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Effect of Soil Application of Humic Acid and Fluvic Acid on Agronomic traits of Barley

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ABSTRACT

One of the most important issues affecting environmental health and sustainable food production is application of organic fertilizers instead of chemical fertilizers. This study set out to investigate the effect of application of soil humic acid and fulvic acid on barley plant. To this end a factorial experiment was carried out on the basis of randomized complete block design with four replications in the research greenhouse of Roudehen in 2012. The first factor included four levels of humic acid concentration (0, 0.5, 1, and 2 g per kg soil) and the second factor included 4 levels of humic acid concentration (0, 0.5, 1, and 2 g per kg pot soil). The results showed that humic acid and fulvic acid had a significant effect on dry weight of stem, leaf, and spike. Moreover, humic acid and fulvic acid had a significant effect on grain yield (at 1% level), biological weight (at 1% level), and 1000-grain weight (at 5% level), but their effect on harvest index was not significant. The highest rate of biological weight was obtained when 1 g humic acid per kg soil and 1 g fulvic acid per kg soil were applied. In general, the results of the research indicated that application of humic acid and fulvic acid had a positive effect on improvement of growth and yield of barley plant.

Keywords: *Hordeum vulgare, Organic Fertilizers, Yield, Yield Components.*

INTRODUCTION

Recently increased use of chemical inputs in agricultural lands has caused many environmental problems such as pollution of water, loss of agricultural products quality, and reduction of soil fertility (Sharma, 2002). Necessity of healthy products, produced in different agricultural systems in terms of presence of residues of pesticides and chemicals and their effect on health of human and environment have caused production methods and applied inputs to be specifically emphasized. One of most important issues affecting environment and food production stability is use of organic fertilizers instead of chemical fertilizers (Ayuso *et al.*, 2008). Humic acid and fulvic acid are extracted from various sources such as soil, humus, peat, oxidized lignite, coal and etc., which are different in molecular size and chemical structure (Sebahattin and Necdet, 2005).

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Humic acid with molecular weight of 30-300 kDa and fulvic acid with molecular weight of less than 30 kDa resulted in the formation of insoluble and soluble stable complex with micronutrients (Sharma, 2001, Michael, 2001). Humic acid has beneficial effects on soil and plant and enhances the absorption of essential nutrients through chelating them and improves the soil fertility and crops yield (Liu and Cooper, 2000). It has been reported that low concentrations (50-60 $mg.l^{-1}$) of humic acid will significantly increase crop growth (Xuenyuan *et al*., 2001). Humic acid dissolved in water quite well and is soluble with other liquid fertilizers and can be used through spraying, soil application, and pressurized irrigation systems (Vaughan and Linehan, 2003). Humic acid and fulvic acid increase the length and weight of root, number of lateral roots and flow of sap through the vessels. Moreover, they improve the quality and quantity of crops such as wheat, maize, etc., via increasing cell division and growth of crops, seeds germination and viability, photosynthesis, nutrients uptake by plant, root growth, plant resistance to drought, resistance to pests and diseases, rate of vitamins and enzymes in plants, and seeds germination percentage, Humic acid also improves physical, chemical, and biological properties of soil (Mayhew, 2004). Experiment on the seeds of tomato and lettuce in petridishes containing unanalyzed humic acid showed that fresh weight of seedlings and water absorption efficiency increased and continued up to the concentration of 5000 $mg.l^{-1}$ humic acid (Piccolo *et al*., 2008). Field experiments on tomato, cotton, and grape used humic acid as soil and foliar spray. Indicated that both treatments produced 10%, 11% and 3% to 70% intomato, cotton and grape yield, respectively (Brownell *et al*., 2009). In another study Sharif *et al*. (2002) showed that application of 50 and 100 mg humic acid per kg soil in maize increased stem dry weight by 20% and 23% and increased root dry weight by 39% and 32%, concentration of soil nitrogen and the nitrogen stored in plant significantly increased. In investigating effect of humic acid and fulvic acid on solubility of aluminum phosphate and iron phosphate and determining their uptake by plant, Lobartini *et al*. (2005) on maize reported that the rate of free phosphate and free orthophosphate increased in presence of humic acid, and solubility inorganic phosphate was more than that of fulvic acid. Considering the soluble phosphate uptake by maize planted in hydroponic solution of aluminum phosphate and humic acid, phosphorus was absorbed by maize in presence of humic acid better than the control treatment (Lobartini *et al*., 2005). Nardi *et al*., (2002) showed most of humic substances containing carbon isotope 14 were absorbed by epidermis of sunflower, radish, and carrot roots and often substances with low molecular weight were absorbed and transferred. Foliar application of fulvic acid in wheat leaves in greenhouse and field increases concentration of chlorophyll in leaves (Xudan, 2000). Application of humic acid and folic acid also inhibited the activity of indole acetic acid oxidase, and components with lower molecular weight showed greater inhibitory effect (Mato *et al*., 2010). Foliar application of fulvic acid during development of spike in presence of hot and dry winds increased grain yield 7% to 8% compared with control treatment (Sebahattin and Necdet, 2005). Seedling fresh weight and water uptake efficiency of lettuce and tomato located in 40 to 5000 $mg.l^{-1}$ humic acid increased (Piccolo *et al*., 2008). Humic acid, by chelating elements such as Mg and Ca, increases plant access to these elements (Mackowiak *et al*., 2001).

