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Effect of different nitrogen fertilizer rates on wheat yield under the arid and semi-arid climatic conditions of Nangarhar province

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ABSTRACT

Nitrogen is one of the essential and primary elements among plant nutrients and it is mainly around 30% accessible to plants as applied. Nitrogen is losing around 70% from the soil due to multiple factors. Therefore, the excessive nitrogen fertilizer application rate can cause soil, air, and underground water pollution and increasing temperature and can create different disorders. Thus, an experiment was conducted to find a suitable nitrogen fertilizer rate to improve the production of PBW-154 wheat variety under arid and semi-arid climatic conditions. The experiment consisted of seven different nitrogen rates, T_1 0, T_2 80, T_3 100, T_4 120, T_5 160, and T_7 180 kg ha^{-1}. Nitrogen was split 25% at germination and initial vegetative growth stage, while the remaining 50% was applied at tillering and flowering stages. Data was collected for vegetative (plant height, number of leaves, number of tillers) and reproductive (length of spike, number of grains per spike, 1000 grains weight, yield kg/ha) growth parameters accordingly. The results revealed that significantly ($P < 0.05$) higher values of vegetative growth and reproductive growth parameters, including production weight, were observed in the T_6 treatment compared to other treatments. Additionally, the T_6 treatment exhibited the highest yield (39.2 gr weight of 1000 grains and 4.47 tons/ha of grains weight). It increased by 41 % suitable nitrogen fertilizer application rate under the arid and semi-arid climatic conditions. The suitable nitrogen rate for arid and semi-arid climatic conditions is 160 kg ha^{-1} compared to 180 kg ha^{-1} and above. It could reduce the extra expenses of the farmers, protect the air, soil, and water from pollution, and increase the benefit-cost ratio of field cultivation for the reference crop.

Keywords: Nitrogen fertilizer, vegetative growth, reproductive growth, grains, yield

INTRODUCTION

Wheat (*Triticum aestivum*) is one of the staple and most-producing crops among the cereals, producing 70-90% calories for humans and 66-90% protein. According to the WFO, wheat covers around 40% of the food diet of the humans (Breiman and Gruar, 1995). Wheat in Afghanistan is one of the most important food sources, needed 170 kg/ year per head. However, in Pakistan, wheat covers human food dietary 106kg/year (Rasta, 2012). Between 2014 and 2015, wheat production reached 2.5 million tones, an increase 9.3% from 2013 and 2014. Consequently, it increased the cultivation area for wheat and improved fertilizer management in remote areas (MAIL, 2014).

Nitrogen is one of the essential and primary elements. Therefore, the influencing factor for wheat crop production is nitrogen fertilizer during the vegetative and reproductive growth stages, especially in leaves and flowering growth periods (Alley *et al.,* 2009). Applying nitrogen fertilizer has increased 7% wheat production back to back for four years (Dass *et al.,* 2015). Half of the world's farmers are keenly interested in applying more nitrogen fertilizers in different growth stages, but almost 30% is absorbed by plants, and 70% is losing depend upon the climatic, soil, and management conditions, more nitrogen not only the sign of more yield to feed the number of world 9.5 billion population by 2050 but need to protect the soil, air, and water from pollution, therefore need to find out the suitable rate, type, time and methods of application to reduce the expense and get more yield (Merrington *et al.,2002 &* Kjellstrom *et al., 2006*).

DAP and urea are the only sources of nitrogen application in Afghanistan. However, a lack of awareness about nitrogen fertilizer rates in the field could decrease wheat yield despite soil, water, and air pollution. Multiple research studies have been conducted on applying nitrogen fertilizer rates in wheat crop fields. In Afghanistan, there is a lack of research data and information on nitrogen fertilizer rates for wheat production, which has not been published yet.

