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Full Length Research Paper

Comparison of the effect of liquid humic fertilizers on yield of maize genotypes in Ardabil region

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In order to investigate the response of maize genotypes against the application of two types of liquid humic fertilizers (derived from peat and leonardite), an experiment was conducted as factorial based on completely randomized block design with three replications. The main factor was included three conditions (application of peat based and leonardite based humic fertilizer, without the application of humic fertilizer) whereas the sub-factor included six maize genotypes. Results indicate that there was a significant difference between experimental conditions in terms of grain yield at 1% and biological yield at 5% probability levels. Results from mean comparison indicate that ZP677 had the highest (20.89 ton/ha) biological yield, whereas OS 499 had the lowest (16.93 ton/ha). Application of leonardite based liquid humic fertilizer proved to be more productive than the two other conditions. This humic fertilizer produced the highest values for biological yield (21.99 ton/ha) and grain yield (7.09 ton/ha).

Key words: Maize, humic, fertilizer, yield.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most highly consumed crops, and the most important foodstuff after wheat and rice around the world. The global production of maize is 604 million tons, with a planting area of up to 140 million hectares. Iran produces 2 million tons of maize on 350000 hectares of land. However, the production from hybrid maize seeds in Iran is highly limited (FAO, 2002). This plant, photosynthetically, is of C4 type and thrives in tropical and semitropical climates (Emam, 2008) and is native for central and southern America (Khodabandeh, 1998). Based on its role in production of grain and forage and providing food for livestock, as well as its industrial use, maize has become an important crop in Iran, as well as in other parts of the world. Expanding the area under maize cultivation in Iran in order to become self-sufficient is one the most important goal pursued by the government and as a result of implementing programs designed to increase grain maize production over the last few years, this crop has seen a very fast growth in terms of planting area and yield (Cakir, 2004).

Humic substances (HS) are the result of organic decomposition of the natural organic compounds comprising 50 to 90% of the organic matter of peat, lignites, sapropels, as well as of the non-living organic matter of soil and water ecosystems. Authors believe that humic substances can be useful for living creatures in developing organisms (as substrate material or food source, or by enzyme-like activity); as carrier of nutrition; as catalysts of biochemical reactions; and in antioxidant activity (Kulikova et al., 2005). Yang et al. (2004) argued that humic substances can both directly and indirectly affect the physiological processes of plant growth. Soil organic matter is one of the important indices of soil fertility, since it interacts with many other components of the soil. Soil organic matter is a key component of land ecosystems and it is associated with the basic ecosystem processes for yield and structure(Pizzeghello etal., 2001).

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Classically, humic substances are defined as a general group of heterogeneous organic materials which occur naturally and are characterized by yellow through dark colors with high molecular weight (Kulikova et al., 2005). Shahryari et al. (2011) experienced the effect of two types of humic fertilizers (peat and leonardite derived) on germination and seedling growth of maize genotypes. They reported that interaction of "genotype × solutions (peat and leonardite based humic fertilizers and control) was significant in terms of the length of primary roots. Application of leonardite based humic fertilizer had a remarkably more effect on relative root growth of Single Cross 794 and ZP 434 than other genotypes. In their experiment, the relation between germination rate and primary roots was positively significant under the condition of application of both types of humic fertilizers; but there was not the same relation for control treatment. They argued that all types of various humic substances as a biological fertilizer can have an either similar or different effect in early growth stages of maize, as peat and leonardite based fertilizers that they applied produced more seedling roots than control, however the length of coleoptiles was higher in treatment with application of leonardite based humic fertilizer and control than treatment with application of peat based humic fertilizer. They believe that if used in lower quantity these natural fertilizers can have a lot of effect on plant growth. Hence, in order to recognize how effective they might be, investigations should be considered based on various amounts of humic fertilizers. Finally, they suggested that both peat and leonardite based humic fertilizers could be used to stimulate growth of primary roots in maize which are critical for an optimal establishment of maize in the field.

Gadimov et al. (2009) claimed that humic substances are natural technological products with a miraculous biological effect on crops and concluded that a scientific and practical program is required to make use of this technology in the world, particularly in developing countries. Also, Shahryari et al. (2009) concluded that potassium humate is a miraculous natural material for increasing both quantity and quality of wheat and can be used to produce organic wheat. Thus, application of biological products such as humic fertilizers to provide nutrition for crops can be one of the useful methods to achieve some of the objects of organic crop production. In addition, Shahryari et al. (2011) studied the response of various maize genotypes against chlorophyll content of the leaves at the presence of the two types of humic fertilizers. In their experiment, solutions (two types of peat and leonardite based liquid humic fertilizers and control) and interaction of "genotypes × solutions" produced significant difference at 1% probability level in terms of chlorophyll content of the leaves. Genotypes such as Single Cross 704 and 505 had the highest index for chlorophyll content when treated by leonardite based humic fertilizer. Peat based humic fertilizer decreased the index for chlorophyll content in genotypes such as 500, OS499 and 505, while leonardite based humic fertilizer decreased the index for chlorophyll content of the leaves in genotypes such as Golden West and Single Cross 704. However, peat based humic fertilizer did not have such an effect on these two maize genotypes. Meanwhile, leonardite based humic fertilizer had no effect on index for chlorophyll content of leaves in genotypes such as 500, OS499 and 505. Genotypes such as ZP677 and ZP434 produced no response against the application of the two types of humic fertilizers.

