Effect of Split Application of Nitrogen on Growth and Yield of Wheat (*Triticum aestivum* L.)

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Authors’ contributions

This work was carried out in collaboration between both authors. Author AA designed the study and analysis. Author MAB performed the statistical analysis and field research. Both authors read and approved the final manuscript.

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ABSTRACT

Studies pertaining to effect of split application of nitrogen on growth and yield of wheat was carried out at Agricultural Research Farm of Kunduz University during 2018-19 using RCBD with three replications. Nitrogen by Urea was applied; 50% N as basal + 50% N at tillering, 50% N as basal + 50% N at flowering, 50% N as basal + 25% N at tillering + 25% N at flowering, 33% N as basal + 66% N at tillering, 33% N as basal + 66% N at flowering, 33% N at basal + 33% N at tillering + 33% N at flowering. The results showed that split application of nitrogen in 2 split (33% N as basal + 66% N at tillering) increases the all growth parameters [height of plant (105.25 cm), number of tillers (6.16 tiller plant⁻¹), spicks (5.63 spick plant⁻¹) and spikelet per spick (16.66 spikelet spick⁻¹)], the yield and yield component; 1000 grain weight (34.60 g), grain yield (5208.22 kg ha⁻¹) and straw yield (8853.98 kg ha⁻¹) increases with 33% N as basal + 33% N at tillering + 33% N at flowering.

Keywords: Nitrogen; spikelet; yield; wheat; *Triticum aestivum*.

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1. INTRODUCTION

Bread wheat (Triticum aestivum L.) is one of the most important cereal crops in the world in terms of area coverage and production. It is a major source of nutrition for humans and livestock, estimated to contribute as much as 60 million tons of protein per year [1]. The total worldwide production of wheat in 2012 was around 767 million tons on an area of 215 million ha [2]. Wheat requirements in Afghanistan are growing at an exorbitant rate due to its rapid expansion in population. Balance use of fertilizers and agronomic measures are needed to raise production of this crop. Wheat is a staple food crop in Afghanistan. Among the cereal crops, it accounts for 81% of total cereal crop production in the country, while rice, barley and maize account for 7, 7 and 5% respectively. The production of wheat in 2019 was 5 million metric tons and grown approximately on 2.55 million hectares area. However, the average yield of wheat in Afghanistan is very low; it is about 1.7-1.9 ton/ha in last 5 year 2015-2019 as compared to the world’s average of about 3.4 ton/ha [3].

The soils of Afghanistan are deficient in N and are supplemented with chemical fertilizers for enhancing crop productivity. N is the motor of plant growth and makes up 1 to 4% of dry matter of the plants [4]. Nitrogen plays a critical role in improving growth, yield and quality of wheat under temperate conditions. Nitrogen is an important constituent of plant protoplasm, proteins, nucleic acids and chlorophyll, its availability at critical stages is of paramount importance and its management plays a key role in improving crop growth, environmental safety and economics of crop production [5]. In many parts of the world, limited research has been done on the effect of split application of N for wheat and its association with grain yield and NUE [6].

Response of wheat to nitrogen splits with reduced basal dose has been reported by several workers [7]. Split application of N is one of the methods to improve N use by the crop while reducing the nutrient loss through leaching, denitrification, runoff and volatilization [8]. So, to maintain crop growth and yield, it is important to reduce nitrogen losses. Therefore, split application of nitrogen in proper propositions as per crop demand is an effective tool. Thus, the present study was carried out to elucidate the effects of split application of nitrogen on the growth and yield of wheat.

2. MATERIALS AND METHODS

A field experiment was conducted during the winter seasons of (2018–19) at the agronomy research farm of Agricultural faculty at Kunduz University. The experimental site is situated between (36.22°58’ N and 68°52.5’E, 404 m above the mean sea-level). The experiment was conducted during the winter seasons (1st of December) of 2018 to spring seasons (1st of June) of 2019 on loam soil (38% sand, 42% silt and 20% clay), neutral in pH (7.4), low in nitrogen (0.5%), available phosphorus (19.2 kg/ha) and potassium (140.1 kg/ha). The rainfall received during the crop growing season extending from December to June was 256.30 mm for 2018–19 respectively. The experiment comprised 6 treatments of nitrogen [T1, 50% N as basal + 50% N at tillering; T2, 50% N as basal + 50% N at flowering; T3, 50% N as basal + 25% N at tillering + 25% N at flowering; T4, 33% N as basal + 66% N at tillering; T5, 33% N as basal + 66% N at flowering; T6, 33% N at basal + 33% N at tillering + 33% N at flowering] using RCBD With three replications. Sowing was done in the 1st week of December with row-to-row spacing of 20 cm and seed rate used was 100 kg per hectare. Recommended dose of nitrogen (120 kg/ha) through urea, was uniformly applied to each plot as per the treatments while. Standard cultural practices were followed until the crop matured but the crop was not irrigated due to sufficient availability of water. To evaluate the observation regarding growth attributes and yield of individual plant, parameters were recorded from randomly 5 selected plants in each plot. The evaluated traits were plant height (cm), tillers plant-1 (no.), spike plant-1 (no.), spikelet spick-1 (no.), thousand grain weight (g), grain yield (kg ha-1) straw yield (kg ha-1) and harvest index (%). The statistical analysis of the data was performed using Microsoft Excel. Statistical significance between mean differences among treatments for various parameters was analyzed using least significant differences (LSD) at 0.05 probability level.