Humic acid on wheat roots showed that the activity of phosphatase enzyme was inhibited and manganese ion reduced the inhibitory effect of humic acid (Malcolm and Vaughan, 2009). The experiment aims were to investigate the effect of soil application of humic acid and fulvic acid on important traits of barley and to determine the best concentration of these substances in barley.

MATERIALS AND METHODS

Field and treatment information

The experiment was conducted in research greenhouse of Faculty of Agriculture, Roudehen Islamic Azad University as a factorial experiment on the basis of randomized complete block design with four replications. The first factor included four levels of humic acid concentration (0, 0.5, 1, and 2 g per kg soil) and the second factor included 4 levels of humic acid concentration (0, 0.5, 1, and 2 g per kg pot soil).

Crop Management

Five barely seeds were planted in 5 kg polyethylene pots after adding different levels of humic acid and fulvic acid to the soil. The pots were watered every other day to keep moisture at field capacity through gravimetric method. Fertilizer was supplied according to the soil analysis result (Table 1).

Table1. Properties of the soil used in experiment (Soil depth: 0-30 cm)

Nitrogen (%)	Phosphorus ($mg.kg^{-1}$)	Potassium ($mg.kg^{-1}$)	Acidity (pH)
0.12	19	154	7.93

Traits measure

To measure the shoot dry weight sample were placed in oven and the height of shoots and then they were placed in the oven at 70°C for 48 hours. The studied traits included spike dry weight, leaf dry weight, stem dry weight, height, 1000-grain weight and biological weight.

Statistical analysis

The data were analyzed by SAS software (Ver. 8) and the means were compared using Duncan's multi range test at 5% probability level. The diagrams were drawn using Excel software.

RESULTS AND DISCUSSION

Stem Dry Weight, Leaf Dry Weight, and Spike Dry Weight

Humic acid and fulvic acid had a significant effect on dry weight of stem, leaf, and spike (Table 2). The highest dry weight of stem, leaf, and spike by 1.43, 0.88, and 1.71 g belonged to the treatment with 1 g humic acid per kg pot soil respectively (Table 3). Sabzevari *et al*. (2010) investigated the effect of humic acid on germination indices of various cultivars of wheat and concluded that there was a significant difference between different concentrations of humic acid. They also showed that concentration of 54 mg humic acid per liter allocated highest rate of germination, seedling vigor index, rootlet length, dry weight of stemlet, and ratio of rootlet length to stemlet. Moreover, the experiments conducted by Kauser and Azam (2006) on wheat showed increase of dry matter by 22% through application of humic acid. There was no significant difference between 1 and 2 g fulvic acid per kg pot soil in terms of stem dry weight. In a greenhouse study conducted reported that fulvic acid increased the wheat growth (Xudan, 2000). Interactive effect of different level of humic acid and fulvic acid on shoots dry weight was not significant (Table 2).