A suitable amount of nitrogen and potassium 160 kg per hector increased the number of effective tillers by 8.7%, grain yield by 17.3%, straw yield by 15.1%, total N uptake by 25.1%, and total K uptake of 16.1% as compared with control and 80 kg N per hector. (Sharma *et al.,* 2022). The right amount of N and the application timing significantly influenced the yield and straw production (Kostic *et al.,* 2021). An efficient amount of N in wheat fields increased the soil water content, root growth, and shelf life of the plants, consequently increasing yield reported by (Haoran *et al.,* 2022).

We conducted an experiment to determine the effect of nitrogen fertilizer on wheat production by suitable rate of nitrogen fertilizer in wheat fields, an essential topic in Afghanistan. As a result, the farmers will understand the suitable rate of nitrogen fertilizer for wheat production.

MATERIALS AND METHODS

Experimental Design and Treatments

The experiment was conducted at the Nangarhar University Faculty of Agriculture Research farm, Jalalabad, Afghanistan, during the winter season of 2014 and 2015. It has geographical points as a latitude degree 31 to 58, a longitude degree 52 to 64, and elevation 980 degrees from sea level. The climatic condition of the cultivated area was a tropical and semi-tropical region, but the winter season is cold while the summer season is warm with annual rainfall around 190.6 mm, mostly from December to March. Wheat needs to be 32 °C for normal growth and production, while it needs to be 15 °C during the cultivation time. The soil was sandy clay loam with 8.3 pH and electrical conductivity (EC) of 0.21 dsm^{-1}. There were seven different treatments based on nitrogen rates 0, 80, 100, 120, 140, 160, and 180 kg nitrogen per hector in three growth stages; 25 and 25% at germination and flowering time, while 50% was applied at tillering stage.

The design was driven by RCBD and wheat variety (PBW-154) used for cultivation on December 29, 2014, with a 20 cm distance between the rows. Phosphorus (DAP) fertilizer was applied (80 kg per hectare).

Statistical Analysis

The data was analyzed based on a one-way analysis of variance (ANOVA) using SPSS (version 16) statistical software. Differences among the treatments were separated using Tukey's test at $\alpha = 0.05$ significance level.

RESULTS AND DISCUSSION

The maximum nitrogen rate being applied is 160 and 180 kg per hector, while the minimum rate is 80 kg per hector. There were no significant differences in growth parameters. However, the plant height, number of tillers per square meter area, and dry matter weight gave high values.

Table 1. Effect of nitrogen fertilizer on wheat crop density and growth parameters

Treatment		No # of plants in treatments during the vegtatative and reproductive stages		Height (cm)	Tillers (m2)	Dry matter g/m^2)
		Vegetative stage	Reproductive stage			
T1	0	120	120	61.9	204	835
T2	80	122	120	69.8	295	1627
T3	100	122	121	73.4	309	2104
T4	120	124	121	76.0	314	1925
T5	140	123	121	78.8	329	2119
T6	160	124	122	83.4	335	2868
T7	180	123	122	85.1	335	2882
	(SE m ±)	1.83	0.69	4.1	11.0	143.5
	CD=(p=0,05)	NS	NS	12.7	33.8	442.3

Applying 180 kg of nitrogen per hectare resulted in a plant height of 85.1 cm, 335 tillers per square meter, and a dry matter weight of 2882 grams per square meter. These values were the highest among the treatments. In the results, 160 and 180 kg of nitrogen per hectare were the most effective compared to other treatments (Table 1). Nitrogen applied increases the chlorophyll, affecting mostly growth parameters, how much the photosynthesis gets more energy from the sun, and effects on growth (Sardana and Randhawa, 2002*;* Kumar *et al.*, 2007).

Application of nitrogen fertilizer during the vegetative growth stages improved vegetative growth, including a number of tillers, ultimately increasing the number of spikes per plant and total yield revealed by (Kumar and Yadav, 2005).

Effect On Phonological Parameters

The results indicated in Table 3 show that the treatments where 180 kg nitrogen per hector took 49 days to booting stages, 91.7 days to flowering stages, and 137.7 days to the physiological maturity stage; however, there were no significant differences among the treatments where 80, 100, 120, 140, and 160 kg nitrogen were applied, respectively.

