Effect of nitrogen scheduling on growth and yield of wheat (*Triticum aestivum* L.)

Abstract

A field experiment was conducted at experimental farm, Department of Agronomy, Faculty of Agriculture and Veterinary Sciences, Mewar University Gangrar, Chittorgarh (Rajasthan) during Rabi season of 2023-24 to effect of nitrogen scheduling on growth and yield of wheat, variety "3077‟ was used in this study. The required quantities of fertilizers as per treatments were applied. The experiment was laid out in randomized block design with three replications consisting of twelve treatments. The data recorded maximum growth attributes like, plant height (94.45 cm), dry matter accum8lation per m row length (248.78 g) and yield attributes such as number of effective tillers per m row length (65.40), number of grains per spike (82.24), grain yield (5230 kg/ha), stover yield (6634 kg/ha), biological yield (11864 kg/ha) and maximum net return (156075 Rs/ha) was recorded with T_{12} : 1/3 at basal +1/3 at CRI (21-25 DAS) + 1/3 at Jointing stage (65-70 DAS) + 2.0% urea + 0.5% $ZnSO_4$ spray at flag leaf stage (80-90 DAS). Therefore, it may be concluded that application of T_{12}: 1/3 at basal +1/3 at CRI (21-25 DAS) + 1/3 at Jointing stage (65-70 DAS) + 2.0 % urea +0.5 % $ZnSO_4$ spray at flag leaf stage (80-90 DAS) was the most suitable treatment for obtaining higher seed yield (5230 kg/ha), gross and net returns (Rs 156075.00/ha and 113116.00/ha) and B: C ratio (2.63) in wheat. However, these results are only indicative and require further experimentation to arrive at more consistent and final conclusion.

Key words: Nitrogen; Scheduling; *Triticum aestivum*; organic manuring, biofertilizers

1. Introduction

Wheat (*Triticum aestivum* L.) is an important cereal crop belongs to family "Poaceae" and genus "Triticum". Wheat [*Triticum aestivum* (L.)] is the most important widely cultivated staple food crop of world due to its adaptability under diversified climatic conditions. Wheat play a major role towards meeting 40 % of world global food demand of world population and act as a boon for mankind to provide half of the dietary protein as well as more than half of the calories. In terms of area, India contributes highest wheat cultivated area (31.61 million hectares) in the world while acquired second position with respect to production (109.52 million tonnes) after china with the average productivity of 3.46 tonnes ha^{-1} (Anonymous, 2022-23).

"Nitrogen is essential nutrient for plant growth and involved in important synthesis and formation of many important substances and compounds in plant such as amino acids, enzymes, DNA, RNA and chlorophyll" (Ram *et al.* 2012). It is responsible for greenness, vigorous growth and overall crop development; therefore, it must be available for plants in adequate amounts. Availability of high yielding and fertilizer responsive crop varieties/ hybrids have created the tendency among the farmers to harvest immediate gains in terms of maximum production per unit area by indiscriminate use of high grade straight chemical fertilizers which are nutritionally incomplete and environmentally hazardous. The yield response to applied chemical fertilizers started to decline after some time when the use of organic manuring was ignored. This indiscriminate use of chemical fertilizers created multi nutrients deficiencies (Hills and Paynter 2009).

The cost of nitrogen fertilizers is increasing continuously and hence there is scope to substitute part of nitrogen requirement of crops through biofertilizers. "The productivity of crop is controlled by many factors of which the mineral nutrition specifically of nitrogen is most important" (Safina (2010). "The most important factor is that the heavy and imbalanced use of chemical fertilizer has led to think about the use of organic manures in intensively growing areas for sustainable production system. Therefore, to sustain the land and to achieve production potential of crops, the experimental finding in India have clearly indicated that there is a need to integrate both the organic and inorganic substances for sustainable crop production; maintenance of soil fertility and conservation of natural resources" (Adela and Paul 2010).

