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Optimization of Humic acid application rate by evaluating the response of mung been (*Vigna radiata*) yield, growth components and soil properties in western region of Saudi Arabia

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Abstract

Discriminate use of fertilizers gradually damaging biological and physical properties of soil as well as bioavailability of nutrients and organic matter resulting results in low crop yield. So there is needed to equilibrate the application of inorganic fertilizer with organic fertilizers especially in arid region of Saudi Arabia to sustain and conserve soil resources for long term and better yield results. A field experiment was carried out at the Agriculture Research Station of King Abdulaziz University to investigate the effect of different rates of humic acid application along with inorganic fertilizers on growth components of mung bean (*Vigna radiata*) crop and soil properties. The design of the experiment was a completely randomized design with four replications. Three treatments of humic acid (HA 20, 20kg/ha; HA 40, 40kg/ha and HA 60, 60kg/ha) along with control (HA 0) was applied. Results indicates that humic acid application caused significant improvement in the growth parameters of mung bean crop at all levels and (HA 40) proved to be optimum application rate for growth improvement. Regarding soil parameters, a significant decrease in pH was observed at (HA 40), while significant decrease in EC was observed at (HA 40). For soil fertility parameters, HA 40 (40 kg/ha) and HA 60 (60 kg/ha) significantly increase the availability of primary macronutrients (N, P and K) in the soil. The results suggested that application of humic acid at optimum rate HA 40; 40 kg/ha) improves plant and soil attributes to play an important role in sustainable agriculture.

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Introduction

Food security and sustainable agricultural production are key concern of people all over the world in these days (khan *et al.*, 2012). Evaluation of soil fertility status of a region is an essential aspect with respect to sustainable agriculture production (Vijayakumar *et al.*, 2011). Soil fertility is key feather to control the crop yield (Canellas and Olivares. 2014). Increasing demand of food for growing population all over the globe indorse intensive agriculture which compelled farmers to use inadequate and imbalance fertilizers to get high yield (Saruhan., 2011). Moreover, introduction of high yielding verities in agriculture system also increase the utilization of macro and micronutrient fertilizers (Mohajerani *et al.*, 2016). This imbalance fertilizers use continuously damaging biological and physical properties of soil as well as nutrients and organic matter bioavailability, which result in low crop yield (Bakery *et al.*, 2013). So there is need to equilibrate the application of inorganic fertilizer with organic fertilizers to sustain and conserve soil resources for long term and better yield results. In this regard, application of commercial humic acid as an organic fertilizer seems to be very suitable action due to diverse action of humic acids in soil plant system.

Commercial Humic acid is a rich source of many essential nutrients including, 6-8% hydrogen, 46-42% oxygen, 44-58% carbon and 4-5%, Nitrogen, as well as many other nutrients which encourage plant growth (Akinci *et al.*, 2009). Humic acid when applied to field converted into readily available humic substances which directly or indirectly effect the plant growth (Buyukkeskin and Akinci, 2011). It was reported that humic substances promote the activity of PGPR to induce the growth promoting hormones in rhizospheric zone and these hormones increase the efficiency of roots to transport water and nutrients from soil solution to plants (El-Hassanin *et al.*, 2016). Humic acid also act as natural antioxidant. Its presence in plant tissues affects many biochemical processes by increasing nutrient uptake and maintaining levels of amino acids and certain vitamins (El-Bassiouny *et al.*, 2014).

Demand of humic acid increasing widely in agriculture due to its several advantages i.e., stimulates plant hormones and enzymes activity, respiration rate, root nutrient uptake, increase root and shoot fresh and dry weight. Humic acid application directly affects plant growth. It was observed that application of humic acid upgraded the values of growth character i.e. no of branches and leaves, plant biomass weight, number of pods per plants, pod length, Root and shoot elongation and total yield (Shafeek *et al.*, 2013). Moraditochaee (2012) reported that the presence of humic acid results in high seed yield and oil content as compare to in peanut. It also increases the percentage of nitrogen and protein contents in seed tissues of broad bean (Hafez *et al.*, 2015). Moreover, it reduces the frost damage, heat stress and enhances disease resistance by promoting the activity of antioxidants (Syedabai and Armin 2014).

