Effect of nitrogen application schedule through integration on nitrogen use efficiency and yields of basmati rice in *Typic Ustochrept* soil

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Abstract

A field trial was conducted during *kharif* 2014 to investigate the nitrogen use efficiency and yield of basmati rice under different schedule of nitrogen application through integration. To this effect ten treatments consisting various nitrogen scheduling were tested in a randomized block design with three replications. Remarkable effect was noted where growth attributes (plant height, number of tillers), yield attributing traits (panicle length and number of grains per panicle), yields viz., grain and straw yield and nitrogen use efficiency (agronomic efficiency, apparent N recovery and physiological efficiency) were improved with the application of 37.5/50% basal N through dhaincha and rest 47.0/37.5% at maximum tillering and 15.5/12.5% at panicle initiation, through urea. Even though, significantly highest grain (42.98 q ha⁻¹) and biological yield (140.87q ha⁻¹) was registered under the application of 50% N as basal through dhaincha + 37.5, and 12.5% N as through urea, at maximum tillering and panicle initiation respectively as compared to all other treatments. While, higher straw yield (105.34 q ha⁻¹) was produced under combined application of 37.5% N as basal through dhaincha + 47.0, and 15.5% N as through urea, at maximum tillering and panicle initiation respectively. Thus, 50% N as basal through dhaincha + 37.5, and 12.5% N as through urea, at maximum tillering and panicle initiation, respectively, is best option for achieving maximum yield and nitrogen use efficiency.

Keywords: Basmati rice Nitrogen use efficiency, Schedule of nitrogen, Yields.


Introduction

Globally rice provides 21% of energy and 15% of protein requirements of human populations (Depar *et al.*, 2011). In Asia, more than two billion people are getting 60-70 per cent of their energy requirement from rice and its derived products. China and India are the largest rice producing and consuming countries in the world. India produced 106.4 m tones of rice and made 40% contribution to the total food grain production of the country (Anon, 2014). A very low nitrogen use efficiency of 30% has been observed in rice-wheat cropping system (Krupnik *et al.*, 2004) due to inefficient splitting of N coupled with application of N in excess of crop demand resulting in poor synchronization between supply and crop demand of N. Nitrogen is most essential elements from crop production point of view. Major cereal crop like rice, wheat and maize consume around more than half of total fertilizer N in the world; however, demand for fertilizer N will increase in future at higher magnitude if fertilizer N recovery is not improved (Singh *et al.*, 2015). Poor synchronization between demand and supply of N leads to its poor use efficiency. Nitrogen use efficiency for most of the crop is lower and ranges from 30-50%. Large portion of applied N
escape soil-plant system to reach water bodies and the atmosphere thus creating pollution problems (Singh et al., 2013). That is why successful nitrogen managements requires better synchronization between crop N demand and supply from all sources throughout crop growing season (Cui et al., 2008) and plant need-based application of N to achieve higher yield and higher N use efficiency.

Rice plant needs a sufficient supply of nutrients from several sources for optimal growth. These nutrients are supplied by indigenous sources such as soil minerals, soil organic matter and manure but the amount supplied is usually insufficient to achieve high and sustainable yields because of relatively low levels of nutrients. (Rama Lakshmi et al., 2012). Integrated nitrogen management (INM) is very important in rice production. Through this, farmers can increase agricultural productivity and safeguard the environment as they efficiently use fertilizer.

Green manuring with dhaincha (Sesbania aculeata) has been identified as critical intervention in this regard. Green manuring alone can meet the total nitrogen requirement of basmati rice but its adoption level among farmers is very poor. Dhaincha is a multipurpose leguminous crop and is widely used as green manure to increase the yield of rice. It is grown during the summer season and is widely adaptable to different adverse climatic conditions like drought, waterlogging, soil salinity, etc. (Kumar and Srivastava, 2011).

The vermicompost may be a another good source of almost all essential nutrients (primary, secondary and micronutrients) for plant growth and it is an eco-friendly natural fertilizer prepared from bio-degradable organic wastes, free from toxic chemical inputs. However, scented rice requires huge quantity of nutrients for obtaining optimum yield. Under such circumstances, integrated use of vermicompost and fertilizers in proper proportions appears to be the right practice of plant-nutrition (Barik et al., 2004). Thus, the information on different schedule of nitrogen application through integration was planned to find out nitrogen use efficiency and yield of basmati rice.