2. Materials and Methods

A field experiment was conducted during Rabi season of 2023-24 at experimental farm, Department of Agronomy, Faculty of Agriculture and Veterinary Sciences, Mewar University Gangrar, Chittorgarh (Rajasthan). Soil of the experimental field was sandy loam intexture, saline in reaction with a pH value of 7.6, poor in organic carbon (0.16%), deficient inavailable zinc (0.48 ppm) and iron (1.2 ppm) low in available nitrogen (176 kg/ha) and phosphorus (20.2 kg/ha) but medium in available potassium (320 kg/ha). The experiment was laid out in randomized block design with three replications which treatment twelve treatments *viz.*, T_1:1/2 at basal + ½ at CRI (21-25 DAS), T_2: 1/2 at basal +1/4 at CRI (21-25DAS) + 1/4 at Jointing stage (65-70 DAS), T_3: 1/3 at basal +1/3 at CRI (21-25 DAS) + 1/3 at Jointing stage (65-70 DAS), T_4: ½ at basal+1/2 at CRI (21-25 DAS) + 2.0% urea spray at flag leaf stage (80-90 DAS), T_5: 1/2 at basal +1/2 at CRI (21-25DAS) + 0.5% $ZnSO_4$ spray at flag leaf stage (80-90 DAS), T_6:1/2 at basal + ½ at CRI (21-25 DAS) + 2.0 % urea + 0.5% $ZnSO_4$ spray at flag leaf stage (80-90 DAS), T_7: 1/2 at basal + 1/4 at CRI (21-25DAS) + ¼ at Jointing stage (65-70DAS)

+2.0 % urea spray at flag leaf Stage (65-70 DAS), T_8:1/2 at basal +1/4at CRI (21-25DAS) + ¼ at Jointing stage (65-70DAS) + 0.5% $ZnSO_4$ spray at flag leaf stage (80- 90 DAS), T_9: ½ at basal +1/4at CRI (21-25DAS)+ ¼ at Jointing stage (65-70DAS) + 2.0% urea + 0.5% $ZnSO_4$ spray at flag leaf stage (80-90 DAS), T_{10} : 1/3 at basal +1/3 at CRI (21-25 DAS) + 1/3 at Jointing stage (65-70 DAS) +2.0%urea spray at flag leaf stage (80-90 DAS) 2.0%urea spray at flag leaf stage (80-90 DAS), T_{11} : 1/3 at basal +1/3 at CRI (21-25 DAS) + 1/3 at Jointing stage (65-70 DAS) + 0.5% $ZnSO_4$ spray at flag leaf stage (80-90 DAS) and T_{12} : 1/3 at basal +1/3 at CRI (21-25 DAS) + 1/3 at Jointing stage (65-70 DAS) + 2.0% urea + 0.5% $ZnSO_4$ spray at flag leaf stage (80-90 DAS).The required quantities of fertilizers as per treatments were applied. The doses of NPK were applied in the form of urea, diammonium phosphate, murate of potash respectively. The half dose of nitrogen gives basal dose and remain two split doses after irrigation and full dose of phosphorus and potassium at basal dose. The yield parameters were calculated from output from the field. The profitability and productivity of mung bean was calculated from cost of field preparation to harvesting and threshing cost and out pot from straw yield and grain yield as per market rate.

3. Results and Discussion

3.1 Growth attributes

The application of different treatments of N scheduling affected the plant height conspicuously. In the treatment where T_{12}- 1/3 at basal + 1/3 at CRI (21- 25 DAS) + 1/3 at Jointing stage (65-70DAS) + 2.0% urea + 0.5 % $ZnSO_4$ spray at flag leaf stage (80-90 DAS) , the plant height was recorded highest at all the growth stages of plant except at 30 DAS followed by treatment T_{11}-1/3at basal+1/3 at CRI (21-25 DAS) + 1/3 at Jointing stage (65-70 DAS) + 0.5% $ZnSO_4$ spray at flag leaf stage (80-90 DAS). The significantly lower plant height was recorded with T_1 i.e., 1/2 at basal + 1/2 at CRI (21-25 DAS). The dry matter accumulation was found highest in the treatment where T_{12}: 1/3 at basal +1/3 at CRI (21-25 DAS) + 1/3 at Jointing stage (65-70 DAS) + 2.0% urea + 0.5% $ZnSO_4$ spray at flag leaf stage (80-90 DAS) was applied. The control recorded significantly lower dry matter accumulation at all the growth stages. The observed improvement in growth attributes under the influence of various liquid formulations might be due to the role played by these manures in providing nutrients to the crops reported earlier by Singh *et al*. (2016) on wheat and Blumenthal *et al* (2008), Lafond *et al* (2009), Adela and Paul (2010), Dubey *et al* (2018a).

