samples (0-15 cm) were determined using standard methods to assess the nutrient status of the soil (Table 1). Plant samples were analyzed for total N, P and K content. After determining the content of N, P and K in representative samples, the total uptake of N, P and K (kg/ha) was calculated. The data were analyzed statistically using the programme OPSTAT, with comparisons made at a 5% level of significance.

Table 1: Physiochemical properties of soil (0-15 cm) of experimental field (Initial status)

Physiochemical properties	Content
Sand content (%)	75
Silt content (%)	10.3
Clay content (%)	14.7
Soil texture	Sandy loam
Soil Ph	7.6
Soil Electrical Conductivity (dS/m)	0.608
Soil Organic carbon (%)	0.58
Available Nitrogen (Kg/ha)	222.66
Available Phosphorus (Kg/ha)	22.66
Available Potassium (Kg/ha)	175.33

Results and Discussion

Growth characters

Plant height (Table 2), leaf area index (Table 3) and days to 75 percent flowering (Table 4) can all be used to gauge the plant's progress. Different nitrogen fertilizer applications and foliar application of urea solution significantly affected plant height except at 30DAS, leaf area index at different growth stages and days to 75% flowering. Under treatment T6 (125% RDN (25% N at Basal + 25% N at CRI + 50% N at Tillering + 3% Urea solution spray at Late Jointing stage) were reported maximum values for all growth parameters and these values are statistically at par with treatment T5(100% RDN (25% N at Basal + 25% N at CRI + 50% N at Tillering stage). Increased photosynthetic activity of the plants could explain the higher value of growth characters. Nitrogen which is found in amino acids, nucleotides, nucleic acid, a variety of co-enzymes, auxins, and cytokinin, may cause cell elongation, enlargement, and division (Salisbury and Ross, 1969) [4].

The difference in tiller numbers due to nitrogen application in the soil and on the leaves was found to be important. Increased translocation of nitrogen to the meristmatic zones resulted in rapid cell division, which in turn induced the production of more tillers per plant. Treatments T6(125% RDF (25% N at Basal + 25% N at CRI + 50% N at Tillering + 3% Urea solution spray at Late Jointing stage) and T7(75% RDF (25% N at Basal + 25% N at CRI + 50% N at Tillering stage) recorded at par values of number of tillers may be due to greater assimilation of nitrogen through combined application of soil and foliar feeding of nitrogen help to produce more number of tillers owing to the fact that increased translocation of nitrogen to the meristmatic zones resulted.

The 75% flowering of wheat plants was directly affected by increased nitrogen availability. The plants that received the highest dose of nitrogen *i.e.* 125% RDN (25% N at Basal + 25% N at CRI + 50% N at Tillering + 3% Urea solution spray at Late Jointing stage) took the longest time to reach 75% flowering, which was comparable to the time taken by the plants in treatments T5 (100% RDF (25% N at Basal + 25% N at CRI + 50% N at Tillering stage) and T7 (75% RDF (25% N at Basal + 25% N at CRI + 50% N at Tillering stage). More vegetative growth due to a small imbalance in the N/P ratio (P was added basally), causing a pause in the onset of the reproductive process with each subsequent urea solution spraying.

Yield and yield attributing characters

Yield is the total effect of various growth characteristics, which is influenced by both genetic traits and the climate in which crops are grown. Crop yield behaviour is heavily influenced by moisture availability and nutrient supply. Nitrogen fertilization increased yield attributing characters, such as spike per square meter, length of the ear head, the amount of grains per ear head and number of grain per spike (Table 4) as well as test weight (Table 5). As a consequence of the soil and foliar application of nitrogen, grain yield and straw yield were significantly increased. The yield of straw followed the same pattern and was adversely affected. As a result, the treatment T6(125% RDN (25% N at Basal + 25% N at CRI + 50% N at Tillering + 3% Urea solution spray at Late Jointing stage) had the greatest positive impact on grain yield, straw yield and harvest index which was statistically at par with treatments T5(100% RDN (25% N at Basal + 25% N at CRI + 50% N at Tillering stage) and T8(100% RDN (25% N at Basal + 50% N at CRI + 25% N at Tillering stage+ 3% Urea solution spray at Jointing stage), respectively (Table 5). This increased yield may be attributed to a large rise in yield attributing characters. There are documented cases where foliar nitrogen application has been shown to increase yield (Altman *et al.*, 1983) [1]. These results are in full agreement with Romheld and El-Fouly, M. (1999) [3] finding that foliar feeding is more efficient than soil fertilization, one explanation being that the needed nutrient is delivered directly to the location of high demand in the leaves and is absorbed relatively quickly. According to them, the time it takes for 50% of nitrogen to be absorbed as urea is 1/2 -2 hours.

