***Original Research Article***

**Effect of soil test response basis nitrogen levels and its time of application on growth, yield and economics of wheat (*Triticum aestivum* L.)**

**Abstract**

A field experiment was conducted during the *Rabi* season of 2023-24 at the Research Farm, Faculty of Agriculture, Tantia University, Sri Ganganagar. The study was conducted in Factorial Randomized Block Design (FRBD) with four levels of nitrogen *viz*.,40, 80, 120, and 160 kg/ha, and four time of application (100% at the time of sowing (basal),½ basal + ½ after first irrigation, ½ basal +1/4 after first irrigation +1/4 after second irrigation, 1/3 basal + 1/3 after first irrigation + 1/3 after second irrigation.). The soil of experimental soil (0-15 cm) was sandy loam in texture, low in organic carbon (0.46%) and available nitrogen (194 kg ha-1), medium in available phosphorus (18.02 kg ha-1) and available potassium (248 kg ha-1). The experimental results revealed that nitrogen application significantly influence plant growth, yield attributes, and yield as well as economic of wheat cultivation. The significantly higher plant height, No. of leaves plant-1 at 90 DAS and maximum No. of tillers per running meter and plant dry weight at 90 DAS as well as maximum Leaf Area Index at 90 DAS of wheat were recorded with treatment combination of N4T3 (160 kg Nitrogen ha-1 ½ basal +1/4 after first irrigation +1/4 after second irrigation). The significantly higher effective tillers, grains spike-1 and test weight (g) were recorded with treatment combination of N4T3 (160 kg Nitrogen ha-1 ½ basal +1/4 after first irrigation +1/4 after second irrigation). Similarly, the significantly higher number of effective tillers per m2, grain, straw and biological yield were recorded with treatment combination of N4T3 (160 kg Nitrogen ha-1 ½ basal +1/4 after first irrigation +1/4 after second irrigation). Economic analysis showed that the treatment with 160 kg Nitrogen ha-1 ½ basal +1/4 after first irrigation +1/4 after second irrigation, provided the highest net returns and benefit-cost (B:C) ratio, making it the most profitable treatment. In conclusion, the combined application of N4T3 (160 kg Nitrogen ha-1 ½ basal +1/4 after first irrigation +1/4 after second irrigation) provide to be the most effective in enhancing growth, yield, and profitability in wheat cultivation.

**Keywords:** DBW-303, Nitrogen, Growth, Yield, Economics

**INTRODUCTION**

“Wheat (*Triticum aestivum* L.) is a staple food of the world and it belongs to family poaceae. India is one of the main wheat producing and consuming countries in the world. It is the most important food grain crop of the world which ranks next to rice consumed by nearly 35% of the world population. Its acreage of 223.00 million hectare with the production of 687 million tones. In India total cultivated area under wheat is 34.10 million hawith the production of 112.19 million tonnes and productivity of 3678 Kg ha-1. It contributes about 34% of the total food grain production of the country” (Anonymous, 2023-24).

“In Rajasthan it ranks second after pearl millet in respect of crop coverage area of 3.25 million ha and production of 11.32 million tonnes but the average productivity is much lower (37.60 q ha-1) than Punjab. Wheat crop in our country is grown during the winter season (*Rabi*) when rains are very less and crop is mainly depended on the irrigation for its water requirement. Therefore, to maintain the optimum soil moisture in the root zone of the wheat is necessary. Nitrogen is one of the most essential plant nutrients which is a constituent of protoplasm, protein, chlorophyll, alkaloids, harmon and vitamins hence increase the growth and development of all living tissues. Besides, it also imparts the dark green colour to the leaves and stem. It increases plumpness and protein percentage in the grain. It plays important role in crop production. Nitrogen utilization efficiency of soil applied nitrogenous fertilizers is very low. The leaching losses and denitrification losses of nitrogen depend upon the type of crop, cultivation practices, soil type, kind of fertilizer, application rate and time of application of fertilizer” (Ramus, 1996). “The response of nitrogen is not only depending upon its optimum dose but it depends upon the proper method of application of nitrogenous fertilizers. Among the major element nitrogen is most important particularly in our country because most of the Indian soils are deficient in the nitrogen. Nitrogen plays a vital role in all living tissue of the plant. No other element has such an effect on promoting vigorous plant growth. Abundant protein tends to increase the size of the leaves, and accordingly, to bring about an increase in carbohydrates synthesis. Nitrogen plays a vital role in increasing the yield of the crop. Application of proper amount of nitrogen is considered as key to obtain bumper crop of wheat. High nitrogen supply favors the conversion of carbohydrates into proteins, which is turn, promotes the formation of protoplasm”.(Yashwant et al.2017)