3.2 Yield attributes and yield

The data in Table 2.0 revealed that the significant increase in total number of effective tillers/m row length was noticed with every increase in nitrogen through liquid fertilizer. The minimum number of effective tillers/metre row length 66.12 was recorded under the control treatment, i.e., no application of nutrient fertilizer and was highest (82.24) in the treatment where 1/3 at basal +1/3 at CRI (21-25 DAS) + 1/3 at Jointing stage (65-70 DAS) + 2.0 % urea + 0.5% $ZnSO_4$ spray at flag leaf stage (80-90 DAS) was applied. These two treatments found significantly superior over rest of the treatments. The maximum spike length (11.20 cm) was recorded with the application of T_{12}: 1/3 at basal +1/3 at CRI (21-25 DAS) + 1/3 at Jointing stage (65-70 DAS) + 2.0 % urea + 0.5% $ZnSO_4$ spray at flag leaf stage (80-90 DAS) . The study further revealed that application of liquid fertilizers too significantly increased grains per spike of wheat. Application of T_{12} :1/3 at basal +1/3 at CRI (21-25 DAS) + 1/3 at Jointing stage (65-70 DAS) + 2.0% urea + 0.5% $ZnSO_4$ spray at flag leaf stage (80-90 DAS) recorded maximum grains per spike on par with rest of the treatments. The grain yield wherein T12: 1/3 at basal+1/3at CRI (21-25 DAS) + 1/3 at Jointing stage (65-70 DAS) + 2.0% urea +0.5 % $ZnSO_4$ spray at flag leaf stage (80-90 DAS) recorded the maximum grain yield of wheat (5230 kg/ha). This treatment was at par with T11-1/3at basal +1/3 at CRI (21-25 DAS) + 1/3 at Jointing stage (65-70 DAS) + 0.5% $ZnSO_4$ spray at flag leaf stage (80-90 DAS) and T10- 1/3 at basal +1/3 at CRI (21-25 DAS) + 1/3 at Jointing stage (65-70 DAS) + 2.0 % urea spray at flag leaf stage (80-90 DAS), T9: 1/2 at basal +1/4 at CRI (21-25 DAS) + ¼ at Jointing stage (65-70 DAS) + 2.0% urea + 0.5% $ZnSO_4$ spray at flag leaf stage (80-90 DAS), This treatment was significantly superior to rest of the treatments except T1-1/2 at basal + 1/2 at CRI(21-25 DAS) , respectively. The straw yield wherein T_{12}: 1/3 at basal +1/3 at CRI (21-25 DAS) + 1/3 at Jointing stage (65-70 DAS) + 2.0 % urea +0.5 % $ZnSO_4$ spray at flag leaf stage (80-90 DAS), recorded the maximum straw yield of wheat (6634 kg/ha) which was at par with rest of the treatment. This treatment was significantly superior to rest of the treatments except T_1: 11/2 at basal + 1/2 at CRI (21-25 DAS). The straw yield wherein T_{12}: 1/3 atbasal+1/3 at CRI (21-25DAS)+1/3 at Jointing stage (65-70 DAS) + 2.0% urea +0.5 % $ZnSO_4$ spray at flag leaf stage (80-90 DAS), recorded the maximum straw yield of wheat (11864 kg/ha) which was at par with rest of the treatment This treatment was at par with T_{11}-1/3 at basal +1/3 at CRI (21-25 DAS) + 1/3 at Jointing stage (65-70 DAS) + 0.5 % $ZnSO_4$ spray at flag leaf stage (80-90 DAS) and T_{10}-1/3 at basal +1/3 at CRI(21-25 DAS)+1/3 at Jointing stage (65-70 DAS) + 0.5 % $ZnSO_4$ spray at flag leaf stage (80-90 DAS). These results authenticate the findings of Kaur *et al* (2010), Meena and Mann (2010), Abedi *et al* (2011), Narolia and Yadav (2013), Singh *et al* (2016), Istipliler *et al* (2017) and Dubey *et al* (2018a).

