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HUMIC ACID IMPROVES GROWTH, YIELD AND OIL CONTENT OF *BRASSICA COMPESTRIS* L.

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ABSTRACT

Humic acid efficiently improves soil fertility and crop productivity, especially on poorly fertile and alkaline-calcareous soils. In this field study, the growth, yield and oil content of three mustard varieties viz., S-9, P-78 and AH-2001 were observed under varying levels of humic acid application to a poorly fertile and alkaline-calcareous soil. The humic acid was applied to soil at the time of sowing @ 0, 3.17, 6.35, and 9.35 kg acre^{-1}. Overall varieties, compared to control, the application of humic acid @ 6.35 kg acre^{-1} positively affected almost all the growth and yield parameters. The variety S-9 responded comparatively better to all the application rates of humic acid than its other two counterparts. The validity of these results is warranted through further experiments.

Keyword: Application rates, *Brassica compestris* L., growth, humic acid, mustard, yield

INTRODUCTION

Humic acid is an organically charged bio-stimulant that significantly affects plant growth and development and increases crop yield. It has been extensively investigated (Nardi *et al*., 2004) that humic acid improves physical (Varanini *et al.,* 1995), chemical and biological properties of soils (Keeling *et al*., 2003; Mikkelsen, 2005). The role of humic acid is well known in controlling, soil-borne diseases and improving soil health and nutrient uptake by plants, mineral availability, fruit quality, etc (Mauromicale *et al*., 2011). Humic acid based fertilizers increase crop yield (Mohamed *et al*., 2009), stimulate plant enzymes/hormones and improve soil fertility in an ecologically and environmentally benign manner (Mart, 2007; Sarir *et al*., 2005).

Several research workers highlighted the positive benefits of humic acid application on higher plants (Vasudevan *et al.,* 1997; Ashraf *et al*., 2005; Susilawati *et al*., 2009). Humic acids also reduce toxic effects of salts on

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monocots (Masciandaro *et al.,* 2002) and dicots (Ferrara *et al.,* 2001), including soybean, wheat (Ozkutlu *et al*., 2006), rapeseed (Keeling *et al*., 2003), forage, turnip (Albayrak, 2005) and mustard (Duval *et al.,* 1998). Enhanced nutrient uptake by plants as a result of humic acid application is also well established (Aydin *et al.,* 1999; Day *et al.,* 2000; Mackowiak *et al.,* 2001; Sharif *et al*., 2004). Likewise, the increased yield is also observed in many crops due to humic acid application, including potato (Grady and Tina, 1999), brassica (Peng *et al.,* 2001; Vetayasuporn, 2006), tomato, onions and other leafy vegetables (Grady and Tina, 1999; Erik *et al.,* 2000).

In Pakistan, the indigenous oilseed production fulfills only 25% of the national oil requirements, mainly through cottonseed (Panhwar *et al.,* 2005). Brassica comes next in oilseed production in Pakistan. However, very little research is available on various aspects of this important crop. In this field experiment, an attempt was made to investigate the effect of varying application rates of humic acid on the growth, yield and oil content of mustard varieties.

MATERIALS AND METHODS

This field experiment was laid out in a four replicated randomized complete block design. Each experimental unit was about 3.5 m long and 3.0 m wide. Before conducting the experiment, land was prepared by applying two dry ploughings. These ploughing operations were followed by clod crushing and leveling to obtain a good quality seed bed. Pure quality seeds of three mustard varieties viz., S-9, PS-78 and AH-2001were obtained from Oilseeds Section, Agricultural Research Institute, Tandojam, Sindh. These seeds were planted carefully by following the methodology generally recommended for the region.

Application of humic acid

A granular commercial product was obtained from the market with 58% humic acid. The humic acid was applied before sowing. In total, four humic acid application rates were tested in this experiment, i.e. 0 (control), 3.17, 6.35 and 9.53 kg acre^{-1}. The recommended rates of nitrogen (46 kg N acre^{-1}) and phosphorus (23 kg P_2O_5 acre^{-1}) were applied to each plot. Nitrogen was applied in the form of urea and diammonium phosphate (DAP). Phosphorus and potassium were applied through DAP and sulphate of potash (SOP) respectively, at the time of sowing. Urea was applied in three equal splits, i.e. at sowing, 1st irrigation and flowering. All the other cultural practices, including irrigation were uniformly adopted in all plots according to the crop requirement throughout the growing period.

