Research Article

Effect of Soil Application of Humic Acid and Hydrogel on Morpho-Physiological and Biochemical Attributes of Potato (Solanum tuberosum L.)

Hafiz Nazar Faried1,*, Muhammad Aslam Pervez1, Choudhary Muhammad Ayyub1, Muhammad Yaseen2, Madiha Butt1 and Mohsin Bashir1

1Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan
2Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad, Pakistan

ARTICLE INFO

Received: May 27, 2013
Accepted: Aug 17, 2014
Online: Sep 10, 2014

Keywords
Biochemical
Humic acid
Hydrogel
Morpho-physiological
Potato

*Corresponding Author:
Hnfw1118@gmail.com

ABSTRACT

Effects of Humic acid and hydrogel with and without recommended dose of NPK in eight different treatments and four replications were studied. Humic acid revealed better results as compared to hydrogel for number of leaves, and potassium contents plant-1 whereas in all the other studied growth and yield parameters hydrogel performance was good. Overall results revealed that both humic acid and hydrogel improved nutrient’s uptake efficiency as well as reduce environmental pollution in agriculture. The treatment T7 (80 mg Hydrogel treatment (two doses) + NPK) exhibited highest tuber’s yield while T0 (control) reported minimum yield.

INTRODUCTION

Potato (Solanum tuberosum L.) is a starchy, tuberous crop belongs to the Solanaceae family (also known as the Nightshades). It is the world’s fourth largest food crop, following rice, wheat and maize. It is high yielding, having high nutritive value and gives high returns to farmers. Its area and production in Pakistan is 185.1(000 ha) and 4104.4 (000 tons), respectively, which increased by 16.5 % and 17.5 % during, 2011-12 (Anonymous, 2012). Potato is a shallow rooted crop. It requires high organic matter in the soil and heavy feeding. It is sensitive to the higher level of irrigation and the fertilizers, more preferably for the quality and high tuber yield (Peralta and Stockle, 2001). Soil health is a crucial factor for obtaining a higher yield in vegetable crops. In Pakistan, the soils are very poor in organic matter (< 1%) due to high temperature for most of the time of the year. It results in poor soil health and structure and subsequently, reduces microbial activity along-with plant growth and yield. So, there is a need to use traditional as well as non-traditional composts, as an effective mean for improving soil structure, fertility, moisture holding capacity and cation exchange capacity of soil. They also help in increasing microbial populations and activity (Marinari et al., 2000). Therefore, in order to feed increasing population, it is imperative to improve crop productivity with least effect on environment. This could only be achieved by an integration of conventional with non-conventional approaches (Humic acid, hydrogel etc.). Humic acid affects chemical and biological properties of the soil as well as morpho-physiological processes of a plant (Ohta et al., 2004). Humic acid is beneficial to shoot and root growth by playing a role in nutrient’s uptake in vegetable crops (Dursun et al., 2002; Cimrin and Yilmaz, 2005). Hassanpanah and Khodadadi (2009) treated potato plants with potassium humate and reported maximum seed germination percentage, number of tubers, average weight of tubers per plant and tuber yield. Mawgoud et al. (2007) applied GrowPlex SP™ (a water soluble fertilizer with humic acid) and testified increased number of leaves, fresh and dry weight along-with increment in endogenous hormonal level and improved production and quality in tomato crop. Also, humic substances have a direct action on plant growth by influencing metabolic processes such as nucleic acid synthesis, and ion uptakes, as a growth regulator to regulate hormone levels (Serenella et al., 2002). In particular, the photosynthesis efficiency and
chlorophyll content were significantly increased in humus-treated plants.

