EFFECT OF HUMIC ACID ON MICRONUTRIENT AVAILABILITY AND GRAIN YIELD OF WHEAT (TRITICUM AESTIVUM L.)

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ABSTRACT

A field experiment was conducted at Institute of Soil Chemistry and Environmental Sciences, Ayub Agricultural Research Institute, Faisalabad, Pakistan during 2009 to 2012 to assess the improvement of the nutrients (Zn, Fe, Mn and B) availability for wheat crop with and without application of humic acid. Its effects ultimately on optimum grain yield for consecutive three years. Humic acid was tested with inorganic fertilizers as solid HA(s) 50 percent and liquid HA (l) 8 percent. There were six treatments of inorganic fertilizers with humic acid solid and liquid i.e. T1 (No fertilizer), T2 (NPK), T3 (NPK+ solid HA), T4 (NPK+ liquid HA), T5 (NPK+B+Zn) and T6 (NPK+B+Zn+ solid HA). Data on yield contributing components, grain and straw yield, uptake of different nutrients in grain were recorded. Results showed that integrated use of humic acid solid and inorganic fertilizers gave significantly similar yield. Three years pooled data showed that maximum yield contributing component were found in T4 (NPK + liquid HA) resulting in 82.6 cm plant height, 10 tillers per plant, 11.7 cm spike length, 49 grains per spike and 59.4 g weight per 1000 grain. Three years pooled wheat grain data showed that maximum grain yield (4.11 t/ha) was obtained in T4 followed by T5 (3.78 t/ha). Maximum nutrients were recorded in case of soil application of humic acid along with T4 showing 8 percent N, 82 percent Fe and 5 percent increase in Boron (B) over T4. It was concluded that humic acid increased N, Fe and B concentration and uptake in wheat grain. However, this increase did not contribute towards yield.

KEYWORDS: Triticum aestivum; wheat; humic acid; NPK; inorganic fertilizers; B; Zn; micronutrient; agronomic characters; grain yield; Pakistan.

INTRODUCTION

Wheat (Triticum aestivum) is an important cereal crop. Higher wheat yield has ever been demanded to feed the continuously growing world population. According to an estimate global demand for wheat in 2020 will be 50 percent

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more than today (38). The unprecedented drought conditions and low soil fertility severely affected the wheat grain yield referring the use of non-conventional approaches. High nitrogen levels are required to harvest optimum wheat yields, however incorporation with non-conventional approaches (like humic material) can enhance wheat yield and growers income. Humic acid is a heterogeneous combination of natural organic substances transformed from decay of animal and plant remains (1, 2, 42). A particular humic acid model have rings of aromatic compounds alongwith aliphatic chain structures that grouped several phenolic, hydroxyl, carboxylic or other functional groups (19, 27). These organic materials contain carbon which serves as food source, 42 to 46, 6 to 8 and 0.5 to 4 percent of oxygen, hydrogen and nitrogen, respectively alongwith different constituents (21, 22). Humic substances exists in recycled nutrient streams therefore the influence of these organic materials on flora and nutritional chemistry was estimated (24). In the global scenario, the humic substances play a significant role in N-cycle by affecting its bioavailability, fate of organic N and finally its re-distribution (13). Present agricultural systems are significantly supported by humic acid due to its potential to complex metal ions. Moreover, humic acid binds the colloidal surfaces of soil which ultimately protect the ions from leaching (39). Some toxic metal ions are firmly complexed by humic substances which ultimately make them unavailable to plants (7, 40). Soil physical, chemical and biological properties can significantly be improved with application of humic acid (9). Humic or fulvic-acids enhance root initiation and increase root growth, hence, both are correlated with more nutrient uptake either macronutrients (N, P, S) or micronutrients (Fe, Zn, Cu and Mn) (8, 24, 29).

Our soils are alkaline and exhibit deficiency of zinc and boron as reported by Rashid (30). Nutrients play a vital role in germination and healthy seedling establishment, therefore, their deficiency results in low grain yield (32). Keeping in view, present study was carried out to assess the improvement in nutrient uptake by wheat crop with or without application of humic acid and its effects on wheat grain yield.