Table 2. Effect of nitrogen Fertilizer on wheat phonological characteristics

Treatments		Booting stage period in days	Flowering stage period in days	Maturity stage period in days
T1	N0	43.7	90,3	134,7
T2	N80	45.7	88.3	128.7
T3	N100	46.1	89.3	130.0
T4	N120	46.7	89.7	130.0
T5	N140	47.3	90.7	131.7
T6	N160	48.7	91.3	134.7
T7	N180	49.0	91.7	137.7
	(SEm±)	1.0	0.7	0.5
	CD=(p=0,05)	3.1	2.0	1.6

The treatment, where 80 kg of nitrogen per hector took fewer days to the physiological maturity stage, and a lower nitrogen rate, shortened the plant's growth. However, control treatment without nitrogen fertilizer took 90.3 days to the physiological maturity stage, while applying a suitable rate of nitrogen 160 kg per hector covered a shelf life of 134.7 days to the physiological maturity stage, meaning properly improved the use efficiency applied nitrogen as well as existing nutrients from soil table 2. The results revealed that 160 kg nitrogen per hectare provided good growth conditions and consequently high wheat production compared with other treatments in the same area and climatic conditions.

Yield attributes

The effect of different nitrogen fertilizer rates on the number of spikes per square meter area, number of spikelet per spike, spike length, and 1000 grains weight in grams was comparatively studied. The treatment where 160 kg nitrogen per hector gave the maximum number of spikes m^2 square meter area, number of spikelet /spike, length of the spike, and 1000 grains weight as comparatively studied among the treatments Table 3.

Table 3. Effect of different rates of nitrogen on yield attributes of wheat crop

Treatments		Spike/m^2	cm Spike length/	Spikelet/spike	Spike weight Cm	Spike weight (g)	Spikelet weight (g)	1000 grains weight (g)	Yield ton/h	Straw ton/h	Total yield (%)
T1	N0	186	8.34	17.1	36.0	1.90	1.10	30.7	1.39	3.06	31.2
T2	N80	277	9.80	17.9	40.3	2.10	1.50	36.9	2.90	4.98	36.0
T3	N100	290	10.2	18.5	41.2	2.23	1.50	37.4	3.34	5.44	38.1
T4	N120	299	10.2	18.5	42.1	2.30	1.57	37.8	3.73	5.73	39.5
T5	N140	312	10.6	19.7	43.5	2.23	1.67	38.0	4.12	5.96	40.9
T6	N160	321	12.0	20.3	46.6	2.50	1.83	39.2	4.47	6.43	41.0
T7	N180	321	11.6	20.1	45.3	2.43	1.77	38.7	4.24	6.63	39.0
	(SEm±)	11.06	0.42	0.67	1.78	0.11	0.08	1.51	0.19	0.29	1.71
	CD=(p=0,05)	34.07	1.30	2.06	5.49	0.32	0.26	4.65	0.57	0.90	5.27

Wheat grains and straw yield

Dramatically increased wheat yield by applying 160 kg nitrogen per hector, followed by 140 and 180 kg nitrogen/ha, were not significantly with each other's, table 3. 160 kg of nitrogen per hector increased yield attributes and significantly differed among the treatments. 5 R rules can improve the fertilizer use efficiency, right source, right type, right amount, right use of time, and right place, according to (Liu *et al.,* 2019).

Therefore, 160 kg nitrogen/ ha was the right amount, and 25% was applied in vegetative and flowering, while the rest of the 50% applied in tillering stages caused a high total yield and percentage. So, the result found a direct proportional link between yield and suitable amount of fertilizers revealed by (Goswami, 2007).

