Impact of foliar supplementation of nitrogenous fertilizer on yield attributes and yield of wheat (*Triticum aestivum* L.)

Abstract

Foliar supplementation of nitrogenous fertilizers has emerged as one of the catalysts in improving nitrogen use efficiency, enhancing crop yield and yield attributes while reducing cultivation costs. Liquid fertilizers play a key role in precise nutrient management, providing required quantity of nutrients throughout the crop growth period and improving yield attributes and yield of the crop.A field experiment was conducted during ~~*Rr*~~*abi* season of 2022-23 ~~&~~and2023-24 to study the effect of ~~soil and foliar supplementation~~foliar sprays of various nitrogenous fertilizers on the performance of wheat. The experiment laid out adopting split plot designwith 3 main plots and 5 sub plots treatment combinations replicating thrice ~~of wheat (DBW187)~~ *viz*, M_1-100% recommended dose of nitrogen (RDN), M_2- 75% recommended dose of nitrogen (RDN), M_3- 50% recommended dose of nitrogen (RDN), and five different sub plots *viz.*S_1-One spray of nano urea at tillering stage, S2- Two sprays of nano urea at tillering and jointingstage,S3- Two sprays of urea (5%) at tillering and jointing stage, S4- One spray of NPK 19:19:19 (1%) at tillering stage and S_5-No Spraying (Control). The results showed that the 100% recommended dose of nitrogen significantly improved wheat yield and related attributes*i.e.*,.~~The full (100%) recommended dose of nitrogen increased~~ grain yield (4309 kg/ha), straw yield (6307 kg/ha), biological yield (10616 kg/ha), harvest index (40.58 %), number of ear heads per square meter (324.39), ear head length (10.11 cm), number of grains per ear head (47.93), and 1000-grain weight (42.49 g) over the treatment of 75% and 50% RDN. Additionally, foliar nitrogen supplementation positively affected grain and straw yields. The ~~highest values for~~maximum ear head number (320.69), ear head length (9.89 cm), grains per ear head (47.44), 1000-grain weight (42.03 g), grain yield (4229 kg/ha), straw yield (6301 kg/ha), biological yield (10530 kg/ha), and harvest index (40.69 %) were achieved with two sprays of urea (5%) at tillering and jointing stages over one spray of nano urea ~~or~~ and one spray of NPK 19:19:19 at ~~the~~ tillering stage,however, the effect of two sprays of urea (5%) was statistically at par with two sprays of nano urea.

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Key words: Foliar Supplementation, Nano urea, Recommended Dose of Nutrient, Wheat, Yield

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Introduction

The state Bihar is one of the promising states in Wheat (*Triticum aestivum* L.) production during *rabi* season. Among different foliar supplementation of nitrogenous fertilizer, urea ~~solution~~ application at various concentrations, water soluble mixed fertilizer of NPK etc. Among them, nano-scale urea particles are gaining popularity now -a days. India has become the first country globally to start commercial production of Nano Urea and is the second largest consumer of Nano urea in the world, after. Nano Urea is the only nano fertilizer approved by the Government of India and included in the Fertilizer Control Order (FCO). Nano Urea contains 4% total nitrogen (w/v) evenly dispersed in water. In Nano Urea, nitrogen particle size varies from 20–50 nm. The particle size of Nano Urea is small, that is why plants absorb nitrogen easily and efficiently. Nano Urea, being an eco-friendly product, will protect the health of the soil. Apart from direct savings, the transportation cost of the Nano Urea is also very small and the storage is also quite easy for the farmers.In general, Nano Urea is sprayed on leaves and it easily enters into the plant through stomata and other openings and is assimilated by the plant cells. It is easily distributed through the phloem from the source to sink inside the plant as per its needs. Unutilized nitrogen is stored in the plant vacuole and is slowly released for proper growth and development of the plant. It effectively fulfills crop nitrogen requirements and increases leaf photosynthesis, root biomass, effective tillers and branches and ultimately the yield and nutrient-use efficiencyof the crop (Kiran andSamal, 2021; Kumar*etal.*,2021; Qureshi et al., 2018). In other hand, N:P:K 19:19:19 is a complete water-soluble, called as perfect fertilizer which provides all major macro-nutrients N-P-K in a balanced ratio to the plants through foliar spray at the time of maximum requirement with the lowest losses. N:P:K :: 19:19:19 can fulfill any deficiency of one or all three major plant nutrients and minimizes the cost of basal fertilizers. N:P:K :: 19:19:19 increases growth, lowers the cost of production per unit crop yield, minimizes the chemical load on the environment and enables the country to strengthen the fertilizer supplies in the event of their shortages or price escalation thereby ensuring a wiser and long-lasting use. FoliarapplicationofN:P:K :: 19:19:19significantly increased yield of the crop by