Material and Methods

A field experiment was conducted during kharif 2014 to investigate the periodic nutrient availability, nitrogen use efficiency and yield of basmati rice under different schedule of nitrogen application schedule through integration. To this effect ten treatments consisting various nitrogen scheduling viz., control (T1), recommended dose (120:60:40) (T2), 50% basal N through dhaincha+ (37.5% + 12.5%) N through urea, at maximum tillering and panicle initiation (T3), 50% basal N through dhaincha+ (12.5% + 37.5%) N through urea, at maximum tillering and panicle initiation (T4), 37.5% basal N through dhaincha+ (47.0% + 15.5%) N through urea, at maximum tillering and panicle initiation (T5), 37.5% basal N through dhaincha+ (15.5% + 47.0%) N through urea, at maximum tillering and panicle initiation (T6), 50% basal N through vermicompost+ (37.5% + 12.5%) N through urea, at maximum tillering and panicle initiation (T7), 50% basal N through vermicompost + (12.5% + 37.5%) N through urea, at maximum tillering and panicle initiation (T8), 37.5% basal N through vermicompost+ (47.0% + 15.5%) N through urea, at maximum tillering and panicle initiation (T9) and 37.5% basal N through vermicompost+ (15.5% + 47.0%) N through urea, at maximum tillering and panicle initiation (T10) were tested in a randomized block design with three replication. Meerut is located on the Delhi-Dehradun highway. Geographically it is located at 29° 04, N latitude and 77° 42 ‘E longitude at an altitude of 237 meters above the mean sea level. The climate of this region is subtropical and semiarid climate characterized with hot conditions.
summers and extremely cold winters. The maximum temperature (33.4°C) and minimum temperature (21.3°C) were recorded during month of June and July, respectively, while the mean relative humidity was 62.00 percent in July to October. The total rainfall as well as its distribution in this region is subjected to very large variation. About 718.4 cm is received during July to October. A composite soil samples to a depth of 0-15 & 15-30 cm were collected from different place of the experimental field prior to sowing of the crop. The samples were analyzed for its physico-chemical properties. The soil of the experimental field was well drained, sandy loam in texture (sand 52.3 %, silt 28.2 %, clay 19.5 %) and slightly alkaline in reaction (pH 8.03). It was low in available nitrogen and medium in available phosphorus and available potassium with an electrical conductivity (1:2.5, soil: water extract) of 0.11dSm\(^{-1}\). Experimental field was prepared by harrow ploughing and two deep ploughing by tractor drawn culture followed by pre-sowing irrigation; the field was finally prepared by disc harrow followed by planning. In order to created ideal condition for good germination, pre-sowing Irrigation was given 10 days before sowing. Various doses of urea, DAP and MOP along with Vermicompost and Sesbaniarostrata as per treatment requirement were applied in different plots, except T\(_1\) where no fertilizers were used. 50% of nitrogen, full dose of phosphorus and potash was applied as basal and remaining 50% nitrogen top dressing in two equal splits.

Data collection

Various rise growth parameters viz., plant height (cm), number of tillers per meter row length and dry matter accumulation (g/plant) was recorded at maturity and yield attributes were also measured at maturity stage. Grain yield was estimated by the obtained produce from net plot area, treatment wise and finally expressed at 14 % moisture from 20 m\(^2\).

Nitrogen use efficiency

The efficiency of applied nitrogen is to be begin by these factor. The important benefit of this index is that, it put a figure on entire economic output from any particular source of nutrient, factor connected to its consumption from all possessions, comprising nutrients from applied inputs and native soil nutrients (Doberman et al. 2002). The following expressions are to be used for determine nitrogen used efficiency:

1. Agronomic efficiency of applied nitrogen (AE\(_N\))

\[ AE_N = \frac{GY+ - GY_{0N}}{FN} \]

Where,

- \( GY+ \) is the grain yield in a treatment with nitrogen application in kg ha\(^{-1}\).
- \( GY_{0N} \) is the grain yield without nitrogen application, and FN is the amount of fertilizer nitrogen applied, all in kg ha\(^{-1}\).

2. Recovery efficiency of applied nitrogen (RE\(_N\))

\[ RE_N = \frac{UN+ - UN_{0N}}{FN} \]

Where,

- \( UN+ \) is the total nitrogen uptake measured in above ground biomass at physiological maturity (kg ha\(^{-1}\)) in a plots that received applied N at the rate of FN (kg ha\(^{-1}\)).

3. Partial factor productivity (PFP\(_N\))

\[ PFP_N = \frac{GY+}{FN} \]

Where,

- \( GY+ \) is the grain yield in kg ha\(^{-1}\) and FN is the amount of fertilizer nitrogen
applied in kg ha$^{-1}$.