Water-retentive chemicals are polymers (e.g., hydrogel) which become gel in contact with water. It leads to its use as soil stabilizers, water purifiers, juice clarifiers, animal feed thickeners, and in the processing of oil, pulp and paper, and fruits and vegetables. Hydrogel does not dissolve, but forms a gel when water is added. As they dry, water is slowly released to the soil. Bharadwaj et al. (2007) reported polymers which retained water (40 and 140 kg kg⁻¹) when mixed with sand. They increased compressive strength of soil particles and developed resistance to wind erosion. They are easily biodegradable and therefore, safe to apply in the field (Yang et al., 2008). Furthermore, pure gel polymers, especially at higher fertilizer rate, improved total and marketable tuber yield (Eisau et al., 2007). Hayat and Ali (2004) reported 30% to 85% increase in moisture contents and 17% elevation in saturation percentage. They also observed 8% reduction in particle density along-with 4% to 80% reduction in bulk density in the soil treated with polymer as compared to non-treated soil. According to another study, polyacrylamides and other soil-wetting polymers, incorporated into sandy potato fields, increased 102% water retention in the soil around the root zone and subsequently, 25% increase in tuber yield (Watt and Peake, 2001). It has also been noted that gel-polymers stimulate seedling growth (Al-Harbi et al., 1999). Magalhaes et al. (1987) found higher retention of NH₄, K, Ca, Mg, Zn, and Fe in an oxisol treated with gel-polymers as compared to untreated soil. In addition, a higher shoot growth as well as N, K, and Fe uptake in radish was found in soils amended with gel-polymers.

The present experiment was designed to monitor the effects of humic acid and hydrogel on growth and yield performance of potato (Solanum tuberosum L.) var. Sante.

MATERIALS AND METHODS

The study was carried out at Vegetable Research Area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan during autumn season, 2009-10. Soil samples were collected from experimental field, air-dried, thoroughly mixed and passed through 2-mm sieve. Physical and chemical characteristics and macro nutritional status of the soil are shown in Table-1. Tubers were planted on ridges, having 15 cm plant to plant and 75 cm row to row distance. Humic acid and hydrogel were applied directly into soil along with NPK.

There were total eight different treatments of Humic acid and Hydrogel that were randomized in selected plots: T₀ (Control), T₁ (Recommended dose of NPK (250:150:150 ha⁻¹)), T₂ (120 ml of 8% Humic acid / treatment in three doses), T₃ (120 mg Hydrogel/ treatment in three doses), T₄ (80 ml of 8% Humic acid/ treatment (two doses) + NPK), T₅ (120 ml of 8% Humic acid / treatment (three doses) + NPK), T₆ (40 mg Hydrogel / treatment (one dose) + 'NPK), T₇ (80 mg Hydrogel / treatment (two doses) + NPK). Design of Experiment was RCBD which was replicated four times. At the stage of 60 day old crop, total emergence (%), Number of shoots/plant, Number of leaves/plant, Height of the plant (cm), Foliage fresh weight/plant (g), Foliage dry weight/plant (g), Tuber dry weight/plant (g), Tuber yield/ha (tones), chlorophyll and protein contents (µg) were sampled from five plants per treatment per replication. Similarly, Leaf samples were used for the estimation of N, P and K. N (mg L⁻¹) contents was studied according to Chapman and Parker method (1961). Whereas P (mg L⁻¹) and K (mg L⁻¹) were estimated according to the method described by Yoshida et al. (1976). Total chlorophyll contents (mg g⁻¹) were determined with the help of chlorophyll meter. Total protein contents were estimated by a formula (Nitrogen calculated x 6.25). The collected data was subjected to ANOVA and treatment means were compared through LSD test at 5% level of probability (Steel et al., 1997).

