Effect of tillage, nitrogen and zinc management on yield and yield components of wheat (*Triticum aestivum*) in North Eastern Plains Zone of India

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**ABSTRACT**

A field experiment was conducted during the winter (*rabi*) seasons of 2014–15 and 2015–16 at Prayagraj, Uttar Pradesh, to evaluate the effect of tillage practices, nitrogen and zinc management on productivity and quality of wheat (*Triticum aestivum* L.) in the North Eastern Plains Zone (NEPZ) of India. Treatments consisted of combinations of 2 tillage practices mainplots, viz. Conventional tillage (T1) and minimum tillage (T2) with different sources of organic manure and nitrogen management, viz. N0 (control); N1, [50% recommended dose of N (RDN) through (urea + diammonium phosphate (DAP) fertilizer)] + 50% RDN through FYM; N2, (25% RDN through (urea + DAP fertilizer) + 75% RDN through FYM; N3, 50% RDN through (urea + DAP fertilizer) + 50% RDN through vermicompost; N4, 25% RDN through (urea + DAP fertilizer) + 75% RDN through vermicompost; and N5, 100% RDN through (urea + DAP fertilizer), in subplots and 0.5% zinc foliar spray (Z1) along with the control (no foliar spray, Z0) were taken in sub-subplots in a split-split plot design with 3 replications. Pooled data indicated that, crop cultivated by conventional tillage resulted in significantly the highest grain yield (3.89 t/ha) and gross returns (¥93,507/ha). However, significantly the highest benefit: cost ratio (1.407) was evident in conservation tillage-based minimum tillage. In balanced nitrogen-fertilization treatment N3 significant and maximum grain yield (4.14 t/ha), straw yield (8.39 t/ha) and gross returns (¥10,025/ha) were obtained. Significant and maximum soil-fertility status was recorded for available N, P, K and B contents in treatment N4. Significantly the highest net returns (¥62,285/ha) and benefit: cost ratio (1.944) were noted in the treatment N5. In zinc foliar spray, significantly higher grain (3.86 t/ha) and straw yields (7.86 t/ha), gross returns (¥93,312/ha), net returns (¥53,251/ha) and benefit: cost ratio (1.372) with soil fertility N (245.54 ppm) were recorded in treatment Z1. Interaction of T1N3Z1 treatment resulted significantly higher grain yield. However, significantly higher net returns were recorded in T1N5Z1. The benefit: cost ratio was maximum in interaction of T2N5Z1.

**Key words**: Growth, Nitrogen management, Tillage practices, Wheat, Yield, Zinc foliar spray

Tillage helps in controlling weeds by burying weed seeds and emerged seedlings leaving a rough surface to hinder weed seed germination, expose underground parts of perennial weeds leading to their desiccation (Subbulakshmi, 2007). Integrated use of organic manures and fertilizers not only helps to maintain the highest productivity but also provides stability in crop production. However, one of the demerits of use of organic manures is that they may carry weed seeds which results not only in weed infestation but also introduces new weed species. The interactive advantages of combining organic and inorganic sources of nutrients in integrated nutrient management have shown additive effect in comparison to the use of each component separately.

Besides, organic manures also supply the traces of micronutrients which are not supplied by chemical fertilizers. Therefore, it is needed to compare various organic manures with chemical fertilizers to find out the most effective combinations. The integrated nutrient management (INM) system envisages use of organic manures and biofertilizers with inorganic nutrient sources. Nitrogen is the key element for plant growth and development, as it is a constituent of chlorophyll. Judicious use of nitrogen is of vital important to exploit the production potential of crop.
Plant nutrients can be supplied from different sources, viz. organic manures, crop residues, chemical fertilizers and bio-fertilizers. For better utilization of resources and to produce crops with less expenditure, integrated nutrient management is the best approach. The supplementary and complementary use of organic manures, viz. FYM, vermicompost, castor cake and inorganic fertilizers plays an important role in the growth and development of crop.

The integrated approach of nutrient supply by using organic, inorganic and bio-fertilizers is gaining importance, because this system not only reduces the use of costly inorganic fertilizers, but also it is an eco-friendly approach. Integrated nitrogen management supply system may offer a new vista to utilize resources available with farmer for intensive production of wheat.