3. RESULTS AND DISCUSSION

3.1 Plant Height

The data related to plant height at harvesting stage have been presented in Table 1. The tallest plant (105.25 cm) was observed in T4 (30% N as basal + 66% N at tillering) which was statistically similar to T3 (33% N at basal + 33% N at tillering + 33% N flowering) and 102.50 cm in T1 (50% N as basal + 50% N at tillering). Nitrogen fertilizers are essential for vegetative growth of plant. These findings are in harmony with [9,10], R.K. Singh et al. [11] also reported the highest plant height (97 cm) was
obtained with the treatment combination of 40 kg N at CRI + 35 kg N at PI. The shortest one (95.75 cm) was observed in T₅ (33% N as basal + 66% N at flowering).

3.2 Tiller Production

Significant differences were recorded for the split application of nitrogen in terms of tillers plant⁻¹ of wheat (Table 1). The study revealed that T₄ (33% N as basal + 66% N at tillering) and T₆ (33% N as basal + 33% N at tillering + 33% N flowering) performed best in producing the highest number of tillers plant⁻¹ of wheat (6.16 and 6.14 tillers plant⁻¹) which were statistically with T₃ and T₁ (5.25 and 5.06 tillers plans⁻¹) respectively. It is possible due to the effect of split application of nitrogen at requirements stages of growth period was significant for number of tillers plant⁻¹, therefore, the number of tillers plant⁻¹ is going to be increased. These findings are in close conformity with the findings of [12]. The lowest number of tillers plant⁻¹ of wheat (4.08 and 4.14 tiller plant⁻¹) were obtained from T₂ (50% N as basal + 50% N at flowering) and T₅ (33% N as basal + 66% N at flowering) treatments.

3.3 Spick Plant⁻¹

Statistically significant variation was recorded for number of spick plant⁻¹ of wheat due to the split application of nitrogen (Table 1). The maximum spick per plant (5.63 and 5.54 spick plant⁻¹) was observed with T₃ (50% N as basal + 25% N at tillering + 25% N at flowering) and T₆ (33% N at basal + 33% N at tillering +33% N at flowering) treatment which were similar with 4.67 spick plant⁻¹ in T₁ (50% N as basal + 50% N at tillering). The lowest number of spick plant⁻¹ of wheat were obtained with remain treatments. These results are in harmony with that of [13].

3.4 Spikelet Spick⁻¹

Table 1 presents that the highest number of spikelet spick⁻¹ (16.66 and 16.33 spikelet spick⁻¹) were obtained with the treatments T₄ (33% N as basal + 66% N at tillering) and T₅ (33% N as basal + 66% N at flowering). It is possible due to the optimum application of nitrogen at spick initiation stage. The application of nitrogen at both stages tillering and flowering has contributed more positively, it might be due to sufficient availability of nitrogen during tillering stage that leads to increased number of tillers per plant and hence increased the number of spikes per plant. These findings are partly in agreement with that of [14]. The less spikelet produced in T₂ and T₅ (13.50 and 13.59 spikelet spick⁻¹) treatments.

3.5 Thousand Grain Weight

The results obtained in case of 1000 grain weight were found to be significant with the split application of nitrogen (Table 2). The highest weight of 1000 grain (34.60 and 34.10 g) were obtained from T₅ (33% N as basal + 66% N at flowering) and T₆ (33% N at basal + 33% N at tillering +33% N at flowering) treatments. On the other hand the lowest 1000 grain weight (27.20 and 28.70 g) was obtained from T₄ and T₁ treatment respectively. The increase in 1000 grain weight might be due to reduce of N in this treatments. These findings are partly in agreement with that of [15,16].

3.6 Grain Yield

Grain yield is a combined output of various yield components such as spick plant⁻¹, spikelet spick⁻¹ and 1000 grain weight. Grain yield of wheat affected significantly due to different split application of nitrogen (Table 2). Treatment T₆ with 3 equal split application of nitrogen produced the highest grain yield (5208.22 kg ha⁻¹) which was statistically similar with (5098.23 kg ha⁻¹) in T₄ (33% N as basal + 66% N at tillering). This higher yield might be attributed to the fact that the plant had nourished with adequate nitrogen fertilizer as it required during growth period thus ultimately gave higher yield components for higher grain yield. These findings are partly in agreement with that of [17,18]. Similarly, higher grain yield of wheat was reported when N was applied in three splits at planting, tillering and post-anthesis compared with two splits at planting and tillering and one-time application at planting [6]. Treatment T₃ (50% N as basal + 25% N at tillering + 25% N at flowering) gave the lowest grain yield (3707.57 kg ha⁻¹). These are because of the applied N was likely susceptible to leaching, denitrification and runoff loss as the amount of rainfall was higher during this period.