RESULTS AND DISCUSSION

Growth parameters
Data regarding growth attributes is given in Table 2. T₀ showed maximum mean emergence percentage (98.75%) as compared to T₃ which represented minimum emergence percentage (93.75%). It can be concluded that days to emergence depend upon internal vigor of the tubers and microclimate in the vicinity of the crop. It is depicted from the data that T₅ displayed maximum number of leaves (231.33) followed by T₇ (227.83) that were 52.65 and 51.94% higher than T₀ which reported least number of leaves (112). Mawgoud et al. (2007) also reported a significant increase in the number of leaves with the application of water soluble fertilizer along with humic acid. Humic compounds subsequently enhanced photosynthetic rate (Zhang et al., 2006). Moreover, Maximum number of shoots exhibited by T₆ (3.42) that were 64.7 % higher than T₀ which disclosed minimum number of shoots (2.66). But number of shoots of T₆ treatment were less vigorous as compared to T₄ (3.37), T₅ (3.27) and T₂ (2.95). Although number of shoots produced by T₄, T₅ and T₂ treatments were less in numbers but more vigorous and strong, more in height and had additional number of leaves as compared to others. Furthermore, both humic acid as well as hydrogel showed decreasing trend with increase in dose regarding number of shoots. It was concluded from experiment that T₇ pointed out maximum plant height (50.93 cm) that was 27.68%
higher than T₀ which showed minimum plant height (36.83 cm). Fresh foliage weight plant⁻¹ (142.75 g) was maximum demonstrated by T₇ that was 42.46% higher than T₀ which unveiled lowest fresh foliage weight plant⁻¹ (82.13 g). Positive effects of humic acid on shoot and root growth of plants were observed by Dursun et al. (2002). Furthermore, these results are also in accordance with Ezzat et al. (2011) who reported significant increase in plant height and relative growth rate in potato leaves due to application of veterra hydrogel. Koupai et al. (2008) observed maximum effect of polymer addition on the height of Ligustrum ovalifolium (an ornamental plant).

Moreover, highest foliage dry weight plant⁻¹ (31.875 g) was recorded in T₇ that was 49.4% higher than T₀ that manifested lowest foliage dry weight plant⁻¹ (18.85 g). Also, both (humic acid and hydrogel) exhibited increasing trend with rise in dose. Humic acid improves shoot and root growth along with nutrient uptakes in vegetable crops (Dursun et al., 2002; Cimrin and Yilmaz, 2005). Furthermore, T₇ displayed maximum dry weight of the tubers plant⁻¹ (4.85 g) that was 21.35 % higher than T₀ which publicized minimum dry weight of tubers plant⁻¹ (3.5 g). Likewise, Ghasemi and Khushkhui (2008) reported that hydrophilic gels (0.8%) had positive and significant effect on average number and area of leaves (42%), shoot fresh and dry weight, shoot number (24%) and plant height (45%) as compared to control. Similarly, Syvertsen and Dunlop (2004) did experiment on citrus seedlings grown in well-watered sand soil amended with hydrogel and reported increase in growth. Tuber’s yield ha⁻¹ (42.54 tones ha⁻¹) displayed an increasing trend with increase in hydrogel (T₇) followed by T₅ (40.16 tones ha⁻¹) that was 55.76 and 53.14%, respectively, higher than T₀ which expressed minimum average yield (18.82 tones ha⁻¹). Probably, increase in yield was due to an increase in vegetative growth traits, chlorophyll content and tuber macro and micronutrients. This yield enhancement as a result of hydrogel application is in agreement with the results obtained by Eiasu et al. (2007) who found that the pure gel polymer, especially at higher fertilizer rate, improved total and marketable tuber yield. Yield performance of humic acid was not satisfactory as compared to hydrogel. Additionally, these results are in harmony to those obtained by Shock et al., (2009). They found that application of Stockosorb® (soil conditioner) produced higher total and marketable yield of U.S. No. 1 tubers of potatoes. Watt and Peake, (2001) stated 25% increase in tuber yield.

### Physiological and biochemical attributes

Data regarding Physiological and Biochemical parameters is presented in Table # 3. As far as average nitrogen contents are concerned T₇ (0.555 mg l⁻¹, 15.52 % > T₀) followed by T₅ (0.551 mg) portrayed an increasing trend with rise in dose. Syvertsen and Dunlop (2004) used hydrogel and reported higher nitrogen uptake and reduction in loss of nitrogen by leaching from soils. In case of phosphorous contents plant⁻¹ T₇ showed best results (0.298 mg l⁻¹) followed by T₅ (0.296 mg l⁻¹) as compared to T₀ (0.268 mg l⁻¹) that demonstrated minimum outcome. So, performance of Humic acid and hydrogel expressed increasing trend with rise in dose regarding P contents. It is obvious from facts that T₅ presented maximum results for potassium contents plant⁻¹ (31.287 mg l⁻¹) followed by T₇ (30.087 mg l⁻¹) among all the treatments applied that were 22.14% and 19.03% higher than T₀ which showed minimum average potassium contents plant⁻¹ (24.36 mg l⁻¹). Moreover, K⁺ contents increased consistently with increased in humic acid and hydrogel. These results are favored by Bredenkamp (2000) who reported that Hydrogel improves macro and micro nutrient uptake especially nitrogen, potassium and phosphorus as Aqua-Soil TM retained up to 400% more nitrogen and 300% more potassium than standard quick and slow release fertilizers. Further, Cimrin and Yilmaz (2005) testified increased nutrient uptake including K⁺ in vegetable crops with humic acid application.