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providing ideal quantity of all three major nutrients N, P and K (Tarafdar *et al.*, 2012). Furthermore, urea 5 % as foliar spray is widely used in agricultural as well as in horticultural crops to provide additional nitrogen supply over recommended doses.Basically, foliar application delivers nitrogen directly to the plant, ensuring quick absorption of nutrients specially at critical growth stages of the plant, showing immediate impact on growth parameters like plant height, canopy spread, and canopy volume. Additional urea supplementation enhances yield components, such as grains per spike, productive tillers, and 1000-grain weight. Moreover, urea foliar spray can also improve quality attributes, such as nitrogen contents in grains of the plant(Ramadas*etal.*,2019). Hence, application effectiveness can bedecreased by runoff from leaf surfaces, rain and overhead irrigation,and rapid drying of spray solutions onleaves and enhance growth, number of productive tillers per unit area, biological yield, grain yield and harvest index (Ramadas*etal.*,2019).

Keeping this advantage of foliar supplementation in mind, the experiment was conducted to study the effect of different nitrogenous fertilizerssoil and foliar supplementation of nitrogenous fertilizer on yield attributes and yield of wheat.

Materials and Methods

The experiment was carried during two consecutive *rabi* seasons of 2022-23 and 2023-24, to investigate the effect of soil and foliar supplementation of nitrogenous fertilizer on yield attributes and yield ofwheat (DBW-187) at the Bihar Agricultural University, Sabour. The UniversityissituatedovertheMiddleGangeticplainsofAgro-climatic Zone III A of Bihar. It is located between 25°50' N latitude and 87°19' E longitude, at an elevation of 37.19 meters above mean sea level. The soil of the experimental site was sandy loam with low 0.43% oxidizableorganiccarbon (0.43%), lowavailableN (180.38kg/ha),both availableP(19.61kg/ha)andavailableK(181.11kg/ha) are in medium range.The climatic condition of this place is tropical to subtropical and somewhat semi-arid in nature and is characterized by very dry summer, moderate rainfall and very cold winter. The experimentlaid outby adopting a split plot design replicated thrice with three(03)main plots treatments *viz.*, M_1-100% recommended dose of nitrogen (RDN), M_2- 75% recommended dose of nitrogen (RDN), M_3- 50% recommended dose of nitrogen (RDN),and five (05) sub plots treatments *viz.*, S_1- One spray of nano urea at tillering stage, S_2- Two spray of nano urea at tillering and jointing stage, S_3-

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Two sprays of urea (5%) at tillering and jointing stage, S_4- One spray of NPK 19:19:19 (1%) at tillering and S_5-~~No Spraying stage~~Control (no application of N)~~(Control~~ with wheat (DBW187) crop. The recommended dose of fertilizer (RDF) was (150: 60: 40 N: P_2O_5: K_2O kg ha^{-1}), where 50% dose of N-fertilizer recommendation was applied as basal and rest 50% was applied in two (02) splits, one at CRI stage (21DAS)and second one atpanicle initiation (55 DAS) in case of M_1. Same trend was followed in M_2 and M_3 with the respective dose of 75% RDN and 50% RDN. Full dose of phosphorus and potassium were applied as basal irrespective of all treatments. The seed rate of 100 kg ha^{-1} was sown in line at 20cm spacing with 4-5 cm depth. Irrigation was given as per the schedule i.e at CRI stage (21DAS), Flowering stage (75 DAS) and Milking stage (95 DAS) of wheat.

Measurement of Yields and Yield attributes:

Yield attributing characters like effectivetillers/m^2,spikelength(cm),spikelets/spike,grains/spikeand1,000-grainweight(g) were calculated by random sampling at four (04) locations of five (05) tagged plants of experimental plots. The panicles/ ear heads at maturity from the 1.0 m^2 demarcated area of each plot was counted. Five (05)panicles/earheadfromeachtaggedplantwereselectedandthreshedseparately.The number of grains per panicle was counted and mean value was determined. The threshed grains of each plot were cleaned and thoroughly dried. From each plot a composite sample of grains was collected and 1000-grains were counted, weighed on the electronic balance and expressed in g.