The Consultative Group on International Agricultural Research (CGIAR) has promoted research aimed at developing new cultivars with higher grain Zn concentration and bioavailability (Bouis, 2003). Zinc fertilization has been used widely in recent years to alleviate Zn deficiency separately:

The prevailing market prices taken for calculation (रू./kg) were (grain and wheat straw 15.00 and 4.00 for 2014–15, 16.00 and 4.50 for 2015–16), respectively.

The data recorded during the course of investigation were subjected to statistical analysis as per method of analysis of variance (Fisher, 1950).

RESULTS AND DISCUSSION

Effect of tillage practices

Significantly highest grain yield was found in the tillage practices treatment T1 [conventional tillage (1 ploughing by tractor drawn disc plough + 2 harrowing + 1 fb cultivator with planking)] in pooled analysis, being superior to T2, minimum tillage 1 ploughing by tractor-drawn rotavator. The magnitude of increase in grain yield under (T1) conventional tillage was 8.05% over cultivation of (T2) minimum tillage (Table 4). On the other hand, weight of the grains/spike, length of spike and number of spikelets/spike were found to be non-significant.

Crop cultivated with T1 treatment showed significantly the highest gross returns owing to increase in yield under conventional tillage (Table 4). Non-significant maximum net returns were found in similar treatment. The positive effect of conventional tillage on yield was well reflected into more favourable economics for wheat production. Results confirm the finding of Nandan et al. (2018).

However, T2 [Minimum tillage (1 ploughing by tractor drawn rotavator)] resulted in significantly the highest benefit: cost ratio (Table 4). Higher benefit: cost ratio in minimum tillage can be attributed mainly to reduced cost of production. It might be owing to minimum tillage resulted in lower cost of cultivation because of less use of machin-
ery, labour and less fuel cost. These results are in agreement with the findings Nandan et al. (2018).

In order to judge the competitive ability of tillage practices, the nutrient status of the soil was assessed. Among the tillage-practices treatments, the soil total available nitrogen was not affected by tillage practices in pooled results. On an average, the nitrogen, phosphorus and potassium increased by 3.34%, 1.22% and 1.17% in association with minimum tillage respectively (Table 6). These might be the lowest values of soil N, P and K which were recorded in conventional till plots and could be due to the inversion of top-soil during ploughing which shifted less fertile subsoil to the surface in addition to possible leaching. Available N, P and K contents of the soil at wheat harvesting were not affected significantly due to tillage methods. Contrarily, the minimum tillage plots recorded numerically higher content of available nutrients which may be attributed to retention of previous crop residues and less leaching losses under minimum tillage. The minimum tillage plots showed gradual improvement in conservation of resources, soil physical properties and soil-moisture content. This is in confirmation to the findings of Busari et al. (2015). On the other hand, solubilization of native phosphorus by the organic acids produced during decomposition of stubbles under minimum tillage could be the reason for higher P availability besides stubble decomposition might have released some amount of K in addition under minimum tillage than conventional tillage (Chatterjee et al., 2016).

Effect of nitrogen management

Nitrogen-management treatment N₃ [50% RDN

<table>
<thead>
<tr>
<th>Table 1. Macro-and micro-nutrient availability of soil at pre-experimental stage</th>
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</thead>
<tbody>
<tr>
<td>Soil properties</td>
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<td></td>
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<tr>
<td>Available nitrogen (kg/ha)</td>
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<td>Available phosphorus (kg/ha)</td>
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<td>Available potassium (kg/ha)</td>
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<td>Available boron (ppm)</td>
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<td>Available iron (ppm)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2. Nutrients availability in applied manures and fertilizers</th>
</tr>
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<tbody>
<tr>
<td>Manures and fertilizers</td>
</tr>
<tr>
<td>-------------------------</td>
</tr>
<tr>
<td>Farm yard manure (FYM)</td>
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<tr>
<td>Vermicompost (VC)</td>
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<tr>
<td>Urea (U)</td>
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<tr>
<td>Diammonium phosphate (DAP)</td>
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<td>Muriate of potash (MOP)</td>
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<tr>
<td>Zinc sulphate (ZnSO₄)</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Table 3. Details of applied manure and fertilizers quantity</th>
</tr>
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<tbody>
<tr>
<td>Treatment combination</td>
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<tr>
<td>-----------------------</td>
</tr>
<tr>
<td>Nitrogen management</td>
</tr>
<tr>
<td>N₀</td>
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<td>N₁</td>
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<tr>
<td>N₂</td>
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<tr>
<td>N₃</td>
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<td>N₄</td>
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<tr>
<td>Zinc foliar spray (Z)</td>
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<td>Z₀</td>
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<tr>
<td>Z₁</td>
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</tbody>
</table>