Soil sampling and analysis

Composite soil samples were taken from 0-15 and 15-30 cm depths before fertilizer application. The soil samples were air-dried, sieved through 2.0 mm sieve and analyzed for texture using Bouyoucos hydrometer (Bouyoucos, 1951), pH (water), ECe (dS m^{-1}) using pH and conductivity meters with glass-electrodes, organic matter content with Walkley-Black method (Jackson, 1958), lime content through acid neutralization method. Total N (%), available P (mg kg^{-1}) and extractable K^+ content (mg kg^{-1}) were determined through the standard methods adopted by the department.

Plant data recorded

Five plants from each plot were selected at random and tagged for data recording purpose. Plants were harvested at maturity from each plot. The observations recorded from each randomly selected plant included plant height (cm), number of branches $plant^{-1}$, number of pods $plant^{-1}$, seed yield ha^{-1} and oil content (%).

Statistical analysis

The data recorded from five plants were subjected to statistical analysis, using analysis of variance (ANOVA) using MINITAB-13.2 statistical software. The differences among various treatments were analyzed through Least Significant Difference test at alpha 0.05.

RESULTS AND DISCUSSION

Some basic properties of experimental soil

The soil of the area under study was analyzed for various physico-chemical properties before the humic acid application. The soil properties at surface (0-15 cm) were: pH of 7.7, EC 0.39 dS m^{-1}, organic matter 0.88%, $CaCO_3$ 16.3%, total N 0.05%, available phosphorus 2.5 mg kg^{-1} and extractable K 161 mg kg^{-1}. The soil properties at subsurface (15-30 cm) were: pH value of 7.92, EC 0.36 dS m^{-1}, organic matter 0.73%, $CaCO_3$ 16.3%, total N 0.04%, available phosphorus 1.99 mg kg^{-1} and extractable K 152 mg kg^{-1}.

Effect of humic acid application rates on plants

Plant height (cm)

The data related to the effect of different humic acid application rates on plant height is presented in Table-1. It is evident from the data that the effect of humic acid levels and interaction of humic acid levels x varieties for plant height was significant (p<0.05). While overall humic acid rates, the difference among varieties for plant height was not-significant (p>0.05). The results further revealed that compared to control, the application of humic acid resulted in significantly taller plants. The statistical analysis also showed that compared to the untreated plants, the difference within the humic acid application rates was not-significant (p>0.05).

Table 1. Response of plant height (cm) of mustard varieties to varying application rates of humic acid.

Humic acid (kg acre^{-1})	Varieties			Mean
	S-9	P-78	AH-2001	
0.0 (Control)	168.5	173.3	170.5	170.7
3.17	178.9	178.2	173.7	176.9
6.35	180.1	178.1	176.2	178.1
9.53	178.3	176.4	177.6	177.4
Mean	176.5	176.5	174.5	-
LSD	Rates	Varieties	Rates x Varieties	
	3.99	Non-significant	3.79	

Number of branches plant^{-1}

The data presented in Table-2 indicated that the effect of humic acid application rates and varieties for number of branches plant^{-1} was significant (p<0.05). However, the interaction of humic acid rates x varieties for number of branches plant^{-1} was not-significant (p >0.05). Compared to control, the plants grown in plots received humic acid produced significantly more branches. The difference among 3.17, 6.35 and 9.53 kg humic acid acre^{-1} application rates for number of branches plant^{-1} was not-significant (p>0.05). Overall humic acid application rates, variety P-78 produced significantly (p>0.05) more branches than the variety S-9 and AH-2001.

Table 2. Number of branches plant^{-1} of three mustard varieties under varying application rates of humic acid.

Humic acid (kg acre^{-1})	Varieties			Mean
	S-9	P-78	AH-2001	
0.0 (Control)	7.5	8.1	7.7	7.8
3.17	8.4	8.4	8.4	8.4
6.35	8.5	8.7	8.4	8.5
9.53	8.4	8.5	8.3	8.4
Mean	8.2	8.4	8.2	-
LSD	Rates	Varieties	Rates x Varieties	
	0.296	0.204	Non-significant	

Number of pods plant^{-1}

The results pertaining to the number of pods plant^{-1} influenced by humic acid application rates are given in Table-3. It is evident from the data that the effect of humic acid application rates, varieties and the interaction of humic acid application rates x varieties for number of pods plant^{-1} was significant (p<0.05). Compared to control, the number of pods plant^{-1} produced by the mustard plants at 6.35 kg humic acid acre^{-1} was maximum. While, the difference between 3.17, 6.35 and 9.53 kg humic acid acre^{-1} application rates was not-significant ($p>0.05$). At almost all humic acid application rates, the performance of variety S-9 was better than P-78 and AH-2001 varieties.

Table 3. Number of pods plant^{-1} produced by three mustard varieties under varying application rates of humic acid.