Regarding total chlorophyll contents plant⁻¹, T₇ (45.38 mg g⁻¹, 30.2% > T₀) and T₅ (43.94 mg g⁻¹, 27.92% > T₀), respectively, revealed better effects while, T₀ (31.67 mg g⁻¹) showed minimum result. It was also observed from experiment (Table 3) that humic acid exhibited decreasing trend with increase in humic acid (T₇) level as compared to hydrogel that expressed increasing drift with increase in hydrogel dose. In case of protein contents T₇ (3.63 µg) and T₅ (3.48 µg) presented maximum and significant results for protein contents plant⁻¹ among all the treatments applied that was 15.71% higher than T₁ that depicted minimum protein contents plant⁻¹ (3.48 µg). Protein contents plant⁻¹ increased consistently with increasing amount of hydrogel (T₇) as well as humic acid (T₅).

### Table 1: Physical and chemical properties and Macro nutritional status of soil

<table>
<thead>
<tr>
<th>Soil analysis</th>
<th>Soil Depth (inches)</th>
<th>Loamy</th>
<th>Loamy</th>
<th>0-6</th>
<th>6-12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>9.30</td>
<td>8.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EC (ds m⁻¹)</td>
<td></td>
<td>0.42</td>
<td>0.37</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exchangeable Sodium (m mole / 100 g)</td>
<td></td>
<td>0.0</td>
<td>0.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic matter (%)</td>
<td></td>
<td>0.51</td>
<td>0.54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrogen mg (mg L⁻¹)</td>
<td></td>
<td>0.032</td>
<td>Weak</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphorous (mg L⁻¹)</td>
<td>4</td>
<td>Too weak</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2: Effect of humic acid and hydrogel on morphological attributes of potato.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Total Emergence (%)</th>
<th>No. of Shoots Plant⁻¹</th>
<th>No. of Leaves Plant⁻¹</th>
<th>Plant Height (cm)</th>
<th>Foliage Fresh wt. Plant⁻¹ (g)</th>
<th>Foliage Dry wt. Plant⁻¹ (g)</th>
<th>Tuber’s Yield (tones/ha⁻¹)</th>
<th>Tuber’s Dry Wt. (g) (15 gram fresh tubers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₀</td>
<td>98.5</td>
<td>2.66</td>
<td>112.00</td>
<td>36.83</td>
<td>82.13</td>
<td>18.85</td>
<td>18.82</td>
<td>3.53</td>
</tr>
<tr>
<td>T₁</td>
<td>97.5</td>
<td>3.55</td>
<td>186.30</td>
<td>45.72</td>
<td>128.57</td>
<td>27.55</td>
<td>35.32</td>
<td>4.12</td>
</tr>
<tr>
<td>T₂</td>
<td>97.5</td>
<td>2.95</td>
<td>154.13</td>
<td>37.57</td>
<td>94.71</td>
<td>20.35</td>
<td>19.89</td>
<td>3.84</td>
</tr>
<tr>
<td>T₃</td>
<td>93.75</td>
<td>3.25</td>
<td>173.00</td>
<td>39.16</td>
<td>87.87</td>
<td>19.93</td>
<td>21.85</td>
<td>3.96</td>
</tr>
<tr>
<td>T₄</td>
<td>97.5</td>
<td>3.37</td>
<td>210.00</td>
<td>43.10</td>
<td>131.84</td>
<td>28.25</td>
<td>36.86</td>
<td>4.29</td>
</tr>
<tr>
<td>T₅</td>
<td>93.75</td>
<td>3.25</td>
<td>231.33</td>
<td>46.05</td>
<td>139.65</td>
<td>30.92</td>
<td>40.16</td>
<td>4.57</td>
</tr>
<tr>
<td>T₆</td>
<td>95.00</td>
<td>3.42</td>
<td>192.63</td>
<td>44.92</td>
<td>133.0</td>
<td>29.21</td>
<td>37.16</td>
<td>4.45</td>
</tr>
<tr>
<td>T₇</td>
<td>95.5</td>
<td>3.27</td>
<td>227.83</td>
<td>50.93</td>
<td>142.75</td>
<td>31.87</td>
<td>42.54</td>
<td>4.85</td>
</tr>
</tbody>
</table>