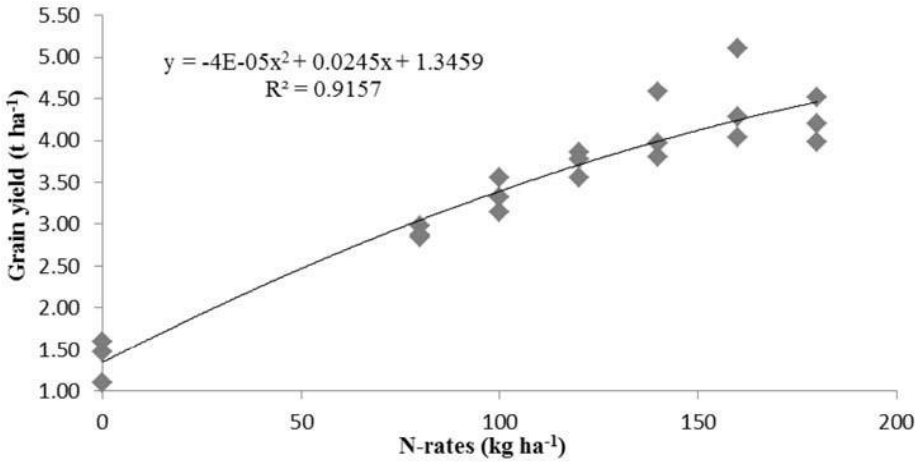

Figure 1. This figure shows the direct proportionally link between fertilizer and yield

Suitable amounts and timing of nitrogen fertilizer increased the leaves' surface area and life duration, ultimately increasing the photosynthesis rate, which affected wheat total yield (Ali *et al.*, 2011).

There were no significant differences among the treatments in straw production, but the highest amount of straw was produced, 6.63 tons per hector, in the treatment with 180 kg nitrogen applied per hector, followed by T_4, T_5, and T_6, which gave 5.73, 5.96, and 6.43 tons of straw production per hector, respectively. The right amount of nitrogen produced more dry matter and caused more tillers per plant, improved plant height and leaf surface area, and was actively photosynthetic, resulting in a high yield. However, a lower rate of nitrogen caused weak vegetative growth and its attributes (*Hussain et al., 2005*).

A suitable amount of nitrogen in T6 (160) kg per hector increased by 41% wheat yield compared to other treatments, followed by 100, 120, 140, and 180 kg nitrogen per hector treatments. However, the control plot produced less wheat yield (T_1 0 kg of nitrogen per hectare). *Jan et al. (2010) suggested that the right amount of nitrogen application in the wheat fields* could improve the grain and total yield.

Conclusion

A nitrogen application rate of 160 kg per hectare was observed as one of the most suitable amounts for arid and semi-arid climatic conditions in Nangarhar province. This rate increased wheat yield by 41% compared to other treatments. Applying 25% of the nitrogen at the vegetative and flowering growth stages is recommended, with the remaining 50% applied at the tillering stage. This recommendation is provided to extension workers and farmers.

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REFERENCES

Alam, I., & Sinha, K. K. (2008). Response of Wheat (*Triticum aestivum*) Genotypes to levels of nitrogen under irrigated condition. *Environment and Ecology*, *20*(4), 1925-1926.

Amjed, A., Ahmad, A., Syed, W. H., Khaliq, T., Asif, M., Aziz, M., & Mubeen, M. (2011). Effects of nitrogen on growth and yield components of wheat.(Report). *Science International (Lahore)*, *23*(4), 331-332..

Alley, M. M., Scharf, P. C., Brann, D. E., Baethgen, W. E., & Hammons, J. L. (2009). Nitrogen management for winter wheat: principles and recommendations.

Ananda, N., & Patil, B. N. (2007). Effect of zinc, iron and split application of nitrogen on growth, yield of durum wheat (Triticum durum Desf.) and on available nutrient status in soil. *Research on Crops*, *8*(3), 515.

Dass, A., Jat, S. L., & Rana, K. S. (2015). Resource conserving techniques for improving nitrogen-use efficiency. *Nutrient use efficiency: from basics to advances*, 45-58.