4. **Physiological efficiency of applied nitrogen (PE$_{N}$)**

$$\text{PE}_N = \frac{\text{kg grain yield increase per kg fertilizer nitrogen taken up}}{\text{kg grain yield increase per kg fertilizer nitrogen taken up}}$$

$$\text{GY}_{+N} - \text{GY}_{0N} / (\text{UN}_{+N} - \text{UN}_{0N})$$

Where,

- $\text{GY}_{+N}$ is the grain yield in a treatment with nitrogen application in kg ha$^{-1}$.
- $\text{GY}_{0N}$ is the grain yield in a treatment without nitrogen application in kg ha$^{-1}$.
- $\text{UN}_{+N}$ are the total N uptake in a treatment with nitrogen application in kg ha$^{-1}$.
- $\text{UN}_{0N}$ is the total N uptake in a treatment without nitrogen application in kg ha$^{-1}$.

**Statistical analysis:** The data on various parameters were exposed to statistically analyze as drew by Gomez and Gomez (1984). The treatment variances were tested by using “F” test and critical differences (at 5 per cent probability).

**Results and discussion**

**Growth parameters:** Significantly maximum plant height (86.80 cm) and number of tillers per meter row length (49.30) recorded with the application of (T$_3$) 50% N as basal through dhaincha and rest 50% N through urea, as 37.5% at maximum tillering and 12.5% at panicle initiation, It remained at par with T$_2$, T$_4$ to T$_8$ and significantly higher than rest of the treatment. Although nitrogen availability did not differ significantly among the fertilized treatments but still higher growth parameters in said treatments may be supposed due to supplementation of micronutrients through the faster decomposition of added dhaincha. Nitrogen is the main regulator of rice productivity. This is a constituent of all protein and non-protein components in rice. An adequate supply of N is associated with high photosynthetic activity, vigorous vegetative growth and a dark green colour. The supply of sufficient N at early growth stage maximizes the plant growth. Mirza et al. (2009), they observed the maximum growth with application of urea in two equal splits at all of the growth stages along with organic manures as a basal. Moreover shortest plant height and number of tillers per meter row length was measured under control plot which might be due to restricted supply of primary nutrients in unfertilized plot and deficient of NPK in experimental soil.

**Yield attributes and yield:** Maximum yield contributing traits viz., panicle length (24.30 cm) and number of grains per panicle (65.60) was observed with the application of 50% basal N through dhaincha and 37.5% and 12.5% N through urea, at maximum tillering and panicle initiation, respectively while minimum attributes were found in control plot (Table 2). This could be due to additional supply of micronutrients through dhaincha at early stage of crop which had responded for higher leaf area, biomass coupled with more number of tillers. These results are in line with the findings of Alam et al. (2010) and Coventry et al. (2011). Whereas, Ravi and Srivastava (1997) reported that combined application of vermicompost and inorganic fertilizers recorded significantly higher yield contributing traits of rice compared to application of inorganic fertilizer alone. Substitution of 37.5 to 50% N though dhaincha was found better than vermicompost by recording more yield contributing traits. This might be due to faster mineralization of dhaincha than vermicompost and indirectly due to rhizosphere effect in increasing the microbial population. Minimum and significantly lowest number of grain panicle$^{-1}$ than the remaining treatments were found in control plot.

Maximum grain yield was registered under the application of 50% N as basal through dhaincha + 37.5, and 12.5% N through urea, at maximum tillering and panicle initiation respectively (T$_3$) as compared to all other treatments. The increment of yield under this treatment may be attributed to scheduling of N
where 37.5% N was applied at maximum tillering stage that lead the production of new meristemic tissue by better growth performance and favourable source, sink relationship. The results is in close conformity of Coventry et al. (2011) and Devi et al. (2012). Moreover, higher straw yield was produced under combined application of 37.5% N as basal through dhaincha + 47.0, and 15.5% N as through urea, at maximum tillering and panicle initiation respectively over rest of the counterparts. While, minimum and significantly lowest yields than the reaming treatments was found in control plot. Applying higher quantity of N at tillering stage accumulate more dry matter and increase the vegetative growth compared to other splits. Devi et al. (2012) observed that grain yield of scented rice obtained higher value with highest level of nitrogen i.e. 175 kg/ha comparable with 150 kg/ha with four equal splits of nitrogen at ¼ basal + ¼ at active tillering + ¼ at panicle initiation and ¼ at heading due to increase yield attributes and growth parameters.