**MATERIALS AND METHODS**

The study was conducted at Institute of Soil Chemistry and Environmental Sciences, AARI, Faisalabad during 2009-12 to evaluate the effect of humic acid on wheat (*Triticum aestivum* L. var. AARI-2011). The experiment was laid out in RCBD with three replications and 5 m × 7.5 m plot size. Six treatments viz. T₁ (No fertilizer), T₂ (NPK), T₃ (NPK+ solid HA), T₄ (NPK+ liquid HA), T₅ (NPK+B+Zn) and T₆ (NPK+B+Zn+ solid HA) were applied.
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Recommended dose of NPK (120-90-60) was applied with Zn (5 kg/ha) and B (51 kg/ha). Humic acid was applied in solid (HA_s) and liquid (HA_L) forms @ 15 kg per hectare and one litre per acre, respectively. The sources of fertilizers and humic acids were urea, SSP, SOP, H_3BO_3 (17 %), ZnSO_4 (18%), commercial granular humic acid solid (50%) and liquid (8%). Nitrogen was applied in two doses i.e. half at sowing, while half nitrogen and liquid humic acid at first irrigation.

Prior to fertilizer application and sowing of wheat composite soil samples were collected and analyzed for physico-chemical properties (Table 1). The data regarding yield contributing components viz. plant height, tillers per plant, spike length, number of grains per spike, 1000 grain weight, grain yield and straw yield were recorded (Table 2). The grain samples were dried at 70 °C till constant weight in an oven and ground in a Wiley micro mill and used for N, P, K, Zn, Fe, Mn and B analysis using standardized protocols and uptake was calculated.

Table 1. Soil physical and chemical properties before the start of experiment (three years pooled data).

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Units</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textural class</td>
<td></td>
<td>Sandy clay loam</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>7.70</td>
</tr>
<tr>
<td>EC_e</td>
<td>dSm⁻¹</td>
<td>2.55</td>
</tr>
<tr>
<td>O. M</td>
<td>%</td>
<td>0.78</td>
</tr>
<tr>
<td>Total nitrogen</td>
<td>Do</td>
<td>0.039</td>
</tr>
<tr>
<td>Available phosphorus</td>
<td>Ppm</td>
<td>7.8</td>
</tr>
<tr>
<td>Extractable K</td>
<td>Do</td>
<td>200</td>
</tr>
<tr>
<td>Zinc</td>
<td>Do</td>
<td>1.37</td>
</tr>
<tr>
<td>Copper</td>
<td>Do</td>
<td>1.30</td>
</tr>
<tr>
<td>Iron</td>
<td>Do</td>
<td>4.59</td>
</tr>
<tr>
<td>Manganese</td>
<td>Do</td>
<td>11.68</td>
</tr>
<tr>
<td>Boron</td>
<td>Do</td>
<td>0.35</td>
</tr>
</tbody>
</table>

For nitrogen estimation, the dried ground material (0.5 g) was digested in sulphuric acid using digestion mixture (CuSO_4, Se and FeSO_4), distilled and titrated against 0.1 N H_2SO_4 (16). Plant samples with tri-acid mixture of HNO_3·H_2SO_4·HClO_4 for the determination of total phosphorus by ammonium metavanadate yellow color method (17). Potassium and micronutrients were determined by following the method of Yoshida et al. (44). Soil samples were collected and analyzed for fertility status after harvesting (Table 3).

The soil pH was measured in a saturated soil paste and electrical conductivity (EC) of the soil extract by method described by Mclean (25).
organic carbon content (SOC) were worked out following the method used by Ryan et al. (31). Whereas, total nitrogen was calculated by the method of Bremner and Mulvaney (6). Available phosphorus was measured by Olsen’s method (34). Soil extraction was made with ammonium acetate (IN of pH 7.0) and potassium was determined by using PFP-7 Janway flame photometer (34). Micronutrients (Zn, Cu, Fe, Mn) were determined by extraction with DTPA following the method of Soltanpour and Schwab (41) and textural class by using hydrometer method (5). Statistical analysis was done by using the M-Stat computer program. ANOVA test following by least significance difference (LSD) test was used to determine the difference among the treatment means at 5 percent level of probability.

RESULTS AND DISCUSSION

Yield contributing parameters

Data (Table 2) showed that wheat responded significantly to treatments. Number of tillers per plant is an important parameter which contributes towards grain yield. Tillers per plant were maximum in both treatments i.e. T5 and T6 which revealed that tillering did not improve by humic acid application (10). The maximum plant height (82.6 cm, 81.0 cm), spike length (11.7 cm, 10.59 cm), maximum number of grains per spike (49, 48) and 1000 grain weight (59, 58 g) were found in T5 and T6, respectively. In the similar manner, the earlier workers reported that mineral fertilizers had significant effects on yield attributes (2, 4, 8, 11). However, the results showed that humic acid did not improve the yield contributing parameters. The results of yield contributing parameters are contrary to the theories of other scientists who proved that yield components significantly increased due to humic acid (3, 10).