According to Seth and Mosluh (1981) [5], nitrogen application in wheat resulted in a substantial increase in grain per ear head. The test weight of grain was highest in the treatment T4(75% RDF (50% N at Basal + 25% N at CRI + 25% N at Tillering stage) being at par with the treatment T6(125% RDN (25% N at Basal + 25% N at CRI + 50% N at Tillering + 3% Urea solution spray at Late Jointing stage). This may be because nitrogen application, promotes the deposition of more photosynthate in the vegetative sections, which is then translocated and utilized in superior grain growth. Yassen *et al*., (2010) [6] also found that when soil and foliar nitrogen feeding were combined, grain test weight increased significantly. Supplemental foliar fertilization during crop growth has also been shown to boost plant mineral status and increase crop yield (Mosluh *et al*., 1978) [2].

Table 2: Effect of different treatment on plant height (cm) 30, 60, 90 and at harvest

Treatments	30 DAS	60 DAS	90 DAS	At Harvest
T0-Control	21.76	45.45	67.20	78.80
T1-75% RDN (50% N at Basal + 50% N at CRI stage.	26.43	47.70	72.66	88.20
T2-100% RDN (50% N at Basal + 25% N at CRI + 25% N at Tillering stage.	26.63	48.85	73.80	89.60
T3-125% RDN (50% N at Basal + 25% N at CRI + 25% N at Tillering stage.	27.00	50.48	73.13	87.46
T4-75% RDN (50% N at Basal + 25% N at CRI + 25% N at Tillering stage.	26.10	50.64	73.6	89.66
T5-100% RDN (25% N at Basal + 25% N at CRI + 50% N at Tillering stage.	24.57	50.89	71.00	88.13
T6-125% RDN (25% N at Basal + 25% N at CRI + 50% N at Tillering + 3% Urea solution spray at Late Jointing stage.	25.40	53.08	79.06	96.86
T7-75% RDN (25% N at Basal + 25% N at CRI + 50% N at Tillering stage.	25.13	51.18	69.40	87.80
T8-100% RDN (25% N at Basal + 50% N at CRI + 25% N at Tillering stage+ 3% Urea solution spray at Jointing stage.	25.46	48.78	68.93	87.33
T9-125% RDN (50% N at Basal +50% N at CRI stage + 4% urea solution spray at Flowering stage.	26.78	50.05	70.40	88.00
SE(m)	0.83	0.691	0.809	0.916
C.D.	2.485	2.068	2.421	2.742
C.V.	5.632	2.406	1.947	1.799

Table 3: Effect of different treatments on Leaf area index (LAI) at 30, 60 and 90 days after sowing

Treatments	30 DAS	60 DAS	90 DAS
T0-Control	0.57	3.56	2.27
T1-75% RDN (50% N at Basal + 50% N at CRI stage.	0.61	3.60	2.29
T2-100% RDN (50% N at Basal + 25% N at CRI + 25% N at Tillering stage.	0.61	3.59	2.25
T3-125% RDN (50% N at Basal + 25% N at CRI + 25% N at Tillering stage.	0.62	3.60	2.28
T4-75% RDN (50% N at Basal + 25% N at CRI + 25% N at Tillering stage.	0.64	3.58	2.29
T5-100% RDN (25% N at Basal + 25% N at CRI + 50% N at Tillering stage.	0.63	3.59	2.30
T6-125% RDN (25% N at Basal + 25% N at CRI + 50% N at Tillering + 3% Urea solution spray at Late Jointing stage.	0.64	3.64	2.32
T7-75% RDN (25% N at Basal + 25% N at CRI + 50% N at Tillering stage.	0.64	3.60	2.27
T8-100% RDN (25% N at Basal + 50% N at CRI + 25% N at Tillering stage+ 3% Urea solution spray at Jointing stage.	0.62	3.60	2.28
T9-125% RDN (50% N at Basal +50% N at CRI stage + 4% urea solution spray at Flowering stage.	0.62	3.59	2.27
SE(m)	0.007	0.008	0.012
C.D.	0.02	0.024	0.035
C.V.	1.826	0.391	0.877

Table 4: Effect of different treatments on days to 75% flowering, spike/m^2, length of spike (cm) and number of grains/spike.