Application of humic acid along with inorganic fertilizer increases the efficiency of inorganic fertilizer which in turn aids to reduce its rate without disturbing the yield of crop (Han, 2011). Application of humic acid not only decreases soil pH and increases organic matter (Daur and Bakhashwain, 2013) but also affect availability and transformation of micronutrients (selim*et al.*, 2010). It was also concluded that addition of humic acid reduces the requirement of primary macronutrients (N,P,K) at optimal growth (Daur and Bakhashwain, 2013). Xi *et al.*, (2010) also observe the stimulatory affect on plant micro and macronutrient uptake due to humic acid application. Najr Hfertilizers enhanced the uptake and utilization of N, P and K by plants compared to inorganic fertilizers (Du *et al.*, 2007). Foliar application of humic acid on beans (*Phaseolus vulgaris* L.), crops enhance plant growth, chlorophyll, pod weight, pods per plant and protein rate of plants by increasing the extent and rate of nutrients absorption (El Bassiony, 2010).

As being from the literature humic acid an organic fertilizer seems to be very suitable action due to diverse action of humic acids in soil plant system.

Therefore, the aim of this study was to optimize the rate of humic acid application by evaluating the performance of different growth parameters of mung bean crop and some soil properties at various application rates of humic acid in western region of Saudi Arabia.

Materials and methods

Experimental location and design

The experiment was conducted at the Agriculture experimental Station of King Abdul-Aziz University located at Hada Alsham, northeast of Jeddah (21° 48′ 3′′ N, 39° 43′ 25′′ E), Saudi Arabia. The dominant climate is arid with mean temperature 27.3 (°C) and relative humidity 49.03 (%) during cropping season. A complete randomized design with four replications was used in this experiment with 16 plots corresponding to the Humic acid with three different rates along with control.

Treatments

Four Humic acid rates constitute 4 treatments were investigated in this experiment. Prior to the start of experiment, soil samples were taken from the experimental sites and analyzed for their physical and chemical properties (table 1). The site was prepared and leveled precisely. Treatments were applied one week before sowing and the entire area of treated plot was covered with humic acid mixed with the upper layer of 15 cm by hand hoeing. Surface drip irrigation system was installed to irrigate the field crop. The distance between the drip lines and drippers was selected by keeping in view the row to row and plant to plant distance of tested crop (40 cm between drip lines and 30 cm between two drippers).

Cultural practices

After installation of surface drip irrigation system, mung bean (*Vigna radiata*) seeds were sown in rows spaced at 20 cm manually in all treatments with a seed rate of 20 kg ha^{-1}. After one week of germination the plants was fertilized by the recommended doses of NPK fertilizers. Moreover, the recommended cultural practices suggested by the Ministry of Agriculture for wheat crop were followed until harvesting.

Measurements of crop yield and yield components data

Plant height at harvesting, number of pods per plants, pod length, number of branches was measured. The measurement and determination procedures were performed as described in Kumar *et al* (2012) where the plant height, number of pods per plants, pod length, number of branches were recorded from 10 randomly selected plants from each plot.

Soil chemical properties

For initial soil analysis, four random soil samples from surface layer (0-30 cm depth homogenize soil layer) were collected from each experimental site before planting using soil auger. For the soil analyses after the end of each growing season, each plot was divided into 4 quarters, one sample was collected from the upper 30 cm soil layer of each quarter using soil auger, then, the four sample of each plot were carefully and homogeneously mixed. One complex sample was collected from the mixture, then air dried, sieved and analyzed for the investigated chemical properties. Soil pH and EC (dSm^{-1}) was measured in 1:1 soil suspension and extraction as described by Jackson (1973). Determination of total nitrogen was done according to the Kjeldahl method (Jackson, 1973) using Kjeltec auto 1030 analyzer. Available P was determined as described in Olsen and Sommers (1982). Available K was determined as described in Carson (1980), and was measured using flame emission spectrophotometry.

Statistical analysis

The obtained data were statistically analyzed after applying the analysis of variance assumptions using the (statistics 8.1) software. The means were compared using the LSD ($p \le 0.05$; steel *et al.*, 1997).

Results

Effects of humic acid on Growth parameters of mung bean

According to the statistical analysis, results indicated that application of humic acid significantly affected Grwoth parameters (Plant height, number of pods, pod length and number of branches) of mung bean crop at $p \le 0.05$.