*5 kg of ZnSO₄ and 2.5 kg of slaked lime is dissolved in 1,000 litres water to spray an area of 1 ha 35 days after sowing. (Prasad, 2012).
through Urea + DAP fertilizer + 50% RDN through vermicompost] resulted in significantly higher grain and straw yields and was superior to the other nutrient management treatments (Table 4). The grain yield, based on pooled analysis, increased to the tune of 55.63, 8.66, 5.34, 4.81 and 4.54% in N3 treatment over N0, N2, N1, N5 and N4. The increment in yield might be owing to favourable effect of N on growth parameter and yield-attributing characters. Our findings confirm the results of Nasrollahzadeh et al. (2015). On the other hand, weight of the grains/spike, length of spike and number of spikelets/spike found non-significant.

The probable reason might be the grain and straw yields being function of cumulative effect of growth and yield-attributing characters owing to fertilization. The results are in close agreement with the findings of Singh et al. (2011). Other possible reasons for more grain yield that nitrogen availability rate and mineralization losses might be responsible for variation in grain yield under different organic sources. However, compensation and deficit of nitrogen from recommended nitrogen doses perhaps caused the yield variation. Concentration variation in FYM and vermicompost resulted variation in yield. Kumar and Dhar (2009) also reported such results.

The increase in grain yield might be owing to photosynthesis which is a key factor affecting crop yield and the effects of N nutrition on yield may be driven primarily by photosynthesis (Makino, 2011). Low N supply generally decreased photosynthesis in crops (Miranzadeh et al., 2011; Zhang et al., 2017) and our results confirm these findings.

Crop fertilized with N1 [50% RDN through urea + DAP fertilizer + 50% RDN through vermicompost resulted in significantly higher gross returns because nitrogen management significantly increased the yield owing to organic and inorganic nitrogen application (Table 4). Among the nitrogen management, crop fertilized with N1 100% RDN through urea + DAP fertilizer) recorded significantly the highest net returns and benefit: cost ratio. Maximum benefit: cost ratio was 54.16% higher than with the control in a nitrogen management. The crop fertilized with 0 kg N0/ha in a nitrogen management showed negative benefit: cost ratio due to very poor yield. The variations in the cost of cultivation under different treatments were recorded due to variable cost of fertilizers. These results are in close conformity with the findings of Reddy et al. (2009).

The available status of major nutrients such (N, P and K) was enhanced due to application of different forms of organic manures. Total N, P and K content of the soil before the experiment was 243.39, 244.85 and 244.12 kg/ha; 22.19 24.30 and 23.24 kg/ha; and 261.76, 269.48 and 265.62 kg/ha during both the years and average and after the experiment a significant improvement in N, P and K status of the soil (Table 1). At the end of the experiment, in this respect treatment N1 [25% RDN through urea + DAP fertilizer + 75% RDN through vermicompost enhanced the N, P and K in the soil by about 4.19, 0.54 and 9.99% from the initial status (Table 6). This might be owing to addition of vermicompost that directly resulted in increases of organic carbon content of the soil, while increases in nitrogen content as a result of organically bond nitrogen converted to mineralizable from N, P as a result of organic materials reducing P-fixing capacity of the soil and available K due to release non-exchangeable K from the soil. This released K and also applied K not only met crop requirement but also build up available K content of the soil. Our results confirm findings of Ahamad et al., (2018).

The decrease in available NPK status of soil was recorded in the control where no fertilizer was applied to the crop. The beneficial effect of conjoint use of inorganic and organic sources of nutrients can be owing to the release of nutrients from the organic sources through mineralization. The increased P-availability might be the result of more solubilization of native and applied P due to the combined solubilizing effect of organic acids produced on decomposition of organic manures and also because of presence of P-solubilizing microorganisms, resulting in lesser P-fixation by the soils rendering it available for crop uptake Sepat et al. (2010). Besides, vermicompost contain high amounts of macro-and micronutrients, which are often present in high enough quantities to facilitate high crop yields when used in conjunction with or in place of synthetic mineral fertilizers (Arancon et al., 2003). The chemical properties of vermicompost are highly variable. Rao et al. (2014) also concluded that though organic farming had an edge over inorganic farming to sustain the soil health. Yadav et al. (2009) also reported improved soil health with the organic manure.