“To get maximum benefit from the fertilizer it should not only be applied in optimum quantity but it should also be applied at right time. The timely application of nitrogenous fertilizers is considerably increased the NUE. It is now very well established that in most of the crops, the nitrogen should be applied in two or three splits dose at different growth stage of the crop. It is the time to assess the effect of optimum dose of nitrogen and at optimum time of application and to work out the fertilizer use efficiency in wheat crop. Proper nitrogen application, timing and rate are critical for meeting crop needs, and indicate considerable opportunities for improving nitrogen use efficiency (NUE). Growth stage of plants at the time of application determines NUE, reports have shown that split nitrogen application in the later stages was effective in attaining higher nitrogen uptake efficiency (NUE). NUPE reflect the ability of the plants in obtaining in nitrogen; while in NUTE reflect the efficiency with which the crop utilizes nitrogen in the plant for the synthesis of grain yield” (Srimannarayan et al. 2018). Tran and Tremblay (2000) reported that “in wheat NUPE was lower in the early applications at planting and tillering than application in the later crop growth stage. The amount of economic yield, therefore, increased by increasing NUPE and NUTE throw efficient nitrogen application that decrease nitrogen losses from the soil-plant system”.

**2 MATERIALS AND METHODS**

**2.1 Experimental Site**

 The experiment was conducted in *Rabi* Season of 2023-24 at Crop Research Farm, Department of Agronomy, Tantia University, Sri Ganganagar, Rajasthan, India. This located at 28.4° N latitude, 72.2° E longitude and 178 m above mean sea level.

**2.2 Climate**

The experimental site comes under North Western Plain Zone (I b) of agroclimatic zones in Rajasthan. The Sri Ganganagar is located between Latitude of 28.40˚ to 30.60˚ and Longitude of 72.30˚ to 75.30˚. The total area of Sri Ganganagar is 11,154.66 km2 or 1,115,466 hectares. It is surrounded on the east by [Hanumangarh district](https://en.wikipedia.org/wiki/Hanumangarh_district), on the south by [Bikaner district](https://en.wikipedia.org/wiki/Bikaner_district), and on the west by [Bahawalnagar district](https://en.wikipedia.org/wiki/Bahawalnagar_District) of [Pakistani Punjab](https://en.wikipedia.org/wiki/Punjab%2C_Pakistan) and on the north by [Fazilika district](https://en.wikipedia.org/wiki/Fazilka_district) of [Indian Punjab](https://en.wikipedia.org/wiki/Punjab%2C_India). This zone receives on an average rainfall of 322 mm out of which about 75% received from July to end of September month. The winter months are very cold whereas, summer months are hot and dry. Westerly hot winds are started from the March and remain continues till onset of monsoon.

**2.3 Experimental Design**

The experiment was conducted in Factorial Randomized Block Design (FRBD) using two factors and each factor having three levels and replicated thrice.

**2.4 Treatment details**

The treatment details are given in Table 1.