This study was aimed to compare the effect of liquid peat and leonardite based humic fertilizers on the yield of maize genotypes in Ardabil Region.

MATERIALS AND METHODS

This experiment was conducted at Agriculture Research Station of Islamic Azad University, Ardabil Branch (5 km west of Ardabil City) in 2009 - 2010 cropping year. The region has a semiarid and cold climate, where the temperature during winter season usually drops below zero. This region is located 1350 m above the sea level with longitude and latitude being 48.2°E and 38.15°N, respectively. Average annual minimum and maximum temperatures are -1.98 and 15.18°C, respectively; whereas maximum absolute temperature is 21.8°C; and mean annual precipitation has been reported to be 310.9 mm. The soil of the field was alluvial clay with a pH ranging from 7.8 to 8.2.

Vegetative materials included six maize genotypes prepared from the Agriculture and Natural Resources Research Center of Ardabil Province. The Experiment was conducted as split plot in the basis of randomized complete block design with three replications. The main factor included three conditions (peat based humic fertilizer; leonardite based humic fertilizer; without the application of humic fertilizer) and the sub factor included six maize genotypes (ZP677, Golden west, OS499, ZP434, Ns540 and Single Cross 704). Each of experimental blocks included 3 plots, 320 cm length in rows, with 80 cm from each other containing plants at 20 cm distances. Pretreatment of seeds were done on the basis of 220 ml per 10 L of water to be applied for 1 ton of seeds. Moreover, irrigation was done in flooding manner. Weed-fighting was done both mechanically and manually during all growth stages. Liquid humic fertilizer was prepared and applied based on 400 ml per 50 L of water for 1 ha of maize plantation. The prepared solution was sprayed upon the aerial part of the plants during 5^{th} leaf stage, appearance of reproductive organs, flowering and grain filling stages. All the samples were taken randomly from competitive plants at middle rows. Study traits included grain number per ear row, number of grain row per ear, ear number, weight of 1000 grains, biological yield, vegetative yield and grain yield.

Statistical analysis

Analysis of variance of data and mean comparison of them was done using MSTATC and SPSS programs. Mean comparison was done using Duncan's multiple range test, at 5% probability level. Due to abnormality of data for ear number and its high coefficient of variation, square root conversion was used to normalize it.

RESULTS AND DISCUSSION

Results from analysis of variance for study traits (Table 1)

Table 1. Analysis of variance of evaluated traits under various experimental conditions for 6 maize genotypes.

Source of variation	df	Mean Square						
		Weight of 1000 grain	Number of grain row per ear	Grain number per ear row	Ear number at harvest	Biological yield	Wet biomass	Grain yield
Replication	2	1441.40	1.60	7.47	0.074	29.80	1009.15	0.44
Experimental conditions (E.C.)	2	184.77^{ns}	0.061^{ns}	30.35^{ns}	0.484^{ns}	238.53^{*}	1385.23^{ns}	41.67^{**}
Error 1	4	541.19	2.32	21.87	0.201	25.48	616.43	0.17
Genotype (G)	5	1059.55^{ns}	4.35^{**}	33.37^{ns}	0.011^{ns}	24.19^{ns}	1267.92^{**}	1.08^{ns}
G × E. C.	10	229.96^{ns}	0.61^{ns}	14.04^{ns}	0.047^{ns}	11.71^{ns}	151.28^{ns}	1.06^{ns}
Error 2	30	538.95	0.75	32.27	0.079	11.64	219.45	0.68
CV (%)		22.83	5.89	19.61	16.85	17.93	15.95	14.46

* and ** Significantly different at $p < 0.05$ and < 0.01, respectively.

Table 2. Mean comparison of traits being studied for maize genotypes.

Genotype	Character			
	weight of 1000 grains (g)	Number of grain row per ear	Biological yield (ton/ha)	Wet biomass (ton/ha)
OS 499	110.70^{a}	14.54^{b}	16.93^{b}	85.20^{bc}
ZP 677	101.05^{ab}	15.48^{a}	20.89^{a}	108.68^{a}
Golden West	100.71^{ab}	15.21^{ab}	19.05^{ab}	85.75^{bc}
ZP 434	107.65^{a}	13.49^{c}	17.19^{b}	77.52^{c}
Single Cross	81.20^{b}	14.94^{ab}	20.29^{ab}	98.52^{ab}
NS 540	108.81^{a}	14.62^{ab}	19.82^{ab}	101.66^{a}

Differences between averages of each column which have common characters are not significant at probability level of 5%.

suggest that there was a significant difference between experimental conditions in terms of grain yield and biological yield at 1 and 5% probability levels, respectively. In addition, there was a non-significant difference between study genotypes in terms of all evaluated traits except for number of grain row per ear and wet biomass at 1% probability level. Furthermore, there was no difference observed between the interaction of genotype and experimental conditions for any trait being studied, and this was in agreement with the report of Shahryari et al. (2009). This means that under study genotypes had the same responses to potassium humate.