**Effect of zinc foliar spray**

Between the zinc treatments, the maximum grain yield of wheat was recorded with Z1 (0.5 % Zinc foliar spray/ha through ZnSO4), which was 6.33% higher than the control (Table 4). The increment in yield might be owing to favourable effect of Zn on growth parameter and yield-attributing characters. Our results confirm findings of Singh and Singh (2007). The increase in grain yield might be owing to the favourable influence of Zn application on the grain yield may be attributed to its role in various enzymic reactions, growth processes, hormone production and protein synthesis and also the translocation of photosynthates to reproductive parts, thereby leading to higher
Table 4. Effect of tillage practices, nitrogen management and zinc foliar spray on grain yield, straw yield, weight of the grains per spike, length of spike (cm), spikelets/spike and economics of wheat (pooled data of 2 years)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Grain yield (t/ha)</th>
<th>Straw yield (t/ha)</th>
<th>Weight of the grains/spike</th>
<th>Length of spike (cm)</th>
<th>Spikelets/spike</th>
<th>Gross returns (× 10^3) ₹/ha</th>
<th>Net returns (× 10^3) ₹/ha</th>
<th>Benefit: cost ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tillage practices (T)</strong></td>
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</tr>
<tr>
<td>T₁, Conventional tillage (1 ploughing by tractor drawn disc plough + 2 harrowing + 1 ) fb cultivator with planking</td>
<td>3.89</td>
<td>7.77</td>
<td>1.55</td>
<td>9.37</td>
<td>16.24</td>
<td>93.51</td>
<td>51.08</td>
<td>1.239</td>
</tr>
<tr>
<td>T₂, Minimum tillage (1 ploughing by tractor drawn rotavator)</td>
<td>3.60</td>
<td>7.56</td>
<td>1.49</td>
<td>9.30</td>
<td>15.88</td>
<td>88.01</td>
<td>51.07</td>
<td>1.407</td>
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<td><strong>Nitrogen management (N)</strong></td>
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</tr>
<tr>
<td>N₀, Control</td>
<td>2.66</td>
<td>5.65</td>
<td>1.36</td>
<td>9.11</td>
<td>15.29</td>
<td>65.28</td>
<td>36.48</td>
<td>1.261</td>
</tr>
<tr>
<td>N₁, 50% RDN through (urea + DAP fertilizer) + 50% RDN through FYM</td>
<td>3.93</td>
<td>7.82</td>
<td>1.63</td>
<td>9.35</td>
<td>15.99</td>
<td>94.31</td>
<td>54.62</td>
<td>1.383</td>
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<tr>
<td>N₂, 25% RDN through (urea + DAP fertilizer) + 75% RDN through FYM</td>
<td>3.81</td>
<td>8.09</td>
<td>1.50</td>
<td>9.39</td>
<td>16.12</td>
<td>93.63</td>
<td>49.97</td>
<td>1.148</td>
</tr>
<tr>
<td>N₃, 50% RDN through (urea + DAP fertilizer) + 50% RDN through vermicompost</td>
<td>4.14</td>
<td>8.39</td>
<td>1.58</td>
<td>9.40</td>
<td>16.36</td>
<td>100.25</td>
<td>54.71</td>
<td>1.199</td>
</tr>
<tr>
<td>N₄, 25% RDN through (urea + DAP fertilizer) + 75% RDN through vermicompost</td>
<td>3.96</td>
<td>8.23</td>
<td>1.47</td>
<td>9.32</td>
<td>16.28</td>
<td>96.57</td>
<td>48.27</td>
<td>1.004</td>
</tr>
<tr>
<td>N₅, 100% RDN through (urea + DAP fertilizer)</td>
<td>3.95</td>
<td>7.82</td>
<td>1.58</td>
<td>9.44</td>
<td>16.30</td>
<td>94.49</td>
<td>62.29</td>
<td>1.944</td>
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<tr>
<td><strong>Zinc foliar spray (Z)</strong></td>
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<tr>
<td>Z₀, Control</td>
<td>3.63</td>
<td>7.48</td>
<td>1.50</td>
<td>9.30</td>
<td>16.02</td>
<td>88.20</td>
<td>48.87</td>
<td>1.274</td>
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<tr>
<td>Z₁, 0.5% Zinc foliar spray/ha through ZnSO₄</td>
<td>3.86</td>
<td>7.86</td>
<td>1.54</td>
<td>9.37</td>
<td>16.09</td>
<td>93.31</td>
<td>53.25</td>
<td>1.372</td>
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<tr>
<td><strong>Interaction CD (P=0.05)</strong></td>
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<tr>
<td>N × T</td>
<td>0.38</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>6.67</td>
<td>6.67</td>
<td>0.175</td>
</tr>
<tr>
<td>Z × T</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>3.39</td>
<td>3.39</td>
<td>0.079</td>
</tr>
<tr>
<td>N × Z</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>0.136</td>
</tr>
<tr>
<td>T × N × Z</td>
<td>0.54</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>8.30</td>
<td>8.30</td>
<td>0.192</td>
</tr>
</tbody>
</table>