**Table 1. Treatment details**

|  |  |
| --- | --- |
| **Treatments** | **Symbols** |
| **(A) Nitrogen levels (kg/ha)** |
| i. 40 | N1 |
| ii. 80 | N2 |
| iii. 120 | N3 |
| iv. 160 | N4 |
| **(B) Time of application** |
| i. (100% at the time of sowing (basal) | T1 |
| ii. ½ basal + ½ after first irrigation | T2 |
| iii. ½ basal +1/4 after first irrigation +1/4 after second irrigation | T3 |
| iv. 1/3 basal + 1/3 after first irrigation + 1/3 after second irrigation | T4 |

Data recorded on different aspects of crop, *viz.,* growth, yield attributes were subjected to statistically analysis by analysis of variance method. (**Gomez and Gomez, 1976)** and economic data analysis mathematical method.

**3 RESULT AND DISCUSSION:**

**3.1 Growth parameters**

The data regarding the growth have been presented in Table 2.

**3.1.1 Plant height**

“Plant height increased successively till the harvest stage but the increase was nominal after 90 DAS. It is quite evident from the data given in Table 2 that different level of nitrogen had significant effect on plant height at all the growth stages over control. Increasing nitrogen level increased plant height. The maximum plant height was recorded significantly with 160 kg N ha-1 which was at per with 120 kg N ha-1 and significantly superior over rest of the treatments”. (Yashwant et al.2017)

There was rapid increased in height of plant from 30 to 90 days after sowing thereafter, increased in height was rather slow. Maximum plant height was recorded under 160 Kg N ha-1 at all the crop growth stage, which was mainly due to more availability of nitrogen. Higher nitrogen levels result in higher nitrogen uptake, which could ultimately result into increased protein synthesis, cell division and cell elongation and finally expressed morphologically on increased in height of the plant. Similar findings were reported by Khan *et al*. (1990) and Kumpawat and Rathore (2003).

**3.1.2 Number of tillers per running meter-1**

The number of tillers was influenced significantly by the rate of nitrogen at all the growth stage. The maximum number of tillers running meter-**1** recorded under 160 Kg N ha-1 which was at per with 120 Kg N ha-1 and significantly superior over the rest of the treatment.

**3.1.3 Dry matter accumulation running meter-1**

The maximum dry matter accumulation was recorded under 160 Kg N ha-1 which was as per with 120 kg N ha-1 and significantly superior over rest of the treatments.

Initially the rate of dry matter production in all the treatment was slow but it increased steadily till harvest. Different nitrogen levels had significant effect on dry matter accumulation at all the successive stages of plant growth except 30 DAS. Maximum dry matter accumulation was recorded under 160 Kg N ha-1 at all stages. This might be due to higher collective contribution of various growth characters like plant height, number of shoots, leaf area index and leaf of vegetative part. Similar finding was reported by May *et al*., (2020), Singh (1990), Zhu *et al*., (2011).

**3.2 Yield attributes**

The data regarding the yield attributes have been presented in Table 3.

**3.2.1** **Number of spikes per running meter**

The maximum number of tillers was recorded under 160 kg N ha-1 which was as per with 120 kg N ha-1 and significantly superior over rest of the treatments (T1 and T2).

Wheat proved detrimental to number of ear bearing shoot. The number of ear bearing shoot was lesser than the number of shoots noted at harvest. According to Darwin’s law of survival of the fittest (1956), There is competition among the shoots due to which the under developed shoot dies off and were not able to bear the spike. Similar finding was reported by Dogan *et al* (2008), Bahrani and Sarvestani (2005), Ananda and Patil (2007).

**3.2.2 Spike length**

“The maximum length of spike recorded with 160 kg N ha-1 significantly superior over rest of the treatments. The time of nitrogen application had significant effect on the length of spike. It was recorded significantly higher under T3 Treatment as compared to rest of the treatments. However, shortest length of spike was observed in T1 treatment where full dose of nitrogen was applied as basal”. (Srimannarayan et al. 2018)

**3.2.3 Number of grains spike-1**

“The maximum number of grains spike-1was found with 160 kg N ha-1 significantly superior over rest of the treatments. The time of nitrogen application had significant effect on the grain of spike. It was recorded maximum under T3 Treatment (½ basal +1/4 after first irrigation +1/4 after second irrigation) as compared to rest of the treatments”. (Yashwant et al.2017)

**3.2.4 1000-grain weight**

The data revealed that the 1000-grain weight (g)was notinfluenced significantly by nitrogen levels and time of application.