Grain yield was determined from 4.0 m^2 selected area in each plot. The grains obtained from the harvested bundle of the selected area was weighed (kg m^{-2}) after threshing, winnowinganddrying(10% moistureforwheat)andthen expressedinterms of kg ha^{-1}.Afterseparatingthe grains from the harvested bundle the straw yield was recorded in kg $m^{-2}$for each plot and then expressed in terms of kg ha^{-1}

Harvest index was calculated by dividing economic (grain) yield by the total biological (grain + straw) yield and expressed as percentage:

$$H.I. = \frac{\text{Economic yield (grain yield) kg ha}^{-1}}{\text{Biological yield (grain + straw yield) kg ha}^{-1}} X\ 100$$

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Results and ~~Discussion~~ discussion

After two years of the field experimentation, it was observed that 100% ~~Recommended Dose of Nitrogen (~~RDN~~)~~ (M_1) had the highest number of effectivetillers/m^2 (324.39), the longest ear heads (10.11 cm), the highest number of grains per ear heads (47.93) and the highest 1000 grain weight (42.49 g). 100% RDN was significantly higher than the other ~~soil supplementations~~treatments i/e. 75% RDN (M_2) and 50% RDN (M_3) (Table 1). This may be due to the fact that, sufficient amount of nitrogen at the critical stages which would have maintained a continuous supply of nitrogen, leading to the meristematic activity and stimulation of cell elongation in plants which resulted in higher effectivetillers/m^2, grains per ear heads,spikelength(cm) and 1000 grain weight.These result findings were in close agreement with the findings of Jassim et al. (2019). Among the foliar ~~supplementation~~sprays, significantly higheryieldattributes,*viz.*,effectivetillers/m^2,spikelength(cm),spikelets/spike,grains/spikeand1,000-grainweight(g) was obtained undertwo sprays of urea (5%) at tillering and jointing stage (S_3) comprising the maximum value of effectivetillers/m^2 (320.69 cm), ear heads (9.89 cm), number of grains per ear heads (47.44 cm) and 1000 grain weight (42.03 g) as compare to the other nutrient spraying i.e. one time nano urea at tillering stage, NPK 19:19:19 (1%) at tillering stage ~~even though from no spraying (control)~~and control. However, the treatment of two sprays of urea (5%) wasstatistically at par withtwo ~~time sprayings~~sprays of nano urea at tillering and jointing stage of wheat. ~~The fact may~~This might due to the formation of more photosynthate assimilation and translocation of photosynthates from the source to the sink in addition to timely supply of nitrogen,stimulates theinitiation of grain formation which helps to increase the yield contributing characters like effectivetillers/m^2, grains per ear heads,spikelength(cm) and 1000 grain weight (AL-gym ~~AJK~~ and ~~AJK,~~ Al-Asady ~~MHS~~, 2020).

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Table 1:Effect of soil and foliar supplementation of nitrogenous fertilizer on yield attributes of wheat

Treatments (Main Plots)	Yield attributing characters			
	effectivetillers/m^2	number of grains per	spikelength(cm)	1000 grain

		ear heads		weight (g)
M1- 100% RDN	**324.39**	**47.93**	**10.11**	**42.49**
M2- 75% RDN	**303.62**	**44.34**	**9.55**	**41.71**
M3- 50% RDN	**292.49**	**40.60**	**8.98**	**40.80**
SEm±	**6.02**	**1.03**	**0.10**	**0.89**
CD (P =0.05)	**19.62**	**3.25**	**0.40**	**NS**
Treatments (Sub Plots)				
S1- One spray of nano urea at tillering stage	**309.11**	**43.11**	**9.49**	**40.28**
S2- Two sprays of nano urea at tillering and jointing	**317.83**	**46.56**	**9.67**	**41.55**
S3- Two sprays of urea (5%) at tillering and jointing	**320.69**	**47.44**	**9.89**	**42.03**
S4- One spray of NPK 19:19:19 (1%) at tillering	**310.58**	**43.89**	**9.50**	**41.19**
S5-No Spraying (Control)	**298.63**	**40.33**	**9.11**	**40.01**
SEm±	**3.16**	**0.87**	**0.13**	**0.69**
CD (P=0.05)	**9.22**	**2.53**	**0.37**	**NS**