NS, Non-significant
Table 5. Interaction effect of tillage practices x nitrogen management x zinc foliar spray on grain yield and economics of wheat (pooled data of 2 years)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Grain yield (t/ha)</th>
<th>Net returns ($10^3$/ha)</th>
<th>Benefit: cost ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$Z_0$</td>
<td>$Z_1$</td>
<td>Mean</td>
</tr>
<tr>
<td>$T_1$ N$_0$</td>
<td>2.57</td>
<td>3.60</td>
<td>3.09</td>
</tr>
<tr>
<td>N$_1$</td>
<td>3.86</td>
<td>4.14</td>
<td>4.00</td>
</tr>
<tr>
<td>N$_2$</td>
<td>4.05</td>
<td>3.73</td>
<td>3.89</td>
</tr>
<tr>
<td>N$_3$</td>
<td>4.13</td>
<td>4.38</td>
<td>4.26</td>
</tr>
<tr>
<td>N$_4$</td>
<td>3.59</td>
<td>4.21</td>
<td>3.90</td>
</tr>
<tr>
<td>N$_5$</td>
<td>4.11</td>
<td>4.37</td>
<td>4.24</td>
</tr>
<tr>
<td>Mean</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>SEm±</td>
<td>–</td>
<td>–</td>
<td>0.19</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>–</td>
<td>–</td>
<td>0.54</td>
</tr>
</tbody>
</table>

$T_1$, Tillage practices; $T_2$, conventional tillage (1 ploughing by tractor drawn disc plough + 2 harrowing + 1 fb cultivator with planking); $T_3$, minimum tillage (1 ploughing by tractor drawn rotavator); $N_0$, control; $N_1$, 50% RDN through (urea + DAP) fertilizer + 50% RDN through FYM; $N_2$, 25% RDN through (urea + DAP) fertilizer + 75% RDN through FYM; $N_3$, 50% RDN through (urea + DAP) fertilizer + 50% RDN through vermicompost; $N_4$, 25% RDN through (urea + DAP) fertilizer + 75% RDN through vermicompost; $N_5$, 100% RDN through (urea + DAP) fertilizer; $Z_0$, control, $Z_1$, 0.5% Zinc foliar spray/ha through ZnSO$_4$