The number of ear bearing shootsrunning meter-1 was affected by various nitrogen levels and its time of application. The maximum ear bearing shoots were recorded under 160 Kg N ha-1 in comparison to lower nitrogen levels. This might be due to enhanced tillering, enhanced photosynthetic area, proper nourishment, more dry matter partitioning to sink and increased sink size at 160 Kg N ha-1. Maximum length of spike, no of spikelets spike-1, and test weight were recorded under 160 Kg N ha-1 as compared to other treatments. The lowest value of yield attributing characters was obtained under lowest nitrogen levels 40 Kg N ha-1 because plant were subjected to utilize the least amount of available nitrogen which resulted into reduced translocation of photosynthates from source of sink and thus led to poor growth and various yield attributes. Similar findings were reported by Singh (1990) Woyema *et al.* (2012), Singh *et al* (2003), Tiessen et al., (2008) in case of spike length, Paula et al., (2011), Ooro *et al.* (2011) in case of no of spikelets spike-1 and no of grains spike-1 Nakano *et al* (2008) and Singh *et al* (1990) in case of test weight.

**3.3 Yield**

The data regarding the yield have been presented in Table 4.

**3.3.1 Grain yield (q ha-1)**

“It is quite evident from the data that significant variation in the grain yield was observed due to different nitrogen levels. Data revealed that yield increased successively with increased in nitrogen levels 160 kg N ha-1. The yield was recorded significantly higher 59.17 q ha-1 under 160 kg N ha-1 significantly superior over the rest of the treatments. The lowest yield was recorded 37.02 q ha-1 under 40 kg N ha-1”. (Srimannarayan et al. 2018)

The yield was recorded significantly higher under 160 Kg N ha-1 as compared to other treatments. This might be due to adequate nitrogen availability which contributed to increase dry matter accumulation. Productivity of a crop is collectively determined by vigour of the vegetative growth, development as well as yield attributes which is the result of better translocation of photosynthates from source of leaves and stem of the grains. Better vegetative growth coupled with higher yield attributes resulted into higher grain yield as 160 Kg N ha-1. Kazemeini and Edalat *et al* (2010)Singh *et al* (1990) Grain yield of wheat was significantly influenced by various time of nitrogen application.

**3.3.2 Straw yield**

“Data revealed that straw yield increased successively with increased in nitrogen levels from 40 to 160 kg N ha-1. The straw yield was recorded significantly higher 84.04 q ha-1 under 160 kg N ha-1 significant superior over the rest of the treatments. This produced the lowest straw yield (53.12 q ha-1) under 40 kg N ha-1”. (Srimannarayan et al. 2018)

Straw yield was influenced significantly by rates and time of nitrogen application. Maximum straw yield was recorded under160 Kg N ha-1. This may be probably due to higher density of tiller and increased rate of dry matter production. Similar finding was reported by Jan *et al* (2010), Haile (2013).

**3.3.3 Harvest index**

“The data revealed that the highest harvest index of wheat (41.31%) was recorded with 160 kg N ha-1. Among different scheduling of nitrogen, the higher harvest index of wheat (41.37%) was recorded with ½ basal + 1/4 after first irrigation +1/4 after second irrigation as compared to rest of the other treatments”. (Yashwant et al.2017)