Treatments	Days to 75% Flowering	Spike per m^2	Length of spike (cm)	Number of grains per spike
T0-Control	84.67	267.83	09.50	32.33
T1-75% RDN (50% N at Basal + 50% N at CRI stage.	85.33	302.86	11.23	40.33
T2-100% RDN (50% N at Basal + 25% N at CRI + 25% N at Tillering stage.	86.33	299.43	11.63	40.00
T3-125% RDN (50% N at Basal + 25% N at CRI + 25% N at Tillering stage	87.00	292.03	11.30	42.00
T4-75% RDN (50% N at Basal + 25% N at CRI + 25% N at Tillering stage	85.33	307.33	11.00	40.00
T5-100% RDN (25% N at Basal + 25% N at CRI + 50% N at Tillering stage	87.67	294.56	11.53	40.66
T6-125% RDN (25% N at Basal + 25% N at CRI + 50% N at Tillering + 3% Urea solution spray at Late Jointing stage.	89.33	307.00	12.46	45.33
T7-75% RDN (25% N at Basal + 25% N at CRI + 50% N at Tillering stage.	86.00	294.60	10.66	40.00
T8-100% RDN (25% N at Basal + 50% N at CRI + 25% N at Tillering stage+ 3% Urea solution spray at Jointing stage.	87.67	295.20	11.06	41.00
T9-125% RDN (50% N at Basal +50% N at CRI stage + 4% urea solution spray at Flowering stage.	88.33	292.26	11.03	40.66
SE(m)	0.562	2.353	0.254	1.013
C.D.	1.683	7.046	0.762	3.035
C.V.	1.122	1.38	3.954	4.363

Table 5: Effect of different treatments on test weight (gm), grain yield (q/ha), Straw yield and harvest index.

Treatments	Test weight (gm)	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index
T0-Control	32.67	21.66	51.16	0.29
T1-75% RDN (50% N at Basal + 50% N at CRI stage.	39.00	40.66	63.28	0.39
T2-100% RDN (50% N at Basal + 25% N at CRI + 25% N at Tillering stage.	41.00	41.00	68.41	0.37
T3-125% RDN (50% N at Basal + 25% N at CRI + 25% N at Tillering stage.	40.00	43.00	65.99	0.39
T4-75% RDN (50% N at Basal + 25% N at CRI + 25% N at Tillering stage.	44.33	42.00	66.09	0.38
T5-100% RDN (25% N at Basal + 25% N at CRI + 50% N at Tillering stage.	40.43	45.50	66.33	0.40
T6-125% RDN (25% N at Basal + 25% N at CRI + 50% N at Tillering + 3% Urea solution spray at Late Jointing stage.	44.00	47.70	70.00	0.40
T7-75% RDN (25% N at Basal + 25% N at CRI + 50% N at Tillering stage.	40.66	43.33	65.92	0.39
T8-100% RDN (25% N at Basal + 50% N at CRI + 25% N at Tillering stage+ 3% Urea solution spray at Jointing stage.	40.00	44.00	62.79	0.41
T9-125% RDN (50% N at Basal +50% N at CRI stage + 4% urea solution spray at Flowering stage.	39.93	41.00	68.96	0.37
SE(m)	0.73	0.63	1.39	0.007
C.D.	2.20	1.90	4.16	0.021
C.V.	3.16	2.68	3.71	3.192

Conclusion

Application of different nitrogen doses on critical stages of late sown wheat (*Triticum aestivum* L.) was found to be an effective and efficient technique for nutrient supplementation of wheat, yielding results that were comparable to those obtained with the full prescribed dose of soil applied fertilizers. Application of combination of urea as a soil and foliar spray (125% RDN (25% N at Basal + 25% N at CRI + 50% N at Tillering + 3% Urea solution spray at Late Jointing stage) was found the most suitable dose of fertilizer to be adopted as it gives significantly higher performance in growth and yield parameters such as plant height, leaf area index, days to 75% flowering, number of tillers, spike per meter square, length of spike, number of grain per spike, test weight, grain yield and straw yield.

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