Pak. J. Bot., 45(S1): 21-25, January 2013.

EFFECT OF HUMIC ACID ON GROWTH AND QUALITY OF MAIZE FODDER PRODUCTION

IHSANULLAH DAUR* **AND AHMED A. BAKHASHWAIN**

Department of Arid Land Agriculture, Faculty of Meteorology, Environment & Arid Land Agriculture, King Abdul aziz University P.O. Box 80208, Jeddah: 21589, Saudi Arabia
Corresponding author's e-mail: iaslam@kau.edu.sa ; Tel: +966-594-133232

Abstract

The present study examined the effectiveness of powder humic acid (HA) as a source for enhancing growth and quality of maize fodder (*Zea mays* L.). The study was conducted at the Agriculture Research Station of King Abdul Aziz University, Saudi Arabia by growing maize 2 times during the crop season in the area spanning from September 2011–February 2012, using randomized block design. The effectiveness of HA was studied as controls (H_0: 0 kg of HA ha^{-1}), and with 6 different levels of HA (H_1 = 5 kg of HA ha^{-1}; H_2 = 10 kg of HA ha^{-1}; H_3 = 15 kg of HA ha^{-1}; H_4 = 20 kg of HA ha^{-1}; H_5 = 25 kg of HA ha^{-1}; and H_6 = 30 kg of HA ha^{-1}). Maize growth and quality parameters including plant height, number of leaves, leaf area, dry matter yield, minerals content, crude protein, and neutral detergent fiber (NDF) were measured 60 days after sowing (R1, Silks visibility stage) each time for the crop. Significant differences ($p<0.05$) were observed for all the mentioned parameters across the HA levels. Based on this study, application of H_4 (25 kg of HA ha^{-1}) may be recommended to improve growth and quality of maize fodder in similar environmental conditions. Further research is required in diverse plant environments to determine economically feasible application level of HA while comparing it with other manures and organic fertilizer sources.

Introduction

Organic agriculture is a lifestyle choice that is of considerable relevance in nutrition and sustains the health of soils and ecosystems-so worldwide there is increasing interest in organic agriculture including Saudi Arabia. Saudi Arabia like many other arid climates has low soil organic matter; in addition to hot arid climate, saline soil and saline water that are limiting factors not only for organic crop production but even for conventional farming (Genxu *et al*., 2004; Al-Moshileh & Motawei, 2007; Raiesi, 2012). Enrichment of organic matter in soil decrease soil temperature and mitigates salinity effect and increase moisture conservation and as result stimulates crop growth and quality (Zribi *et al*., 2011; Hamayun *et al*., 2011).

To manage agriculture production in unfavorable soil conditions by enriching their organic matter, various options are found in literature for example, crop rotation, green manures, residue or animal manures incorporation, blood meal, fish meal, vermi compost and humic acid application (Delfine *et al*., 2005; Selim *et al*., 2009; Johnson *et al*., 2012; Ludibeth *et al*., 2012). All these options basically aim to improve soil conditions for growth and quality of the crop. Keeping in consideration the magnitude for shipment and universal availability-humic acid seems a choice amongst the various options. Many studies have demonstrated the practical importance of humic acid in agriculture for example Nardi *et al*., (2002), Buyukkeskin & Akinci (2011), Çelik *et al*., (2011), Tahir *et al*., (2011) and Humintech (2012) have reported beneficial effects of humic substances on plant growth, mineral nutrition, seed germination, seedling growth, root initiation, root growth, shoot development and the uptake of macro-and microelements—in addition to the claim that 1 kg of HA can substitute for 1 ton of manure. Masciandaro *et al*., (2002) have indicated that humic substances might counteract abiotic stress conditions e.g., un-favourable temperature, pH, and salinity enhancing the uptake of nutrients and reducing the uptake of some toxic elements. However, Hartz & Bottoms (2010) have reported that HA neither improves crop nutrient uptake nor productivity. Also, no comprehensive study is available on optimization of HA for any crop especially for maize fodder production.

The present study for that reason explore full potential of HA on growth and quality of maize fodder production-with optimization of HA application to soil. The research findings are based on the key parameters necessary for evaluation of maize yield and quality as fodder and hoped to be valuable information for farmers and researchers.