Mean comparison of mung bean growth parametrs (Table 2) indicated that increasing trend with increased application rates of humic acid (HA). On comparing means, The result shows that plant height increased (41.50 to 48.60 cm) significantly with the increasing rates of HA application from (HA 0 kgha^{-1} To HA 40 kgha^{-1}), while decrease in plant height was observed on further increase in rate (Ha 60 kgha^{-1}) of humic acid application. Humic acid at the rate (HA 40 kgha^{-1}) gave maximum plant height (51.85 cm) and it was minimum (41.50) at (Ha 0 kgha^{-1}).

Statistically, the number of pods increased significantly with the increased rates of humic acid and plants attain their maximum (24) at third level (HA 40 kgha^{-1}). Humic acid rate (HA 0 kgha^{-1}) and (HA 20 kgha^{-1}) seemed to affect similarly in this regard. For number of branches, result shows that significant affect of HA application was observed from (HA 0 kgha^{-1} To HA 40 kgha^{-1}), while decrease in number of branches was observed on further increase in rate (Ha 60 kgha^{-1}) of humic acid application.

Table 1. Initial Physical and chemical properties of soil before start of the experiment.

Feature	Unit	Value
Sand	%	77
Silt	%	13
Clay	%	10
Textural class	-	Sandy loam
Saturation percentage	%	38
pH	-	8.3
EC	dSm^{-1}	4.1
Organic matter	%	0.72
Total nitrogen	%	0.17
Available phosphorus	mg kg^{-1}	11
Extractable potassium	mg kg^{-1}	122

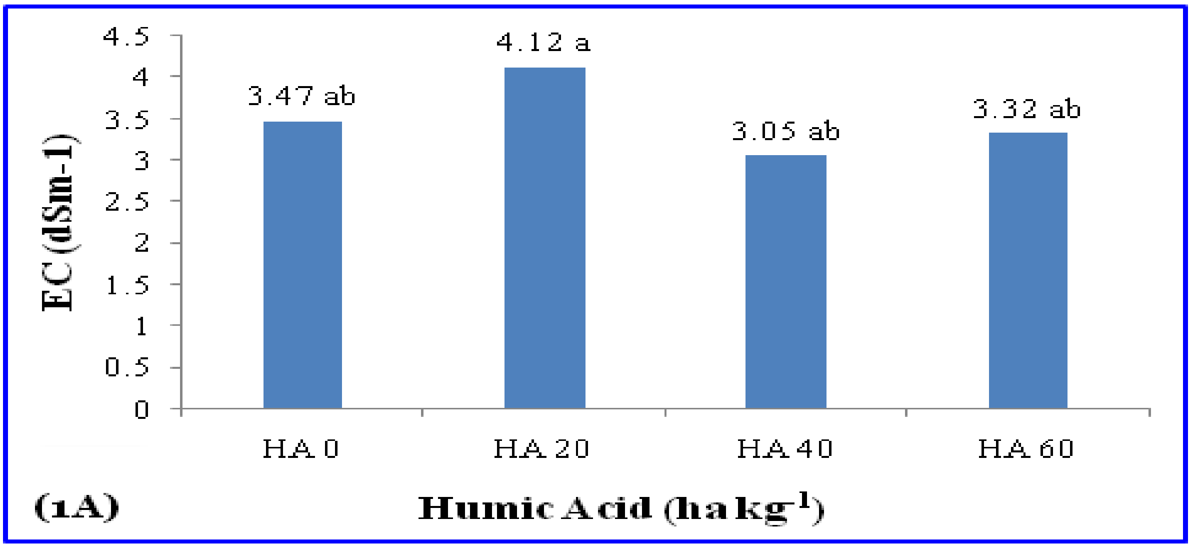
The grain yield increased significantly with the increased rates of humic acid and maximum grain yield was attained (1.69 th^{-1}) at fourth level (HA 60 kgha^{-1}) followed by third level (HA 40 kgha^{-1}) with (1.63th^{-1}) statistically similar to (HA 60 kgha^{-1}). Humic acid rate (HA 0 kgha^{-1}) and (HA 20 kgha^{-1}) seemed to affect similarly in this regard. Overall, increasing trend in the growth parameters of mung bean crop was observed with the increasing application rates of humic acid up to certain tare of application.

Table 2. Effect of Humic acid rates on Plant height, Pod length, Pod length and No of branches.