3.3 Economics

It is clear from the data (Table 3.0) that foliar application of different liquid formulations significantly increased the net returns and B:C ratio in wheat as compared to control. The treatment T_{12}: 1/3 at basal +1/3 at CRI (21-25 DAS) + 1/3 at Jointing stage (65-70 DAS) + 2.0 % urea +0.5 % $ZnSO_4$ spray at flag leaf stage (80-90 DAS) recorded the highest gross returns of Rs 156075.00/ha and net returns of Rs 113116.00/ha thereby registering a significant increase of 94.38 and 92.21 per cent over control and water spray, respectively. It also recorded the highest B: C ratio (2.63) among all the treatments. The low investment under this treatment coupled with good economic yield might be the only reason for higher net monetary return and benefit cost ratio. Similar findings were also reported by Ali (2011), Narolia and Yadav (2013), Hundal *et al* (2014), Singh *et al* (2016), Dubey *et al* (2018a).

Conclusion

Based on the results of one-year experimentation, it may be concluded that application of T12: 1/3 at basal +1/3 at CRI (21-25 DAS) + 1/3 at Jointing stage (65-70 DAS) + 2.0 % urea +0.5 % $ZnSO_4$ spray at flag leaf stage (80-90 DAS) was the most suitable treatment for obtaining higher seed yield (5230 kg/ha), gross and net returns (Rs 156075.00/ha and 113116.00/ha) and B: C ratio (2.63) in wheat. However, these results are only indicative and require further experimentation to arrive at more consistent and final conclusion.

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Details of the AI usage are given below:

1.
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3.

Table 1.0 Effect of nitrogen scheduling on plant height and dry matter accumulation at different stages of wheat

Treatments	Plant height (cm)				Dry matter accumulation (g per m row length)			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
T_1	17.10	32.15	59.24	71.36	12.62	45.28	132.62	158.25
T_2	17.15	38.5	38.5	71.96	12.77	46.10	133.98	161.22
T_3	18.01	41.2	41.2	83.42	13.12	52.14	173.62	192.62
T_4	18.12	37.29	68.14	84.11	13.19	52.92	177.62	199.45
T_5	18.35	37.33	68.95	84.65	13.35	53.64	179.63	206.63
T_6	18.69	40.12	71	85.00	13.49	54.00	180.14	208.58
T_7	18.75	40.69	71.62	85.25	13.55	54.92	188.63	217.63
T_8	18.88	40.89	72.19	85.39	13.82	57.24	194.24	229.47
T_9	19.05	41.45	74.14	89.97	14.10	59.99	207.44	242.87
T_{10}	20.21	42.3	75.3	92.20	15.20	60.30	210.35	245.60
T_{11}	21.23	43.2	76.23	93.34	16.20	61.40	212.30	247.50
T_{12}	22.30	115.6	175.2	94.45	16.60	62.30	215.30	248.78
S. Em. +	0.95	1.40	2.17	2.63	0.79	1.30	4.40	5.16
CD(P=0.05)	2.74	4.07	6.29	7.63	2.29	3.78	12.78	14.97
CV (%)	9.56	6.87	5.89	5.90	7.84	7.53	7.60	7.64

Table 2.0 Effect of nitrogen scheduling on yield attributes and yield of wheat

Treatments	**Number of effective tillers per meter row length**	**Number of grains per spike**	**Grain yield (kg ha^{-1})**	**Straw Yield (kg ha^{-1})**	**Biological yield (kg ha^{-1})**
T_1	38.36	6.65	2526	3995	6521
T_2	43.44	6.69	2594	4098	6692
T_3	45.50	7.65	3425	5112	8537
T_4	46.84	7.69	3472	5194	8666
T_5	48.20	7.92	3645	5464	9109
T_6	55.60	8.12	3665	5554	9219
T_7	58.22	8.45	3895	5894	9789
T_8	59.65	8.69	4062	6021	10083
T_9	61.20	8.77	4965	6221	11186
T_{10}	2.50	9.32	5061	6340	11401
T_{11}	64.30	9.89	5120	6524	11644
T_{12}	65.40	11.20	5230	6634	11864
S. Em. +	1.09	0.20	161	329	171
CD(P=0.05)	3.16	0.58	467	955	497
CV (%)	7.87	7.59	8.00	8.03	8.12