Materials and Methods

Field experiments were conducted on maize at the Experimental Farm of King Abdul aziz University in Hada Al-Sham, Saudi Arabia. The maize was grown for fodder two times on same field at different location during the crop season in the area spanning from September 2011-February 2012-in randomized block design. HA was applied in powder form to the crop rows after seed emergence as controls (H_0: 0 kg of HA ha^{-1}), and with 6 different levels of HA (H_1 = 5 kg of HA ha^{-1}; H_2 = 10 kg of HA ha^{-1}; H_3 = 15 kg of HA ha^{-1}; H_4 = 20 kg of HA ha^{-1}; H_5 = 25 kg of HA ha^{-1}; and H_6 = 30 kg of HA ha^{-1}). Composite soil samples were collected from the experimental area at 0–30 cm depth before sowing to test the soil properties. Similarly composite soil samples were collected after sowing from only control and H_5 (25 kg of HA ha^{-1}) plots. The soil samples were oven-dried and crushed to pass through a 2-mm sieve. The sand, silt and clay proportion of the soil were determined using the hydrometer method (Arshad *et al*., 1996). Soil pH was determined in a soil saturation extract as described by Thomas (1996). Organic matter was determined by the

Walkley–Black method (Nelson & Sommers, 1996). Nitrogen (N) content was determined with the Khjeldahl method (Bremner, 1996). Phosphorus (P), potassium (K), copper (Cu), zinc (Zn), iron (Fe), and manganese (Mn) were extracted by the Mehlich 1 extracting solution [0.05 M hydrochloric acid (HCl) + 0.0125 M sulfuric acid (H_2SO_4)]. Phosphorus was determined colorimetrically and K, Cu, Zn, Fe, and Mn by atomic absorption spectroscopy. Calcium (Ca) and magnesium (Mg) were extracted with 1 M potassium chloride (KCl). Soil analysis methods used in this study are described by Ryan *et al*., (2001). Based on soil analysis (Table 1) and nutrient requirements of crops comparable to maize, it was assumed that the experimental site had sufficient nutrients required for adequate crop growth. The climatic condition for the experimental site is shown in Fig. 1.

In the experiments seeds of Sunshine F1 hybrid maize (Royal Sluis, Sakata Seed America Inc.) were hand planted at proper moisture on 25 September 2011 and 01 December 2012 in 6 row plots, 6m long with a spacing of 60cm between rows and 20cm plant-to-plant using randomized complete block design with three replications. After planting, drip irrigation with at 3 days interval was kept continues till the end of the experiment using underground water. Plots were kept weed-free thereafter by hand weeding. Other cultural practices were consistent with local agronomic practices. Data on maize growth and quality parameters including plant height, number of leaves, leaf area, dry matter yield, minerals content, crude protein, and neutral detergent fiber (NDF) were measured 60 days after sowing (R1, Silks visibility stage) each time for the crop.

Table 1. Chemical properties of the 0–30 cm clay-loam soil layer of the experimental site.

Soil properties	Before experiment	After experiment	
		Control	H_5
pH	7.4	7.4	7.6
Organic matter	2.01%	1.85%	2.14%
Total N	0.11%	0.05% ^{L}	0.12%
Quantity (mg kg^{-1})			
P	148	142	144
K	392	300	395
Ca	4122	3940	4158
Mg	228	214	256
Fe	48.6	38.0	62.7
Cu	1.58	1.40	1.58
Zn	2.63	2.12	2.96
Mn	11.1	10.5	12.3

H_5: 25 kg of H ha^{-}1

In the table value having superscript L indicates Low soil N according to Sillanappa (1982) while other nutrients are considered enough in soil for a crop growth according to Soltanpur (1985), and Rashid *et al*., (1994)