**3.4 Economics**

“The data regarding the gross return, cost of cultivation, net return and cost benefit ratio have been presented in Table 5. As data clearly revealed that cost of cultivation increased linearly with increasing nitrogen levels from 40 to 160 kg N ha-1 in combination to all the treatments. The maximum cost of cultivation was recorded with 160 kg N ha-1 with ½ basal +1/4 after first irrigation +1/4 after second irrigation. The maximum gross return was recorded with the treatment with 160 kg N ha-1 and ½ basal +1/4 after first irrigation +1/4 after second irrigation. The Highest net return and B:C ratio was found 160 kg N ha-1 and ½ basal +1/4 after first irrigation +1/4 after second irrigation”. (Yashwant et al.2017)

**CONCLUSION:**

Based on the findings of the present investigation, it may conclude that the wheat performed well with application of 160 kg N per hectare in three split doses as ½ basal, ¼ with first irrigation and ¼ with second irrigation in terms of better growth, yield attributes and yield of wheat and economic return. Based on the above findings it can recommended that wheat grown with application of 160 kg N per hectare in three split doses as ½ basal, ¼ with first irrigation and ¼ with second irrigation can successfully sustain the productivity and profitability of wheat.

|  |  |
| --- | --- |
| **Treatments** | **Growth** |
| **Plant height At harvest** | **Number of tillers per running meter At harvest** | **Dry matter accumulation (g)****At harvest** |
| **Nitrogen levels (kg ha-1)** |
| 40 | 90.480 | 109.14 | 159.35 |
| 80 | 98.00 | 115.78 | 173.45 |
| 120 | 104.00 | 120.13 | 184.30 |
| 160 | 108.00 | 120.91 | 191.35 |
| SEm± | 2.224 | 2.536 | 3.868 |
| CD (P=0.05) | 6.480 | 7.325 | 11.171 |
| **Time of application** |
| 100% at basal | 95.00 | 110.43 | 168.20 |
| ½ basal + ½ after first irrigation | 97.00 | 112.88 | 172.18 |
| ½ basal + ¼ after first irrigation + ¼ after second irrigation | 105.00 | 122.54 | 186.00 |
|  1/3 basal + 1/3 after first irrigation + 1/3 after second irrigation  | 103.00 | 120.11 | 182.08 |
| SEm± | 2.224 | 2.536 | 3.868 |
| CD (P=0.05) | 6.480 | 7.325 | 11.171 |

**Table 2 Effect of different treatment on growth of wheat**

**Table 3 Effect of different treatment on yield attributes of wheat**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **Number of spikes per running meter** | **Spike length (cm)** | **Number of grains spike-1** | **1000-grain weight** |
| **Nitrogen levels (kg ha-1)** |
| 40 | 84.20 | 8.40 | 36.03 | 41.30 |
| 80 | 91.72 | 9.26 | 39.19 | 41.58 |
| 120 | 97.34 | 9.95 | 41.59 | 42.13 |
| 160 | 98.84 | 10.39 | 43.20 | 42.25 |
| SEm± | 2.077 | 0.192 | 0.823 | 0.859 |
| CD (P=0.05) | 5.998 | 0.555 | 2.378 | NS |
| **Time of application** |
| 100% at basal | 87.58 | 8.94 | 37.99 | 41.50 |
| ½ basal + ½ after first irrigation | 89.51 | 9.16 | 38.81 | 41.88 |
| ½ basal+ ¼ after first irrigation + ¼ after second irrigation | 99.92 | 10.06 | 42.01 | 42.13 |
| 1/3basal+1/3after first irrigation + 1/3after second irrigation  | 95.10 | 9.84 | 41.19 | 42.06 |
| SEm± | 2.077 | 0.192 | 0.823 | 0.859 |
| CD (P=0.05) | 5.998 | 0.555 | 2.378 | NS |