Moreover, results from mean comparison of data (Table 2) for studied genotypes indicate that genotype OS499 (110.70 g) had the highest 1000 grain weight, whereas genotype Single Cross (81.20 g) had the lowest 1000 grain weight on average. Based on mean comparison of 1000 grain weight, genotypes OS499 and ZP434 were placed in the same group as NS540, whereas genotype ZP677 was placed in the same group as Golden West. Genotype ZP677 (with a mean value of 15.48) and genotype ZP434 (with a mean value of 13.49) had the highest and lowest values of number per ear, respectively; and genotypes

Table 3. Mean comparison of traits being studied for various experimental conditions.

Experimental condition	Character	
	Biological yield (ton/ha)	Grain yield (ton/ha)
Without the application of humic fertilizer	14.97^{b}	4.07^{c}
Peat based humic fertilizer	20.13^{a}	5.89^{b}
Leonardite based humic fertilizer	21.99^{a}	7.09^{a}

Differences between averages of each column which have common characters are not significant at probability level of 5%.

such as Golden West and Single Cross were placed in the same group as NS540 and had no difference in terms of this trait. Genotype ZP677 (with a mean value of 20.89 ton/ha) and genotype OS499 (with a mean value of 16.93 ton/ha) had the highest and lowest biological yield respectively and genotype OS499 was placed in the same group as ZP434, whereas genotypes such as Golden West and Single Cross were placed in the same group as NS540. Genotype ZP677 (with a mean value of 108.68 ton/ha) was the best among other genotypes in terms of wet biomass, whereas ZP434 (with a mean value of 77.52 ton/ha) had the lowest value for wet biomass. ZP677 was placed in the same group as NS540, whereas genotypes Golden West and OS499 were placed in the same group as ZP434 and had no difference in terms of this trait.

Shahryari and Shamsi (2009a) reported that potassium humate increased the rate of biological yield of wheat from 3.26 to 3.72 g/plant; but it had no effect on harvest index. Also, they found that uses of potassium humate increased grain yield. Results from mean comparison of data (Table 3) for experimental conditions being studied indicate that application of leonardite based liquid humic fertilizer produced the highest biological yield(21.99 ton/ha on average), whereas no application of humic fertilizer produced the lowest biological yield(14.97 ton/ha on average). In this respect, both types of applied humic fertilizers had similar effects. Application of leonardite based liquid humic fertilizer produced the highest grain yield (7.09 ton/ha on average) among the conditions being studied, whereas under the condition of without humic fertilizer obtained the lowest value(4.07 ton/ha). Ayas and Gulser (2005) reported that humic acid leads to increased growth and height and subsequently increased biological yield through increasing nitrogen content of the plant. It has also been reported that application of humic acid in nutritional solution led to increased content of nitrogen within aerial parts and growth of shoots and root of maize (Tan, 2003). In another investigation, the application of humic acid led to increased phosphorus and nitrogen content of bent grass plant and increased the accumulation of dry materials (Mackowiak et al., 2001). Humic acid leads to increased plant yield through positive physiological effects such as impact on metabolism of plant cells and increasing the concentration of leaf chlorophyll (Naderi et al., 2002). Also, spraying humic acid on wheat crop increased its yield by 24% (Delfine et al., 2002).

In general, the results from this study indicate that the application of leonardite based humic fertilizer increased biological yield by 46.89% compared to control, whereas peat based humic fertilizer increased biological yield by 34.47% compared to control. Seyedbagheri (2008) evaluated commercial humic acid products derived from lignite and leonardite in different cropping systems from 1990 to 2008. The results of those evaluations differed as a result of the source, concentration, processing, quality, types of soils and cropping systems. Under their research, crop yield increased from a minimum of 9.4% to a maximum of 35.8%. However, application of humic fertilizer in this study increased the biological yield by 40.68% on average. Application of leonardite based humic fertilizer increased the grain yield of maize by 74%. Also, peat based humic fertilizer increased the grain yield by 44.7%. Overall, the mean increase for grain yield under the condition of application of humic fertilizers was as high as 59.45%. Similar results were also presented by Shahryari et al. (2009b) on wheat. They reported increase of grain yield (by 45%) from 2.49 ton/ha to 3.61 ton/ha affected potassium humate derived from sapropel in normal irrigation conditions.

Conclusion

Results from this experiment indicate that the application of liquid humic fertilizer can positively affect the maize yield and some agronomic traits related to it. These desirable effects can be a consequence of its effect on the physiology of the maize. In general, application of humic acid can lessen the need for chemical fertilizers and subsequently reduce environmental pollution, and compared with other chemical and biological fertilizers, they are affordable. Finally, it can be said that application of humic fertilizer not only increases the yield of maize, but also can play a significant role in achieving the goals of sustainable agriculture.

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