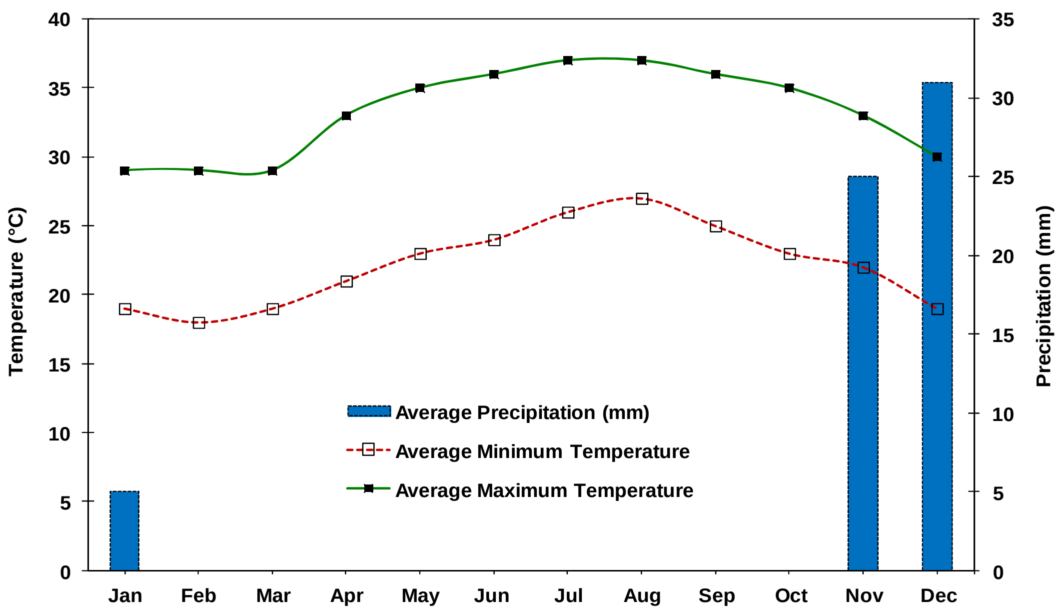

Fig. 1. Average daily maximum and minimum temp (°C), and rainfall of the experimental site.

Procedures for data recording: Plant height was determined on the basis of the average of 5 plants from root separation point to the tip of the plant. Similarly, average number of leaves Plant^{-1} was determined on the basis of 5 plants. Leaf area for individual leaf was determined following the procedure of McKee (1964) by measuring the length of leaf blades from their base to the leaf tip ($Leaf_L$) and the width of the leaf at its widest point ($Leaf_W$) and multiplied these values with a correction factor (0.75) as shown in the following equation.

$$\text{Individual Leaf Area} = Leaf_L \times Leaf_W \times 0.75$$

Green fodder yield was determined in each sub-plot for three central rows and the values were converted to kg ha^{-1}. Dry matter yield was determined using the procedure of Daur *et al*., (2011) where 5 sampled plant in each sub-plot were dried in an oven at 70^{o}C and the values of the sample were converted into kg ha^{-1} based on average 5 plant covered area in the experiment.

Procedures for quality data recording: The dried plant material (plant DM) was ground and digested with a 2:1mixture of nitric acid (HNO_3) and perchloric acid ($HClO_4$) to determine concentration of various nutrients. N content was determined by the Kjeldahl method. Phosphorus was determined colorimetrically, K was determined by flame photometer, while Ca and Mg were determined by atomic absorption spectroscopy. Plant analysis methods were described by Ryan *et al*., (2001). Crude protein content was estimated by conversion of nitrogen percentage to protein (Kang *et al*., 2012). Protein % = N% x Conversion factor (6.25). Neutral detergent fibers (NDF) were determined using the methods of Faichney & White (1983).

Statistical analysis: Data were analyzed statistically by using MSTATC software for analysis of variance, and means were compared using the least significant differences test (Russell, 1986).

Results and Discussion

Growth parameters: All the growth parameters studied in the experiment were significantly ($p<0.05$) effected by humic acid application (Table 2). The mean data from the 2 subsequent growths of maize fodder in the experiment showed that the maximum plant height was observed for H_5 (201 cm) level of HA but statistically it was similar to H_4, and H_6 levels of HA. Similarly leaves number plant^{-1} and LAI indicated highest values for H_5 and lowest for H_0 across HA levels, though non-significant ($p<0.05$) differences were observed between treatments from H_2 to H_6 levels of HA. Green fodder yield was maximum and same for both H_4 and H_5 that was found to be 67384 kg ha^{1}. Dry matter yield (11980 kg ha^{-1}) was higher for H_5 but statistically it was similar to H_4 and H_6. The growth parameters, including plant height, leaves number plant^{-1}, LAI, green fodder yield and dry matter yield generally indicated improvement with increasing increment of HA upto 25kgha^{-1} while beyond that it was found with negative affect or ineffective.