Table 2. Yield contributing parameters (three years pooled data).

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Shoot length (cm)</th>
<th>Tillers/plant</th>
<th>Spike length (cm)</th>
<th>Grains/spike</th>
<th>1000 grain weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 = Control</td>
<td>71.3 f</td>
<td>6 d</td>
<td>8.91 f</td>
<td>36 e</td>
<td>45.7 f</td>
</tr>
<tr>
<td>T2 = NPK</td>
<td>74.0 e</td>
<td>8 c</td>
<td>9.82 e</td>
<td>45 d</td>
<td>55.6 e</td>
</tr>
<tr>
<td>T3 = NPK+ HA(s)</td>
<td>78.6 c</td>
<td>9 b</td>
<td>10.57 c</td>
<td>47 c</td>
<td>57.5 c</td>
</tr>
<tr>
<td>T4 = NPK+ HA(l)</td>
<td>78.3 d</td>
<td>9 b</td>
<td>10.38 d</td>
<td>45 d</td>
<td>57.0 d</td>
</tr>
<tr>
<td>T5 = NPK+ B+ Zn</td>
<td>82.6 a</td>
<td>10 a</td>
<td>11.70 a</td>
<td>49 a</td>
<td>59.4 a</td>
</tr>
<tr>
<td>T6 = NPK+ B+ Zn+ HA(s)</td>
<td>81.0 b</td>
<td>10 a</td>
<td>10.59 b</td>
<td>48 b</td>
<td>58.5 b</td>
</tr>
<tr>
<td>LSD</td>
<td>0.19</td>
<td>0.18</td>
<td>0.02</td>
<td>0.15</td>
<td>0.17</td>
</tr>
</tbody>
</table>

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Grain and straw yield

Data (Fig.1) showed that yield obtained from mineral fertilizers and humic acid applications was statistically at par. The highest wheat grain yield (4.10 t/ha) was recorded in T5 where NPK+B+Zn was applied followed by T6 (3.78 t/ha) where soil application of humic acid was used alongwith NPK+B+Zn. Minimum grain yield (2.18 t/ha) was recorded where no fertilizer was added. While humic acid liquid and solid application alongwith NPK produced 3.56 and 3.48 tons per hectare yield which is 6 percent and 4 percent higher than NPK alone application, respectively. Results also revealed that application of humic acid(s) + NPK is not enough to produce better yield. This improvement in yield was contributed by B and Zn application, as boron fertilization improved wheat cultivar yield and zinc is directly involved in germination and healthy seedling development (20). Some researchers also revealed that fertigation of humic acid combined with NPK fertilizer was more efficient than single N, P and K fertilizer in improving tuber yield quality (35). Similar results were also recorded in case of straw yield (Fig.2).
Nutrient uptake by wheat grain

The data (Fig. 3) show the macronutrient (N, P and K) uptake by grain. Maximum uptake of N (105 kg/ha) was observed in T6 which is 8 percent more than T5. Leaf interval chlorosis during early growth stage of wheat seedlings is ameliorated with the use of humic acid (23). Earlier scientists also supported the results that N uptake of wheat is increased with the use of soil applied humic acid (2). Phosphorus and potassium uptake (17.6 and 21.7 kg/ha) was more in T5 followed by T6 (16.6 and 20.3 kg/ha). The results of phosphorus and potassium uptake are not in line with those of earlier scientists (3, 4, 10, 14) who reported that humic acid application significantly increased nitrogen, phosphorus and potassium contents in plants.

The data presented in Fig. 4 showed that maximum uptake of Zn and Mn (153 and 255 g/ha) was found in T5 which is 6 and 10 percent more over the treatment where NPK+B+Zn were applied. Similar increase in uptake of nutrients (Fe and B) with humic acid application was also observed by earlier scientists (1, 14, 33, 37). Humic acid solid application with B and Zn (T6) increased the Fe and B uptake to 2910 and 15 gram per hectare as compared to T5 which gave Fe and B uptake as 1597 and 14 gram per hectare, respectively. It was inferred that increased uptake of micronutrients
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did not improve the wheat grain yield. The results related to Zn and Mn uptake are contrary to those of earlier scientists (10, 14, 37).

Fig. 3. Effect of humic acid on macronutrient (N, P and K) uptake in wheat grain.