Rates (kgha^{-1})	Plant height (cm)	No of pods	Pod length (cm)	No of branches	Yield (t/ha)
HA 0	41.50 c	16 c	7.50 c	13 c	0.96 c
HA 20	45.75 b	18 bc	8.25 b	14 bc	1.22 b
HA 40	51.85 a	24 a	10.00a	19 a	1.63 a
HA 60	48.60 ab	20 b	8.75 b	16 b	1.69 a
$LSD_{0.05}$	3.90	2.62	0.70	1.84	0.26

Effects of humic acid on soil pH, EC, total N and available P and K

Response of pH and EC (dSm^{-1}) is demonstrated in figure (1A. B). It is illustrated from the graph that pH respond negatively to humic acid application. With the increased concentration of humic acid from (HA 0 to HA 60mgkg^{-1}) the value of pH decreased continuously. Regarding EC the result indicated that it remained stagnant. Electrical conductivity (EC) of the tested soil is much affected by the rate (HA 20 mgkg^{-1}) which results in increase its value from all other rates significantly. Fig (2. A.B.C) indicated the effect of humic acid application on primary macronutrients (N,P, K) of tested soil. No significant result was observed at first two rates but third rate (HA 40 $mgkg^{-1}$) increased the concentration of nitrogen significantly and it remained non significant at rate (HA 60 $mgkg^{-1}$). A significant difference is observed in concentration phosphorus for first three HA application rates. Similar to Nitrogen maximum concentration of phosphorus was observed at third rate (HA 40 $mgkg^{-1}$). It is also illustrated from the figure that the response of Potassium is statistically similar to phosphorus response.



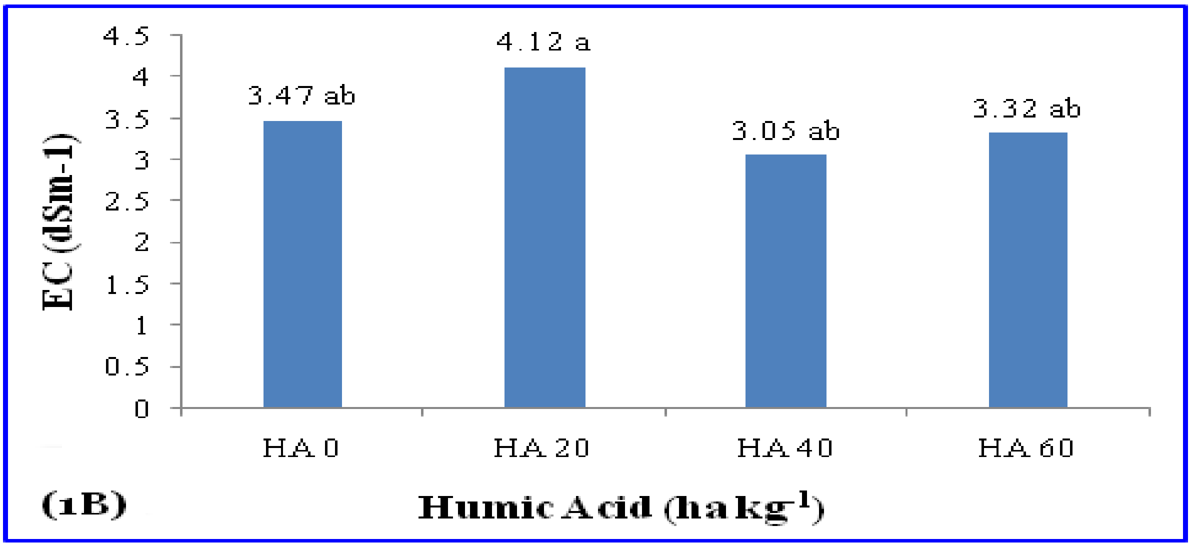


Fig. 1. Relation between humic acid rates with pH (1A) and EC (1B).

Discussion

Effects of humic acid on Growth parameters of mung bean

It was observed that all the grain yield and growth parameters of mung bean crop increased with the application of humic acid.

This improvement in growth parameters is due to functional involvement of humic substances in different mechanisms of plants. It was observed that application of humic acid upgraded the values of growth character i.e. no of branches and leaves, plant biomass weight, number of pods per plants, pod length, Root and shoot elongation and total yield by activating the hormonal activity of mung bean plant (Shafeek *et al.*, 2013). Gao *et al* (2012) demonstrated that humic acid accelerates the shoot growth due to various processes in the root and shoot such as PM H^+-ATPase activity that is directly related with production of gene isoform (Cs-HA2).