The increase in the growth parameters of maize fodder in the HA-amended treatments most probably was due to the improvement of soil condition of the root zone (Table 1), where the soil analysis indicated that HA maintain soil nutrients supply compared to control. Our results are supported by Suganya & Sivasamy (2006), Selim *et al*., (2009), Buyukkeskin & Akinci (2011), Çelik *et al*., (2011), Tahir *et al*., (2011), Yoon-Ha Kim *et al*., (2012) who have reported that HA increase crop growth and productivity, and help in moisture retention and mitigation of salinity.

Table 2. Effect of humic acid levels on various growth parameters of fodder maize.

Humic Acid (H)	Plant height (cm)	Leaves number plant^{-1}	Leaf area index	Green fodder yield (kg ha^{-1})	Dry matter yield (kg ha^{-1})
H_0	177^{c}	8.1^{b}	5.78^{c}	59996^{e}	10267^{d}
H_1	180^{c}	10.5^{b}	6.26^{b}	61540^{d}	10941^{c}
H_2	187^{b}	11.2^{ab}	7.24^{ab}	62385^{c}	11298^{b}
H_3	198^{a}	11.5^{ab}	7.52^{ab}	65190^{b}	11590^{b}
H_4	200^{a}	12.4^{a}	7.88^{a}	67384^{a}	11855^{a}
H_5	201^{a}	12.6^{a}	8.02^{a}	67384^{a}	11980^{a}
H_6	195^{ab}	12.3^{a}	7.08^{ab}	67197^{a}	11867^{a}

H_0: No humic acid (H); H_1: 5 kg of H ha^{-1}; H_2: 10 kg of H ha^{-1}; H_3: 15 kg of H ha^{-1}; H_4: 20 kg of H ha^{-1}; H_5: 25 kg of H ha^{-1}; H_6: 30 kg of H ha^{-1}
Mean values with different superscript letters in the same column differ significantly ($p<0.05$)

Quality parameters: The minerals content and CP of maize fodder significantly ($p<0.05$) varied between HA levels while NDF content of maize fodder across HA levels revealed non-significant ($p<0.05$) difference (Table 3). The values of minerals (N, P, K, Ca and Mg) contents of maize fodder showed good results for H_5 treatment HA, though statistically the values were similar to H_2, H_3, H_4 and H_6 levels. CP of the maize fodder showed highest value for H_5 that was statistically at par with H_3, H_4 and H_4 treatments. NDF content of the crop non-significantly ($p<0.05$) varied between the HA levels. Our results are supported by Delfine *et al*., (2005), Morard *et al*., (2011) who have reported that humic substances provoked a better efficiency of plant water uptake and improved the mineral nutrition and grain protein content. Our results are further supported by Turan *et al*., (2011) that salinity had negative impacts on the dry weight and the N, P. K, Ca, Mg, Fe, Cu, Zn and Mn uptake of maize plants, the humic acid mitigate salinity and increase dry weight and nutrients composition of plants.

Table 3. Effect of humic acid levels on mineral content, CP and NDF of maize.

Humic acid levels	N	P	K	Ca	Mg	CP	NDF
(kg ha^{-1})	(% of dry matter)						
H_0	1.28^b	0.10^b	1.75^d	0.08^b	0.10^b	8.00^c	56.20
H_1	1.34^{ab}	0.12^b	2.56^c	0.15^{ab}	0.12^b	8.38^c	55.14
H_2	1.62^a	0.18^{ab}	2.87^{bc}	0.18^a	0.22^a	10.13^b	56.48
H_3	1.81^a	0.20^a	2.91^b	0.17^a	0.21^a	11.31^a	56.20
H_4	1.82^a	0.19^a	2.94^b	0.17^a	0.21^a	11.38^a	55.82
H_5	1.84^a	0.21^a	3.05^a	0.18^a	0.24^a	11.50^a	55.96
H_6	1.80^a	0.21^a	3.05^a	0.16^a	0.23^a	11.25^a	57.11

H_0: No humic acid (H); H_1: 5 kg of H ha^{-1}; H_2: 10 kg of H ha^{-1}; H_3: 15 kg of H ha^{-1}; H_4: 20 kg of H ha^{-1}; H_5: 25 kg of H ha^{-1}; H_6: 30 kg of H ha^{-1}
Mean values with different superscript letters in the same column differ significantly ($p<0.05$)

Conclusions

Humic acid increment increased growth and quality of maize in the present experiment. Based on the present study findings 25kgha^{-1} of powder HA application to soil may be recommended. The beneficial effect of humic acid might be due to mitigation of saline condition that needs to study in future. Further research is required in diverse plant environments to determine economically feasible application level of HA while comparing it with other manures and organic fertilizer sources.