T₀ (Control), T₁ (Recommended dose of NPK (250:150:150 ha⁻¹)), T₂ (120 ml of 8% Humic acid/treatment in three doses), T₃ (120 mg Hydrogel/treatment in three doses), T₄ (80 ml of 8% Humic acid/treatment (two doses) + NPK), T₅ (120 ml of 8% Humic acid/treatment (three doses) + NPK), T₆ (40 mg Hydrogel/treatment (one dose) + NPK), T₇ (80 mg Hydrogel/treatment (two doses) + NPK).

Table 3: Effect of humic acid and hydrogel on Physiological and Biochemical parameters of potato

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Nitrogen estimation (mg l⁻¹)</th>
<th>Phosphorous evaluation (mg l⁻¹)</th>
<th>Potassium inference (mg l⁻¹)</th>
<th>Chlorophyll contents (mg g⁻¹)</th>
<th>Protein contents (µg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₀</td>
<td>0.491</td>
<td>0.268</td>
<td>24.36</td>
<td>31.67</td>
<td>3.06</td>
</tr>
<tr>
<td>T₁</td>
<td>0.515</td>
<td>0.291</td>
<td>27.507</td>
<td>43.535</td>
<td>3.21</td>
</tr>
<tr>
<td>T₂</td>
<td>0.50</td>
<td>0.271</td>
<td>26.89</td>
<td>33.821</td>
<td>3.125</td>
</tr>
<tr>
<td>T₃</td>
<td>0.499</td>
<td>0.286</td>
<td>26.92</td>
<td>35.635</td>
<td>3.12</td>
</tr>
<tr>
<td>T₄</td>
<td>0.549</td>
<td>0.292</td>
<td>28.857</td>
<td>44.38</td>
<td>3.437</td>
</tr>
<tr>
<td>T₅</td>
<td>0.551</td>
<td>0.296</td>
<td>31.287</td>
<td>42.44</td>
<td>3.44</td>
</tr>
<tr>
<td>T₆</td>
<td>0.544</td>
<td>0.293</td>
<td>29.705</td>
<td>41.635</td>
<td>3.40</td>
</tr>
<tr>
<td>T₇</td>
<td>0.555</td>
<td>0.298</td>
<td>30.085</td>
<td>45.94</td>
<td>3.468</td>
</tr>
</tbody>
</table>

T₀ (Control), T₁ (Recommended dose of NPK (250:150:150 ha⁻¹)), T₂ (120 ml of 8% Humic acid/treatment in three doses), T₃ (120 mg Hydrogel/treatment in three doses), T₄ (80 ml of 8% Humic acid/treatment (two doses) + NPK), T₅ (120 ml of 8% Humic acid/treatment (three doses) + NPK), T₆ (40 mg Hydrogel/treatment (one dose) + NPK), T₇ (80 mg Hydrogel/treatment (two doses) + NPK).

In a nutshell, it can be concluded that the effect of applied humic acid and hydrogel with recommended dose of NPK on plant morpho-physiological, biochemical and yield attributes, were persistent. Furthermore, effects of addition of humic acid and hydrogel reinforced with full recommended dose of NPK produced a significant increase in potato yield. So, their use offers great potential as a low cost natural fertilizer with sustainable yield. Additionally, they will not only be helpful in optimizing the yield but also ameliorating the stress as well as controlling erosion.

REFERENCES


Chapman, HD and F Parker, 1961. Determination of NPK. Method of analysis for soil, plant and
Effect of soil application of humic acid and hydrogel on potato

water. Division of Agriculture, University of California, pp: 150-79.