Table 3.0 Effect of nitrogen scheduling on economics

Treatments	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio
T_1	79336.00	40182.00	1.03
T_2	81449.00	41095.00	1.02
T_3	106047.50	64875.50	1.58
T_4	107562.00	67208.00	1.67
T_5	112977.50	71424.50	1.72
T_6	113897.50	72855.50	1.78
T_7	121002.50	78761.50	1.86
T_8	125562.00	84520.00	2.06
T_9	147782.50	105661.50	2.51
T_{10}	150633.50	108233.50	2.55
T_{11}	152940.00	110261.00	2.58
T_{12}	156075.00	113116.00	2.63

References

1. Adela, J. and Paul, P. (2010). The influence of total doses, time and spliting of nitrogen on the grain protein content of two row spring wheat (*Hordeumvulgare* L., conv. Distichum Alef.). *Research Journal of Agricultural Science,* **42**: 76-81.
2. Ali, E. A. (2011) Impact of nitrogen application time on grain and protein yields as well as nitrogen use efficiency of some two-row wheat cultivars in sandysoil. *Am Eurasian Journal of Agriculture and Environ Sci* **10**: 425-33.
3. Anonymous 2022-23. Government of India, Ministry of Agriculture & Farmers Welfare Department of Agriculture, Cooperative & Farmers Welfare Directorate of Economics and Statistics. *Agricultural Statistics at a Glance* 56-57.
4. Bluementhal, J. M., Baltensperger, D. D., Cassman, K. G., Mason, S. C. and Pavlista, A. D. (2008). Importance and effect of nitrogen on crop quality and health. *Nitrogen in the Environment : Sources, Problems, and Management*, Second edition, edited by J.L. Hatfield and R.F. Follett (Amsterdam: Elsevier, 2008). pp. 51-70.
5. Dubey, S, Tiwari, A., Pandey, V.K., Singh, V., and Singh, G. (2018a). Effect of nitrogen levels and its time of application on growth parameters of wheat (*Hordeum vulgare* L.). *J Pharmacogn Phytochem* **7**: 333-38.
6. Hills A L and Paynter B H (2009) Time of nitrogen application effects on grain yield and quality of malting wheat. *14th Australian Wheat Technical Symposium,* 13-16 September.
7. Hundal, J.S., Kumar, B., Wadhwa, M., Bakshi, M. and Ram, H. (2014) Nutritional evaluation of dual purpose wheat as fodder. *Indian J Anim Sci* **84:**298-301.
8. İştipliler D, Çakaloğullari U and Tatar O (2017) Mitigate grain yield losses of wheat under terminal drought stress by different nitrogen applications. *Sci Pap Ser A Agron LX:* 275-80.
9. Kaur A, Pannu R K and Buttar G S (2010) Impact of nitrogen application on the performance of wheat (*Triticumaestivum*) and nitrogen use efficiency under different dates of sowing. *Indian Journal of Agronomy,* **55**: 40-45.
10. Lafond G P, Holzapfl C B and May W E (2009) Validating post-emergent N application algorithms for the Green Seeker TM optical sensor incerealsand canola using small plot studies and UAN solution. *www.fluidfertilizer.com*.
11. Meena, L.R. and Mann, J.S. (2010). Response of wheat to nitrogen management

at varying growth stages under semi-arid conditions of Rajasthan. *Range Manag Agro for* **31**: 20-23.

12. Narolia, G. Pand, Yadav R.S. (2013). Effect of Nitrogen Levels and its Scheduling on Growth, Yield and Grain Quality of Malt Wheat (*Hordeum vulgare* L.) under Normal and Late Sown Conditions in North-West Rajasthan. *Ann Arid Zone* **52**: 95-9.
13. Ram, H., Kumar, B., Chaudhary, D.P. and Bakshi, M. (2012). Productivity, quality and economics of dual purpose wheat (*Hordeum vulgare* L.) varieties under different nitrogen scheduling. *Soc Plant Res* **25:** 68-70.
14. Safina, S. A. (2010) Effect of nitrogen levels on grain yield and quality of some wheat genotypes grown on sandy soil and salinity irrigation. *Egypt Journal of Agronomy*, **32**: 207-22.
15. Singh R K, Kumar P, Prasadi B, Das A K and Singh S B (2016) Effect of split application of nitrogen on performance of wheat (*Triticum aestivum* L.). *International Journal of Agricultural Science.* **12**: 32-37.