Acknowledgement

This article was funded by the Deanship of Scientific Research (DSR), King Abdul aziz University, Jeddah. The author, therefore, acknowledge with thanks DSR technical and financial support.

References

Al-Moshileh, A.M. and M.I. Motawei. 2007. Effect of biofertilization (chicken and pigeon manures) on growth and yield of potato under central Saudi Arabia conditions. *Acta Hort*., 742: 169-173.

Arshad, M.A., B. Lowery and B. Grossman. 1996. Physical tests for monitoring soil quality. In: *Methods for assessing soil quality*. (Eds.): J.W. Doran and A.J. Jones. SSSA Spec. Publ. 49. SSSA, Madison, WI. pp. 123-141.

Bremner, J.M. 1996. Nitrogen-total. In: *Methods of Soil Analysis.* (Ed.): D.L. Sparks, Part 3. *Am. Soc. Agron*., 37: 1085-1122.

Buyukkeskin, T. and S. Akinci. 2011. The effects of humic acid on above-ground parts of broad bean (*Vicia faba* L.) seedlings under $Al^{(3+)}$ toxicity. *Fresenius Env. Bull.*, 20(3): 539-548.

Çelik, H., K.A. Vahap, A.B. Bulent and M.A. Turan. 2011. Effect of foliar-applied humic acid to dry weight and mineral nutrient uptake of maize under calcareous soil conditions. *Comm. Soil Sci. Plant Anal*., 42(1): 29-38.

Daur, I., H. Sepetoglu and B. Sindel. 2011. Dynamics of faba bean growth and nutrient uptake and their correlation with grain yield. *J. Plant Nutr*., 34: 1360-1371.

Delfine, S., R. Tognetti, E. Desiderio and A. Alvino. 2005. Effect of foliar application of N and humic acids on growth and yield of durum wheat. *Agron. Sustain. Dev*., 25(2): 183-191.

Faichney, G.J. and G.A. White. 1983. *Methods for the analysis of feeds eaten by ruminants*. Commonwealth Scientific and Industrial Research Organization, Melbourne, Australia.

Genxu, W., Y. Jinzhong, L. Lin and Q. Ju. 2004. Soil C and N content under evolving landscapes in an arid inland river basin of Northwest China. *Landsc. Ecol*., 19: 621-629.

Hamayun, M., S.A. Khan, A.L. Khan, Z.K. Shinwari, N. Ahmad, Y-Ha Kim and In-J Lee. 2011. Effect of foliar and soil application of nitrogen, phosphorus and potassium on yield components of lentil. *Pak. J. Bot*., 43(1): 391-396.

Hartz, T.K. and T.G. Bottoms. 2010. Humic substances generally ineffective in improving vegetable crop nutrient uptake or productivity. *Hort Sci*., 45(6): 906-910.

Humintech. 2012. Is it possible to replace Humus with organic manure?http://www.humintech.com/001/industry/ information/ faq.html#top (accessed 02 Feb, 2012).

Johnson, H.J., J.B. Colquhoun, A.J. Bussan. 2012. The feasibility of organic nutrient management in large-scale sweet corn production for processing. *Horttech*., 22(1): 25-36.

Kang, S.M., A.L. Khan, M. Hamayun, Z.K. Shinwari, Y.H. Kim, G.J. Joo and I.J. Lee. 2012. Acinetobacter calcoaceticus ameliorated plant growth and influenced gibberellins and functional biochemicals. *Pak. J. Bot*., 44(1): 365-372.

Ludibeth, S.M., I.E. Marina and E.M. Vicenta. 2012. Vermicomposting of sewage sludge: earthworm population and agronomic advantages. *Compost Sci. Util*., 20(1): 11-17.