Fig. 4. Effect of humic acid on micronutrient (Zn, Mn, B and Fe) uptake in wheat grain.
Post harvest soil analysis:

Soil organic matter (%): The combined effect of humic acid alongwith inorganic fertilizers on soil fertility analysis after harvest of crop is given in Table 3. Soil application of humic acid alongwith NPK+B+Zn slightly enhanced soil organic matter contents. It was 0.85 percent in T₆ as compared to 0.81 percent in T₅ receiving NPK+B+Zn alone. It showed that humic acid is an effective organic fertilizer to increase the carbon source of food and stimulate microbial activity.

Table 3. Post harvest soil analysis (three years pooled data).

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Organic matter (%)</th>
<th>P (ppm)</th>
<th>K (ppm)</th>
<th>Zn (ppm)</th>
<th>Fe (ppm)</th>
<th>Mn (ppm)</th>
<th>B (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₁ = Control</td>
<td>0.65 e</td>
<td>6.45 f</td>
<td>165 e</td>
<td>0.85 f</td>
<td>4.21 f</td>
<td>11.7 f</td>
<td>0.43 f</td>
</tr>
<tr>
<td>T₂ = NPK</td>
<td>0.77 d</td>
<td>7.67 e</td>
<td>173 d</td>
<td>1.13 e</td>
<td>4.72 e</td>
<td>12.9 e</td>
<td>0.48 e</td>
</tr>
<tr>
<td>T₃ = NPK + HA(s)</td>
<td>0.83 b</td>
<td>8.12 c</td>
<td>180 b</td>
<td>1.49 c</td>
<td>5.70 b</td>
<td>13.5 c</td>
<td>0.52 c</td>
</tr>
<tr>
<td>T₄ = NPK + HA(l)</td>
<td>0.80 c</td>
<td>7.99 d</td>
<td>178 c</td>
<td>1.27 d</td>
<td>5.20 c</td>
<td>13.3 d</td>
<td>0.50 d</td>
</tr>
<tr>
<td>T₅ = NPK + B + Zn</td>
<td>0.81 c</td>
<td>8.35 b</td>
<td>175 d</td>
<td>1.58 b</td>
<td>5.15 d</td>
<td>13.9 b</td>
<td>0.54 b</td>
</tr>
<tr>
<td>T₆ = NPK + B + Zn + HA(s)</td>
<td>0.85 a</td>
<td>10.35 a</td>
<td>198 a</td>
<td>1.60 a</td>
<td>6.22 a</td>
<td>14.2 a</td>
<td>0.57 a</td>
</tr>
<tr>
<td>LSD</td>
<td>0.018</td>
<td>0.017</td>
<td>0.636</td>
<td>0.018</td>
<td>0.018</td>
<td>0.159</td>
<td>0.019</td>
</tr>
</tbody>
</table>

Available P and K (ppm)

The available P and K were significantly increased with humic acid application in T₆ which is 23 percent and 13 percent more than T₅. The humic acid addition in soil resulted in phosphate dissolution that increased the availability of phosphorus. The results are in line with the work of earlier scientists (12, 15, 28). The results of potassium are in agreement with findings of scientists who reported that fixed K is released by humic acid (10, 43).

Available micronutrient Zn, Mn, Fe, B (ppm)

The data related to micronutrients showed that T₆ recorded maximum Zn (1.60 ppm), Cu (1.62 ppm), Fe (6.22 ppm), Mn (14.2 ppm) and B (0.57 ppm) which are 1 percent, 6 percent, 20 percent, 2 percent and 5 percent more than treatment T₅. Senn (36) revealed that humates are natural organic substances high in trace elements necessary for development of plant life and soil health. Further humic acid binds to soil colloidal surfaces, promotes heavy metal absorption (Zn, Mn, Cu, Fe) to soil minerals and enhance their availability (18,40). Humic acid chelated the micronutrients and increased the
solubility and their extractability. This may be the reason of Boron availability as it also goes inline with findings of earlier scientists (10, 26, 30).

CONCLUSION

This study concluded that soil application of humic acid in both forms (solid and liquid) did not improve wheat grain yield as compared to inorganic fertilizers like NPK+ B+ Zn. However as chelating agent, humic acid slightly increased the micronutrients in soil. It was also concluded that combined application of NPK+B+Zn with humic acid solid is better than NPK+HA(S) and NPK+HA (L). Organic fertilizers like humic acid have the ability to make soil perform better and improve its fertility.

REFERENCES


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**CONTRIBUTION OF AUTHORS:**

- **Shabana Ehsan**: Conducted the experiment in the field and prepared the writeup.
- **Shahid Javed**: Planned the research and review the literature.
- **Ifra Saleem**: Helped in experimental work.
- **Abid Niaz**: Reviewed the literature