**Table 4 Effect of different treatment on yield attributes of wheat**

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatment** | **Grain yield (q ha-1)** | **Straw yield (q ha-1)** | **Harvest index (%)** |
| **Nitrogen levels (kg ha-1)** |
| 40 | 37.02 | 53.12 | 41.06 |
| 80 | 45.68 | 65.29 | 41.16 |
| 120 | 53.89 | 76.79 | 41.23 |
| 160 | 59.17 | 84.04 | 41.31 |
| SEm± | 0.63 | 0.92 | 0.005 |
| CD (P=0.05) | 1.83 | 2.66 | 0.015 |
| **Time of application** |
| 100% at basal | 45.42 | 65.26 | 41.02 |
| ½ basal + ½ after first irrigation | 48.31 | 69.14 | 41.11 |
| ½ basal + ¼ after first irrigation + ¼ after second irrigation | 51.33 | 72.73 | 41.37 |
| 1/3basal+1/3after first irrigation + 1/3after second irrigation  | 50.70 | 72.11 | 41.27 |
| SEm± | 0.63 | 0.92 | 0.005 |
| CD (P=0.05) | 1.83 | 2.66 | 0.015 |

**Table 5 Effect of different treatment on Economics of wheat**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **Cost of cultivation****(Rs.ha-1)** | **Gross Return****(Rs.ha-1)** | **Net Return****(Rs.ha-1)** | **B:C****Ratio** |
| **Nitrogen levels (kg ha-1)** |
| 40 | 34090 | 89284 | 55194 | 1.62 |
| 80 | 34326 | 110138 | 75811 | 2.21 |
| 120 | 34563 | 129865 | 95302 | 2.76 |
| 160 | 34800 | 142534 | 107733 | 3.09 |
| SEm± | - | 1532 | 1532 | - |
| CD (P=0.05) | - | 4426 | 4426 | - |
| **Time of application** |
| 100% at basal | 34195 | 109572 | 75377 | 2.20 |
| ½ basal + ½ after first irrigation | 34395 | 116480 | 82085 | 2.38 |
| ½ basal + ¼ after first irrigation + ¼ after second irrigation | 34595 | 123619 | 89024 | 2.57 |
| 1/3 basal+1/3 after first irrigation + 1/3 after second irrigation | 34595 | 122149 | 87554 | 2.53 |
| SEm± | - | 1532 | 1532 | - |
| CD (P=0.05) | - | 4426 | 4426 | - |

**Disclaimer (Artificial intelligence)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

**REFERENCES**

Ananda, N. Patil, B. N. (2007) Quality parameter of durum wheat as influenced by iron & time of nitrogen application. *Research on Crops*; **8**(3):520-525.

Anonymous. (2023-24). Ministry of Agriculture & Farmers Welfare, Department of Agriculture and Farmers Welfare (DA&FW)

Bahrani, A. Sarvestani, Z. T. (2005) Effect of rate and time of nitrogen fertilizer application on quantitative and qualitative traits, nitrogen and dry matter remobilization efficiency in bread and durum wheat. *Iranian Journal of Agricultural Sciences*; **36**(5):1263-1271.

Dogan, R. Celk, N. Yurur, N. (2008) Requirment and application frequencies of nitrogen fertilizer on bread wheat variety. *Asian Journal of Chemistry*; **20**(4):3069-3078.

Haile Deressa Nigussie-Dechassa, R. (2013) Seed and seedling performance of bread wheat as influenced by rate and in-season nitrogen application. *American Journal of Experimental Agriculture*; **3**(4):857-870.

Jan, M. T. Khan, M. J. Ahmad Khan Mohammed Arif Mohammed Shafi Farmanullah (2010) Wheat nitrogen indices response to nitrogen source and application time. *Pakistan* *Journal of Botany*; **42**(6):4267-4279.

Kazemeini, S. A. Edalat, M. (2010) Investigation of competition between wheat and wild oat in different nitrogen application time. *Proceedings of 3rd Iranian Weed Science Congress*, Volume **6**(1):419-421.

Khan, R.A.; Tomar, S.S; Yadav, N.S. Sharma, R.B. and Jain, M.P. (1990) Response of wheat to irrigation and nitrogen. *Indian J. Agron.* **35**(4):414-416.