Masciandaro, G., B. Ceccanti, V. Ronchi, S. Benedicto and L. Howard. 2002. Humic substances to reduce salt effect on plant germination and growth. *Comm. Soil Sci. Plant Anal*., 33: 365-378.

McKee, G.W. 1964. A coefficient for computing leaf area in hybrid corn. *J. Agron*., 56: 240-241.

Morard, P., B. Eyheraguibel, M. Morard and J. Silvestre. Direct effects of humic-like substance on growth, water, and mineral nutrition of various species. *J. Plant Nutr*., 34(1): 46-59.

Nardi, S., D. Pizzeghello, A. Muscolo and A. Vianello. 2002. Physiological effects of humic substances on higher plants. *Soil Biol. & Biochem*., 34(11): 1527-1536.

Nelson, D.W. and L.E. Sommers. 1996. Total carbon, organic carbon, and organic matter. In: *Methods of Soil Analysis*, (Eds.): A.L. Page *et al.,* Part 2, 2nd ed., *Agronomy*. 9: 961-1010. Am. Soc. of Agron., Inc. Madison, WI.

Raiesi. F. 2012. Soil properties and C dynamics in abandoned and cultivated farmlands in a semi-arid ecosystem. *Plant and Soil*, 351: 161-175

Rashid, M.T., M. Yaseen and M.S. Zia. 1994. Phosphorus availability to wheat in three calcareous soils of rice tract. *Proc. 4th National Congress of Soil Science*., Islamabad. pp. 265-270.

Russell, D.F. 1986. MSTAT-C Package Programme. Crop and Soil Science Department, Michigan State University, USA.

Ryan, J., G. Estefan and A. Rashid. 2001. *Soil and Plant Analysis Laboratory Manual* (2nd ed.). Jointly published by the International Center for Agricultural Research in the Dry Areas (ICARDA) and the National Agricultural Research Center (NARC). Available from *ICARDA*, Aleppo, Syria. pp. 172.

Selim, E.M., A.A. Mosa and A.M. El-Ghamry. 2009. Evaluation of humic substances fertigation through surface and subsurface drip irrigation systems on potato grown under Egyptian sandy soil conditions. *Agr. Water Manage*., 96: 1218-1222.

Sillanappa, M. 1982. Micronutrients and the nutrient status of soils. A Global Study FAO Soils. Bulletin, No: 48, *FAO*, Rome, Italy.

Soltanpur, P.N. 1985. Use of ammonium bicarbonate soil test to evaluate elemental availability and toxicity. *Comm. Soil Sci. Plant Anal*., 16(3): 323-338.

Suganya, S. and R. Sivasamy. 2006. Moisture retention and cation exchange capacity of sandy soil as influenced by soil additives. *J. Appl. Sci. Res*., 2: 949-951.

Tahir, M.M., M. Khurshid, M.Z. Khan, M.K. Abbasi and M.H. Kazmi. 2011. Lignite-derived humic acid effect on growth of wheat plants in different soils, *Pedosphere*, 21(1): 124-131.

Thomas, G.W. 1996. Soil pH and soil acidity. In: *Methods of soil analysis*. (Ed.): D.L. Sparks. part 3. *Am. Soc. Agron*., 16: 475-490.

Turan, M.A., B.B. Asik, A.V. Katkat and H. Celik. 2011. The effects of soil-applied humic substances to the dry weight and mineral nutrient uptake of maize plants under soil-salinity conditions. *Not. Bot. Hort. Agrobot. Cluj*., 39(1): 171-177.

Yoon-Ha Kim, Y-H., A.L. Khan, Z.K. Shinwari, D-H Kim, M. Waqas, M. Kamran and In-J. Lee. 2012. Silicon treatment to rice (*Oryza sativa* L. cv 'Gopumbyeo') plants durin different growth periods and its effects on growth and grain yield. *Pak. J. Bot*., 44(3): 891-897.

Zribi, W., J.M. Faci and R. Aragues. 2011. Mulching effects on moisture, temperature, structure and salinity of agricultural soils. *Itea- Inf. Tec. Econ. Ag*., 107(2): 148-162.

(Received for publication 1 September 2012)