Table 2. Analysis of variance of dry matter of barley shoots, yield and yield component affected humic acid and fluvic acid treatments

S.O.V	df	Stem dry matter	Leaf dry matter	Spike dry matter	Grain weight	Biological yield	1000-Grain weight	Plant height	Harvest index
Humic acid	3	1.165^{**}	0.594^{**}	0.783^{**}	1.03^{*}	8.67^{**}	130.6^{**}	55.8^{**}	3.33^{ns}
Fluvic acid	3	0.441^{**}	0.293^{**}	0.436^{*}	1.87^{**}	13.83^{**}	39.4^{*}	76.5^{**}	5.45^{ns}
Humic acid * Fluvic acid	9	0.142^{ns}	0.073^{ns}	0.182^{ns}	0.58^{ns}	3.73^{**}	28.2^{*}	11.4^{ns}	22.4^{ns}
Error	48	0.101	0.050	0.141	0.35	1.18	11.7	35.8	24.2

ns, * and ** non significant and significant at 5 and 1% level of probability, respectively.

Table 3. Means Comparison of dry matter of barley shoots, yield and yield component in different levels of humic acid

Humic acid ($g.kg^{-1}$)	Stem dry matter (g)	Leaf dry matter (g)	Spike dry matter (g)	Grain weight (g)	Biological yield (g)	1000- Grain weight (g)	Plant height (cm)	Harvest index (%)
0	0.83^{c}	0.44^{c}	1.29^{b}	4.78^{b}	11.95^{b}	32.50^{c}	33.96^{b}	40.55a
0.5	0.89^{bc}	0.52^{bc}	1.21^{b}	4.91^{b}	12.18^{b}	33.37^{bc}	34.93^{b}	40.27a
1	1.43^{a}	0.88^{a}	1.71^{a}	5.37^{a}	13.57^{a}	38.93^{a}	38.31^{a}	39.90a
2	1.08^{b}	0.67^{b}	1.43^{b}	4.99^{ab}	12.25^{b}	35.31^{b}	36.06^{ab}	40.98a

Means with the same letter in each column are not significantly different.

1000-Grain Weight, Grain Yield and Biological Weight

Humic acid and fulvic acid had a significant effect on the grain yield (at 1% level), biological yield (at 1% level), and 1000-grain weight (at 5% level) (Table 2). The highest weight of the grain yield belonged to the treatment with 1 g humic acid per kg pot soil. However, there was no significant difference between this treatment and of 2 g humic acid per kg pot soil treatment (Table 2). Moreover, the use of 1 g humic acid per kg of pot soil increased the biological yield. The highest weight of 1000-grain weight was obtained in the second level of humic acid. Ghorbani *et al.* (2010) showed that the humic acid increased the grain yield in maize. In the fulvic acid treatment the highest and the lowest grain yield belonged to the treatment with 1 g fulvic acid per kg pot soil and control treatment, respectively (Table 4).

Table 4. Means Comparison of dry matter of barley shoots, yield and yield component in different levels of fluvic acid

Fluvic acid ($g.kg^{-1}$)	Stem dry matter (g)	Leaf dry matter (g)	Spike dry matter (g)	Grain weight (g)	Biological yield (g)	1000- Grain weight (g)	Plant height (cm)	Harvest index (%)
0	0.87^{c}	0.49b	1.32^{b}	4.61^{c}	11.59^{c}	33.75^{b}	33.15^{c}	40.42^{a}
0.5	0.96^{bc}	0.58b	1.31^{b}	4.93^{bc}	12.05^{bc}	34.37^{b}	35.62^{b}	41.11^{a}
1	1.21^{a}	0.81a	1.66^{a}	5.43^{a}	13.75^{a}	37.31^{a}	38.50^{a}	39.68^{a}
2	1.18^{ab}	0.62b	1.37^{b}	5.09^{b}	12.56^{b}	34.68^{b}	36^{ab}	40.50^{a}

Means with the same letter in each column are not significantly different.