Kumpawat, B.S. and Rathore S.S. (2003) Effect of preceding grain legumes on growth, yield, nutrient content and uptake by wheat (*Triticum aestivum*) under different nitrogen levels. *Crop-research-Hisar*. **25**(2): 209-214.

Nakano, H. Morita, S. Kusuda, O. (2008) Effect of nitrogen application rate and timing on grain yield and protein content of the bread wheat cultivar. *Plant Production Science*; **11**(1):151-157

Ooro, P. A. Malinga, J. N. Tanner, D. G. Payne, T. S. (2011) Implication of rate and time of nitrogen application on wheat yield and quality in Kenya. *Journal of Animal and Plant Sciences*; **9**(2):1141-1146

Paula, J. M. Agostinetto, D. Schaedler, C. E. Vargas, L. Silva, D. R. O. (2011). Competition of wheat with ryegrass as a function of application times and nitrogen doses.*Planta Daninha*; **29**(9):557-563.

Ramus, J., Duke, C. S., & Litaker, W., (1989). Effects of temperature, nitrogen supply, and tissue nitrogen on ammonium uptake rates of the chlorophyte seaweeds ulva curvata and codium decorticatum 1. *Journal of Phycology*, **25**(1), 113-120.

Singh, K. And Verma, H.D. (1990) Response of varieties to sowing date and fertility levels. *Indian J. Agron.* **35**(4):424-425.

Singh, Ved; Bhunia, S.R. and Chauhan, R.P.S. (2003) Response of late sown wheat (*Triticum aestivum* *L.*) to row spacing cum-population densities and level of nitrogen and irrigation in north-western Rajasthan.  *Indian J. Agron.,* **48**(3):178-181.

Tiessen, K. H. D. Flaten, D. N. Bullock, P. R. Grant, C. A. Karamanos, R. E. Burton, D. L. Entz, M. H.(2008) [Interactive effects of landscape position and time of application on the response of spring wheat to fall-banded urea.](http://ovidsp.tx.ovid.com/sp-3.12.0b/ovidweb.cgi?&S=AJCMFPDNBIDDDFAKNCMKGEMCDKPKAA00&Complete+Reference=S.sh.18%7c2%7c1) *Agronomy Journal*; **100**(3):557-563

Tran, T. S., & Tremblay, G. (2000). Recovery of 15N-labeled fertilizer by spring bread wheat at different N rates and application times. *Canadian Journal of Soil Science*, *80*(4), 533-539.

Woyema, A. Bultosa, G. Taa, A. (2012) Effect of different nitrogen fertilizer rates on yield and yield related traits for seven durum wheat (*Triticum turgidum L. var* durum) cultivars grown at Sinana, south eastern Ethiopia. *African Journal of Food, Agriculture, Nutrition and Development;* **12**(3):6079-6094.

Zhu XinKai Guo WenShan Ding JinFeng Li ChunYan Feng ChaoNian Peng YongXin (2011) Enhancing nitrogen use efficiency by combination of nitrogen application amount and time in wheat. *Journal of Plant Nutrition;* **34**(12):1761-1761.

May WE, Aldous L, Lafond GP. Feasibility of a wider row spacing and recommended nitrogen in no‐till wheat. Agronomy Journal. 2020 Sep;112(5):4076-91

Yashwant Yadav, B.N. Singh and R.C. Tiwari. Effect of nitrogen levels and its time of application on growth, and yield on wheat (Triticum aestivum L.) in eastern U.P. Bull. Env. Pharmacol. Life Sci., Vol 6 Special issue 2, 2017: 296-301

Srimannarayan Dubey, Ankit Tiwari, Vivek Singh, Vinay Kumar Pandey and Ghanshyam Singh. 2018. Effect of Nitrogen Levels and Its Time of Application on Yield Attributes, Yield and Economics of Barley (Hordeum vulgare L.). Int.J.Curr.Microbiol.App.Sci. 7(01): 1695 1705. doi: <https://doi.org/10.20546/ijcmas.2018.701.205>