Gangwar, K.S., Singh, K.K. and Sharma, S.K. 2004. Effect of tillage on growth, yield and nutrient uptake in wheat after rice in the IndoGangetic Plains of India. Journal of Agricultural Sciences, 142: 453-459.

Goswami, V.K. 2007. Response of wheat (Triticum aestivum) to nitrogen and zinc application. Annals of Agricultural Research, 28(1): 90-91.

Haoran Li, Hongguang Wang, Qin Fang, Bin Jia, Dongxiao Li, Jianning He, Ruiqi Li, Effects of irrigation and nitrogen application on NO3--N distribution in soil, nitrogen absorption, utilization and translocation by winter wheat, Agricultural Water Management,

Hussain, M.F., Kabir, M.A., Majunder, U.K., Sikder, M.S. and Chaudhary, M.M.A.A. 2005. Influence of irrigation and nitrogen level on yield of wheat Pakistan and nitrogen level on yield of wheat. Pakistan Journal of Biological Scice, 8(1): 152-155.

Jan, M. T., Khan, M. J., Ahmad, K., Mohammad, A., Mohammad, S. and Farmanullah, 2010. To test the effects of sources and timing of N application on wheat biological yield and N indices. *Pakistan Journal of Botany*, **42**(6): 42674279.

Kjellstrom, T., Lodh, M., McMichael, T., Ranmuthugala, G., Shrestha, R., & Kingsland, S. (2006). Air and water pollution: burden and strategies for control. Disease Control Priorities in Developing Countries. 2nd edition.

Kumar, R. and Yadav, D.S. 2005. Effect of zero tillage in conjunction with nitrogen management in wheat *(Triticum aestivum)* after rice *(Oryza sativa)*. *Indian Journal of Agronomy*, **50**(1): 54-57.

Kumar, S., Singh, K. and Jatav, A.L. 2007. Effect of nitrogen levels on growth and yield of recently released wheat variety Malviya 468 under late sown condition. *Progressive Agriculture*, **7**(1/ 2): 25-27.

Kostić, M. M., Tagarakis, A. C., Ljubičić, N., Blagojević, D., Radulović, M., Ivošević, B., & Rakić, D. (2021). The Effect of N Fertilizer Application Timing on Wheat Yield on Chernozem Soil. Agronomy, 11(7), 1413. MDPI AG. Retrieved from http://dx.doi.org/10.3390/agronomy11071413

MAIL (Ministry of Agriculture, Irrigation and Livestock) Agricultural prospects Report. 2014- 15.

Merrington, G., Nfa, L. W., Parkinson, R., Redman, M., & Winder, L. (2002). Agricultural pollution: environmental problems and practical solutions. CRC Press.

RASTA (Food Security Response Analysis Support Team Afghanistan). 2012. Wheat markets and wheat availability in Afghanistan. pp.7

Sharma, S., Kaur, G., Singh, P., Alamri, S., Kumar, R., & Siddiqui, M. H. (2022). Nitrogen and potassium application effects on productivity, profitability and nutrient use efficiency of irrigated wheat (Triticum aestivum L.). Plos one, 17(5), e0264210.

Sardana, S.K. and Randhawa, A.S. 2002. Performance of wheat varieties under different sowing date and nitrogen levels in sub-mountain region of Punjab. *Indian Journal of Agronomy*, **34**(3): 372-377.

Tisdale, S.L. and Nelson, W.L. 1984. Soil Fertility and Fertilizers, 3rd Ed. *McMillan Publ. Co., Inc.*, New York. pp. 68-73.

Yadav, D.S., Shukla, R.P. and Susant, B.K. 2005. Effect of zero tillage and N level on wheat *(Triticum aestivum)* after rice *(Oryza sativa)*. *Indian Journal of Agronomy*, **50**(1): 52-53.

Wheat food Council Est. 1972