Further, significantly highest grain yield (4309.23 kg/ha), straw yield (6307.7 kg/ha), biological yield (10616.93 kg/ha) and harvest index (40.58) was recorded under application of 100% RDN, which was statistically superior over the value obtained under 75 % RDN and 50% RDN. Basically, theyieldsofcrop~~is~~weredeterminedbytheprevailingagronomic management techniques besides its genotypicalpotential and environmental condition in which it ~~is~~ wasexposed during its life cycle (Kumar *etal*., 2020; Khalil et al., 2019). ~~100% recommended dose of fertilizer providesthe nutrients as per the region specific recommendation of the crop leads to optimum yield level.~~

Among the foliar nitrogenous fertilizer application, the maximum grain yield (4229.6 kg/ha) , straw yield (6301.8 kg/ha), biological yield (10530.6 kg/ha) and harvest index (40.69) was recorded in two sprays of urea (5%) at tillering and jointing stage and it

was statistically superior over the value obtained under one spray of nano urea at tillering stage, one spray of NPK 19:19:19 (1%) at tillering stage and over ~~No Spraying (~~Control~~)~~, hence, the results was statistically at par with two spray of nano urea at tillering and jointing stage (Table 2). The reason behind the fact that nitrogenous fertilizer conjugation with traditional nitrogen fertilizers improve nutrient absorption efficiency, enhance photosynthesis, increase nutrient translocation, and ultimately increased the yield level.These ~~results~~ findingsare close with results of Kumar *etal*., 2020; Khalil *et al*., 2019; Ma *et al*., 2010 and Liu and Liao, 2008.

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Table 2: Effect of soil and foliar supplementation of nitrogenous fertilizeronyield performance of wheat

Treatments (Main Plots)	Yield			
	Grain yield (kg ha-1)	Straw yield (kg ha-1)	Biological yield (kg ha-1)	Harvest Index (%)
M1- 100% RDN	4309.23	6307.7	10616.93	40.58
M2- 75% RDN	4071.65	5967.2	10038.85	40.45
M3- 50% RDN	3765.29	5617.3	9382.59	40.03
SEm±	55.10	82.02	136.99	0.23
CD (p=0.05)	192.33	287.98	537.80	NS
Treatments (Sub Plots)				
S1- One spray of nano urea at tillering stage	4075.7	6075.2	10150.9	40.15
S2- Two spray of nano urea at tillering and jointing	4197.8	6157.8	10355.6	40.54
S3- Two spray of urea (5%) at tillering and jointing	4229.6	6301.8	10530.6	40.69
S4- One spray of NPK 19:19:19 (1%) at tillering	4104.6	6113.4	10218	40.35

S5-No Spraying (Control)	**3843.9**	**5751.6**	**9595.5**	**40.06**
SEm±	**35.51**	**51.61**	**87.10**	**0.29**
CD (p=0.05)	**103.65**	**150.66**	**254.24**	**NS**

Conclusions:

Location specific fertilizer recommendation provides right amount of fertilizer at the right time can help to achieve optimal yields. ~~Thesignificantlyh~~Higher yield attributes and yield were~~as~~ obtained ~~with~~ under100% recommended dose of fertilizer (150: 60: 40 N: P_2O_5: K_2O kg ha^{-1}) significantly over the other treatments. ~~Location specific fertilizer recommendation provides right amount of fertilizer at the right time can help to achieve optimal yields.~~ Foliar fertilization can be an efficient way to supplement nutrients during the middle and late stages of wheat growth. Additional supplementation through foliar spraying of nitrogenous fertilization offers added advantage to boost the physiological processes of the plants at critical stages of their development. While, two sprays of urea (5%) at tillering (45DAS) and jointing (65 DAS) stage of wheat, increased the yield as compared to other foliar sprays.~~Foliar fertilization can be an efficient way to supplement nutrients during the middle and late stages of wheat growth. Additional supplementation through foliar spraying of nitrogenous fertilization offers added advantage to boost the physiological processes of the plants at critical stages of their development.~~ Further, the study revealed that nano urea did not outperform over other foliar sprays, but no yield reduction due to spaying of nano urea was found.

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