Humic acid (kg acre^{-1})	Varieties			Mean
	S-9	P-78	AH-2001	
0.0 (Control)	168.5	180.0	196.5	181.6
3.17	204.7	204.7	218.5	209.3
6.35	210.7	225.2	206.0	214.0
9.53	209.0	210.7	220.7	213.5
Mean	198.5	180.0	196.5	-
LSD	Rates	Varieties	Rates x Varieties	
	12.30	12.64	11.67	

Seed yield (kg ha^{-1})

The results related to seed yield produced by three mustard varieties with different humic acid application rates are given in Table-4. It is evident from the data that the effect of application rates and varieties for mustard seed yield was significant ($p<0.05$). Whereas, the effect of interaction of humic acid application rates x varieties was non-significant ($p>0.05$). Compared to control, the application of humic acid resulted in significantly ($p<0.05$) higher seed yield. The difference between 6.35 and 9.53 kg humic acid acre^{-1} rates for mustard seed yield was not-significant ($p>0.05$). Overall application rates, variety S-9 gave more yield than other two varieties tested. The non-significant effect of interaction of humic acid application rates x varieties indicates that the application of humic acid is an equally effective for all mustard varieties.

Table 4. Seed yield (kg ha^{-1}) of mustard varieties under varying application rates of humic acid.

Humic acid (kg acre^{-1})	Varieties			Mean
	S-9	P-78	AH-2001	
0.0 (Control)	2355.5	2255.2	2357.7	2323.5
3.17	2496.2	2382.0	2397.5	2425.2
6.35	2660.7	2522.7	2599.7	2594.4
9.53	2661.5	2558.5	2529.0	2583.0
Mean	2543.5	2429.6	2471.5	-
LSD	Rates	Varieties	Rates x Varieties	
	144.5	112.0	N.S	

Oil content (%)

It is evident from the data related to oil content presented in Table-5 that the effect of humic acid application rates, varieties and interaction of humic acid application rates x varieties for oil content was significant (p<0.05). Compared to control, the effect of application of humic acid at almost all rates was significant (p<0.05). However, the difference between 6.35 and 9.53 kg humic acid acre^{-1} rates was not-significant (p>0.05). At all application rates, the seed obtained from variety S-9 contained more oil than the seed obtained from P-78 and AH-2001 varieties.

Table 5. Oil content (%) of mustard varieties under varying application rates of humic acid.

Humic acid (kg acre^{-1})	Varieties			Mean
	S-9	P-78	AH-2001	
0.0 (Control)	20.6	19.8	19.8	20.1
3.17	21.1	20.8	20.8	20.9
6.35	22.0	21.7	21.8	21.8
9.53	22.0	21.7	21.8	21.8
Mean	21.4	21.0	21.0	-
LSD	Rates	Varieties	Rates x Varieties	
	0.29	0.30	0.28	

The manifold significance of humic acid application to plants is now well established. The application of humic acid alone and/or in combination with other fertilizers has significant beneficial effect on the growth and yield of mustard (David and Samule, 2002). Rao *et al.* (2002) also reported such results in case of increased dry matter yields of mustard due to 30 kg humic acid application ha^{-1}. Humic acid beyond this level caused adverse effect on the growth and yield of plants. Similarly, Albayrak (2005) reported that humic acid significantly affected most of the yield components of *Brassica raya.* In another study Chris *et al.* (2005) reported that both the foliar and soil application of humic acid significantly improved seed yield and oil content of mustard. Earlier, Chen and Aviad (1990a) elucidated that humate had a positive effect on the growth of various groups of microorganisms. They also found, in another study, that humic acid can be applied @ 5.0 kg acre^{-1} to all types of plants (Chen and Aviad, 1990b). MacCarthy *et al.* (2001) concluded that humates enhance nutrient uptake, improve soil structure, and increase the yield and quality of various oilseed crops. Researchers also found lower dose of humic acid equally effective to their higher levels in increasing plant growth and enhancing the nutrient uptake (Salt *et al*., 2001). Humic acid influence plant growth both in direct and indirect ways. Indirectly, it improves physical, chemical and biological conditions of soil. While directly, it increases chlorophyll content, accelerates plant respiration and hormonal growth responses, increases penetration in plant membranes, etc. These effects of humic acid operate singly or in integration. The above discussion clearly validiates the suitability of humic acid as a beneficial fertilizer product.

CONCLUSION

Humic acid improves growth, yield and oil content of *Brassica compestris* L. under poorly fertile alkaline-calcareous soils. However, the validity of these results is warranted through further long-term experimentation.

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