Nitrogen use efficiency: The values of all nitrogen use efficiency (NiUE) in India were lower as against global. Moreover, values of NiUE in the field experiment in western U. P. showed that, N is much more efficiently utilized in world as compared with western U. P. in India. Consequently, in western U. P., there is a considerable scope for increase efficiency of nitrogenous fertilizer (Naresh et al., 2014). Maximum agronomic efficiency and apparent N recovery efficiency recorded with the integration of N as 50% basal though dhaincha and 37.5 and 12.5% N though urea at maximum tillering and panicle initiation (T3) was significantly higher than most of the treatments (Fig. 1 to 3). Whereas, maximum physiological efficiency was recorded with the application of 50% N as basal through vermicompost + 12.5, and 37.5% N as through urea, at maximum tillering and panicle initiation respectively. Among the integrated nitrogen treatments, agronomic efficiency and apparent N recovery efficiency was higher for those treatments where N was supplied through dhaincha rather than vermicompost. Higher nitrogen use efficiency and more recovery of applied nitrogen in T3 may be supposed possibly due to reduced N losses through volatilization and denitrification from added dhaincha which releases nitrogen slowly. Similar opinion was also put forward in rice (Naresh et al., 2016).

Table 1: Composition of vermicompost and Sesbaniarostrata

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Nutrient Content</th>
<th>Vermicompost</th>
<th>Sesbaniarostrata</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>N %</td>
<td>2.80</td>
<td>2.71</td>
</tr>
<tr>
<td>2</td>
<td>P %</td>
<td>1.01</td>
<td>0.53</td>
</tr>
<tr>
<td>3</td>
<td>K %</td>
<td>1.81</td>
<td>2.21</td>
</tr>
<tr>
<td>4</td>
<td>Fe mg kg⁻¹</td>
<td>321.0</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>Mn mg kg⁻¹</td>
<td>105.0</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>Zn mg kg⁻¹</td>
<td>41.0</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>Cu mg kg⁻¹</td>
<td>29.0</td>
<td>-</td>
</tr>
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</table>
Table 2: Effect of different nitrogen scheduling on growth, yield attributes and yield of basmati rice

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Growth attributes at harvest</th>
<th>Yield attributes</th>
<th>Yields (qha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plant height (cm)</td>
<td>Number of tillers per meter row length</td>
<td>Dry matter accumulation (qha⁻¹)</td>
</tr>
<tr>
<td>T₁</td>
<td>61.80</td>
<td>34.17</td>
<td>72.91</td>
</tr>
<tr>
<td>T₂</td>
<td>85.10</td>
<td>47.97</td>
<td>135.16</td>
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<td>T₃</td>
<td>86.80</td>
<td>49.30</td>
<td>142.71</td>
</tr>
<tr>
<td>T₄</td>
<td>84.70</td>
<td>47.33</td>
<td>135.00</td>
</tr>
<tr>
<td>T₅</td>
<td>81.60</td>
<td>47.00</td>
<td>132.00</td>
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<tr>
<td>T₆</td>
<td>80.60</td>
<td>45.20</td>
<td>128.12</td>
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<tr>
<td>T₇</td>
<td>85.20</td>
<td>46.67</td>
<td>133.33</td>
</tr>
<tr>
<td>T₈</td>
<td>83.80</td>
<td>45.86</td>
<td>128.00</td>
</tr>
<tr>
<td>T₉</td>
<td>78.30</td>
<td>44.83</td>
<td>125.00</td>
</tr>
<tr>
<td>T₁₀</td>
<td>77.60</td>
<td>43.20</td>
<td>123.00</td>
</tr>
<tr>
<td>SEm±</td>
<td>2.83</td>
<td>1.34</td>
<td>6.97</td>
</tr>
<tr>
<td>CD at 5%</td>
<td>8.49</td>
<td>4.03</td>
<td>20.88</td>
</tr>
</tbody>
</table>

Fig. 1: Effect of different treatments on Agronomic efficiency
Conclusion

On the basis of experimental findings it can be concluded in the soil with extremely low nitrogen availability for achieving maximum yield and nitrogen use efficiency application of 50% N as basal through dhaincha + 37.5, and 12.5% N as through urea, at maximum tillering and panicle initiation, respectively, is best option.

References

4. Coventry, D.R., Yadav, A., Poswal, R.S., Sharma, R.K., Gupta, R.K., Chhokar, R.S., Gill, S.C., Kumar, V., Kumar, A.,