3.7 Straw Yield

Split application of nitrogen significantly influenced on straw yield of wheat (Table 2).

The highest Straw yield (8853.98 kg ha⁻¹) was obtained from T₆ (33% N at basal + 33% N at tillering +33% N at flowering) which was statistically similar with T₄ (8666.98 kg ha⁻¹). The higher straw might be owing to the cumulative
Table 1. Effect of split application of nitrogen on growth attributes of wheat

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Plant height (cm)</th>
<th>No. tillers plant$^{-1}$</th>
<th>No. spick plant$^{-1}$</th>
<th>No. spikelet spick$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_1$ 50% N as basal + 50% N at tillering</td>
<td>102.50 ab</td>
<td>5.06 ab</td>
<td>4.67 ab</td>
<td>15.50 ab</td>
</tr>
<tr>
<td>$T_2$ 50% N as basal + 50% N at flowering</td>
<td>96.42 bc</td>
<td>4.08 b</td>
<td>3.70 b</td>
<td>13.50 b</td>
</tr>
<tr>
<td>$T_3$ 50% N as basal + 25% N at tillering + 25% N at flowering</td>
<td>97.25 bc</td>
<td>5.25 ab</td>
<td>4.00 b</td>
<td>15.00 ab</td>
</tr>
<tr>
<td>$T_4$ 33% N as basal + 66% N at tillering</td>
<td>105.25 a</td>
<td>6.16 a</td>
<td>5.63 a</td>
<td>16.66 a</td>
</tr>
<tr>
<td>$T_5$ 33% N as basal + 66% N at flowering</td>
<td>95.75 c</td>
<td>4.14 b</td>
<td>3.70 b</td>
<td>16.33 a</td>
</tr>
<tr>
<td>$T_6$ 33% N at basal + 33% N at tillering +33% N at flowering</td>
<td>97.25 bc</td>
<td>5.25 ab</td>
<td>4.00 b</td>
<td>15.00 ab</td>
</tr>
</tbody>
</table>

(P=0.05) 6.09 1.45 1.04 2.36

Table 2. Effect of split application of nitrogen on yield attributes of wheat

<table>
<thead>
<tr>
<th>Treatments</th>
<th>1000 grain weight (g)</th>
<th>Grain yield (kg ha$^{-1}$)</th>
<th>Straw yield (kg ha$^{-1}$)</th>
<th>Harvest index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_1$ 50% N as basal + 50% N at tillering</td>
<td>28.70 b</td>
<td>4150.51 b</td>
<td>6832.98 b</td>
<td>37.84</td>
</tr>
<tr>
<td>$T_2$ 50% N as basal + 50% N at flowering</td>
<td>30.30 ab</td>
<td>3026.72 d</td>
<td>4736.26 c</td>
<td>39.13</td>
</tr>
<tr>
<td>$T_3$ 50% N as basal + 25% N at tillering + 25% N at flowering</td>
<td>30.90 ab</td>
<td>3707.57 c</td>
<td>6163.83 b</td>
<td>37.63</td>
</tr>
<tr>
<td>$T_4$ 33% N as basal + 66% N at tillering</td>
<td>27.20 b</td>
<td>5098.23 a</td>
<td>8666.98 a</td>
<td>37.16</td>
</tr>
<tr>
<td>$T_5$ 33% N as basal + 66% N at flowering</td>
<td>34.10 a</td>
<td>4119.46 b</td>
<td>6467.17 b</td>
<td>39.05</td>
</tr>
<tr>
<td>$T_6$ 33% N at basal + 33% N at tillering +33% N at flowering</td>
<td>34.60 a</td>
<td>5208.22 a</td>
<td>8853.98 a</td>
<td>37.16</td>
</tr>
</tbody>
</table>

C.D. (P=0.05) 4.27 112.11 915.25 NS

NS: non-significant

3.8 Harvest Index

The harvest index was significantly affected by different split application of nitrogen (Table 2). The highest harvest index (39.13%) was recorded with $T_2$ (33% N as basal + 66% N at flowering) treatment. The lowest harvest index (37.16%) was recorded from $T_4$ and $T_6$ treatments. These findings are in line with those of [19,20].

4. CONCLUSION

The data revealed that the split application of nitrogen had a significant growth response was observed with 2 split (33% N as basal + 66% N at tillering) and application of nitrogen in 3 equal split (33% N at basal + 33% N at tillering +33% N at flowering) seems to be best yield and viable and sustainable as compared to other recommended practices. The importance of splitting nitrogen in three split doses was also evidenced in the optimum yields and improving nitrogen recovery.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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