Among humic acid treatments highest biological yield and 1000-grain weight belonged to treatment 1 g fulvic acid per kg pot soil, Other researchers (Chen and Aviad, 2010) confirmed similar results. Interactive effect of different levels of humic acid and fulvic acid on grain yield was not significant, but it was significant on biological yield (at 1% level) and 1000-grain weight (at 5% level).

Mean comparison of the interactive effects of humic acid and fulvic acid on 1000-grain weight indicated that the simultaneous application of 0.5 g humic acid and fulvic acid per kg pot soil was better than the time when each one of them was used by alone (Fig. 1). Fig. (2) show that the interactive effect of humic acid and fulvic acid on the second level (1 g per kg pot soil) was significant.

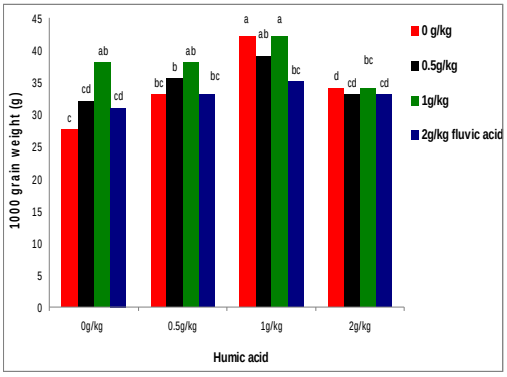

Fig. 1. Interactions effect of humic acid and fluvic acid on 1000-grain weight of barley. The mean of each column contains at least one letter in common don't have significantly different at the 5% level according to Duncan test.

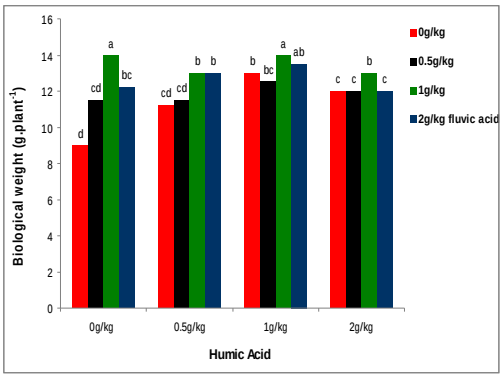

Fig. 2. Interactions effect of humic acid and fluvic acid on biological weight of barley. The mean of each column contains at least one letter in common don't have significantly different at the 5% level according to Duncan test.

Liu and Cooper (2000) Humic acid has the beneficial effects on soil and plant, and by chelating necessary elements increase absorption resulted in increase the soil fertility and plant yields.

Plant height and harvest index

The ANOVA results showed that humic acid and fulvic acid had a significant effect on plant height at 1% level. The highest and the lowest plant height belonged to 1 g humic acid per kg pot soil and control treatment. The effect of fulvic acid on plant height was more than humic acid. Ulukan (2008) reported that plant height had greatest response to humic acid. The interactive effect of humic acid and fulvic acid on plant height was not significant. Effect of humic acid and fulvic acid on harvest index was not significant (Table 2). Nevertheless, the lowest harvest index belonged to the treatment with 1 g per kg pot soil, which had the highest grain weight and biological weight. In other words, although the dry weight of stem, leaf, and spike increased due to the use of humic acid and fulvic acid, the growth rate of stem and leaf was more than the increase of weight of spike and grain. It seems like that as the rate of humic acid and fulvic acid increases, the percentage of allocating nutrients to vegetative organs increases. Ayuso *et al*. (2008) reported that stem height was one of the traits which showed the greatest response to humic acid.

CONCLUSION

The effect of humic acid and fulvic acid on dry weight of stem, leaf, and spike, 100-grain weight, grain yield, and biological yield was significant. The highest values was obtained when 1 g humic acid per kg soil and 1 g fulvic acid per kg soil were applied. In general, humic acid and fulvic acid have had a positive effect on the improvement of barley growth and yield.

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