Table 6. Fertility status of soil after crop harvesting as influenced tillage practices, nitrogen management and zinc foliar spray in wheat (pooled data of 2 years)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>N (kg/ha)</th>
<th>P (kg/ha)</th>
<th>K (kg/ha)</th>
<th>Boron (ppm)</th>
<th>Iron (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_1$, conventional tillage (1 ploughing by tractor drawn disc plough + 2 harrowing + 1 fb cultivator with planking)</td>
<td>237.82</td>
<td>18.83</td>
<td>264.60</td>
<td>0.612</td>
<td>8.38</td>
</tr>
<tr>
<td>$T_2$, Minimum tillage (1 ploughing by tractor drawn rotavator)</td>
<td>245.78</td>
<td>19.06</td>
<td>267.71</td>
<td>0.623</td>
<td>8.44</td>
</tr>
<tr>
<td>$N_0$, Control</td>
<td>216.67</td>
<td>16.88</td>
<td>255.27</td>
<td>0.499</td>
<td>8.09</td>
</tr>
<tr>
<td>$N_1$, 50% RDN through (urea + DAP fertilizer) + 50% RDN through FYM</td>
<td>249.64</td>
<td>18.81</td>
<td>277.20</td>
<td>0.634</td>
<td>8.50</td>
</tr>
<tr>
<td>$N_2$, 25% RDN through (urea + DAP fertilizer) + 75% RDN through FYM</td>
<td>245.54</td>
<td>17.75</td>
<td>265.07</td>
<td>0.614</td>
<td>8.33</td>
</tr>
<tr>
<td>$N_3$, 50% RDN through (urea + DAP fertilizer) + 50% RDN through vermicompost</td>
<td>246.08</td>
<td>18.88</td>
<td>264.13</td>
<td>0.638</td>
<td>8.50</td>
</tr>
<tr>
<td>$N_4$, 25% RDN through (urea + DAP fertilizer) + 75% RDN through vermicompost</td>
<td>253.59</td>
<td>22.31</td>
<td>287.93</td>
<td>0.695</td>
<td>8.57</td>
</tr>
<tr>
<td>$N_5$, 100% RDN through (urea + DAP fertilizer)</td>
<td>239.26</td>
<td>19.06</td>
<td>247.33</td>
<td>0.623</td>
<td>8.49</td>
</tr>
</tbody>
</table>

$T, T_1, T_2$, Tillage practices; $N_0$, control; $N_1$, 50% RDN through (urea + DAP) fertilizer + 50% RDN through FYM; $N_2$, 25% RDN through (urea + DAP) fertilizer + 75% RDN through FYM; $N_3$, 50% RDN through (urea + DAP) fertilizer + 50% RDN through vermicompost; $N_4$, 25% RDN through (urea + DAP) fertilizer + 75% RDN through vermicompost; $N_5$, 100% RDN through (urea + DAP) fertilizer; $Z_0$, control, $Z_1$, 0.5% Zinc foliar spray/ha through ZnSO$_4$.
yield of the crop. On the other hand, weight of the grains/spike, length of spike and number of spikelets/spike found to be non-significant.

The maximum gross returns, net returns and benefit: cost ratio were recorded with Z treatment as a result of significant increase in yield owing to foliar spray of zinc application (Table 4).

Available boron and iron content of the soil before the experiment (0.55, 0.58 and 0.56 ppm and 8.35, 8.47 and 8.41 ppm) during both the years and average, and after the experiment there was significant improvement up to some extent in the boron and iron content status of the soil (Table 1). At the end of the experiment, treatment N4 [25% RDN through urea + DAP fertilizer + 75% RDN through vermicompost enhanced the boron, iron in the soil by about 12.36 and 0.23 from the initial status in pooled analysis (Table 6).

**Interaction effect**

Regarding interaction effect of tillage practices, nitrogen management and zinc foliar spray showed significantly higher grain yield in T N Z, during pooled analysis (Table 5). This might be owing to creating favourable condition for crop growth resulting in superiority of yield and yield attributes. It also helped in the efficient absorption and utilization of the other required plant nutrients which ultimately increased the grain yield (Sepat and Rai, 2013).

The interaction effect of T × N × Z resulted in significantly higher net returns in the crop cultivated and fertilized with T N Z, owing to very higher yield (Table 5). In case of benefit: cost ratio, the significantly the highest was recorded with T N Z.

It can be concluded that for securing higher seed yield and gross return from wheat crop variety ‘HUW 234’, the land should be tilled with conventional tillage (1 ploughing by tractor-drawn disc plough + 2 harrowing + 1 fb cultivator with planking), apply 50% nitrogen–60 kg from urea (117.69 kg/ha) and DAP (32.60 kg/ha) fertilizers/ha as basal application and remaining top-dressing of 50% nitrogen [60 kg from manure fertilizer vermicompost (3,000 kg/ha) before sowing at land preparation] as well as foliar spray of zinc application 0.5% zinc sulphate (2.50 kg/ha) 35 day after sowing.

**REFERENCES**