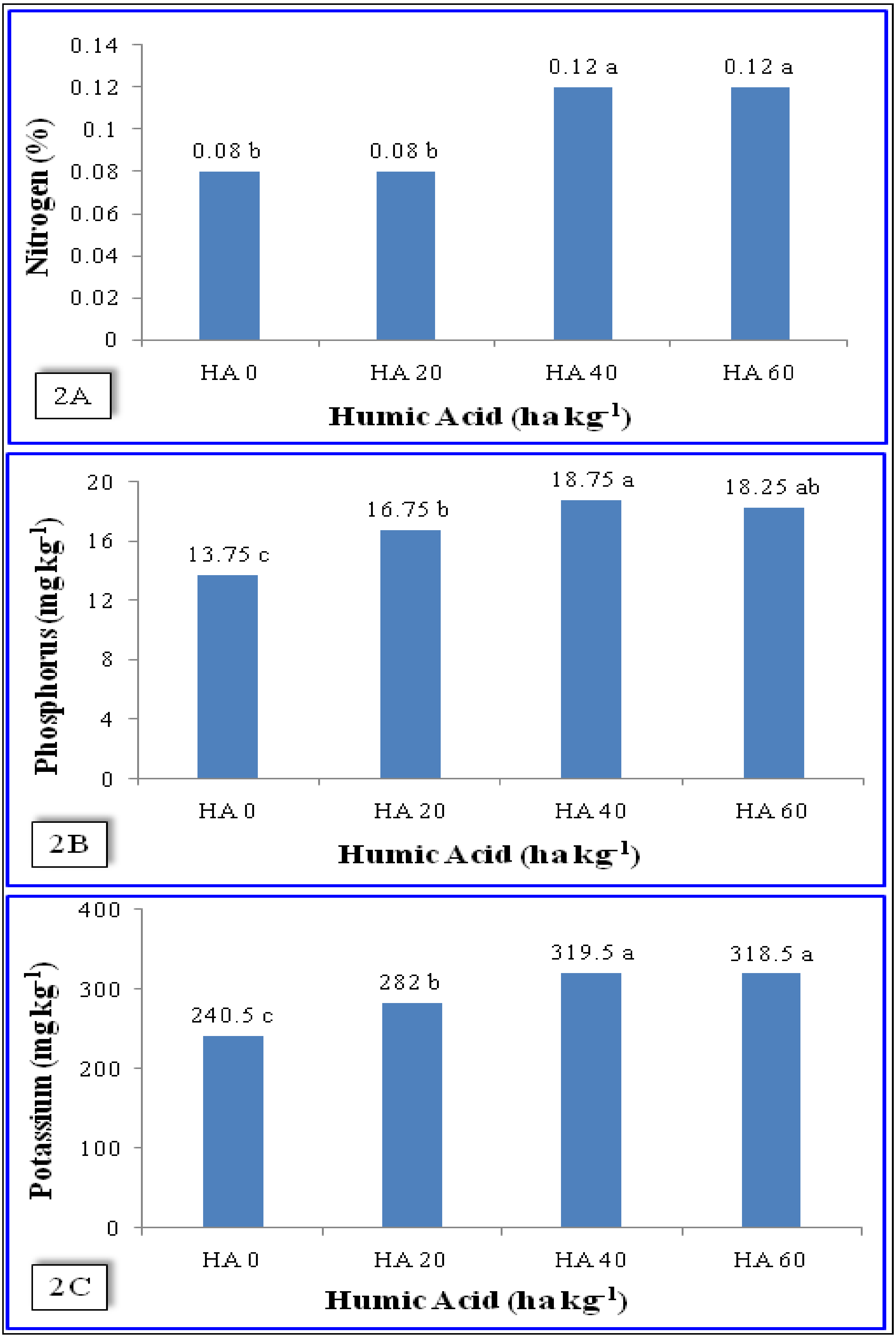


Fig. 2. Relationship of humic acid rates with N (2A), P (2B) and K (2C).

The up-regulation of these isoforms is strongly correlated with increase in mobility of activated forms of cytokinins and nitrates from root to shoot. Ulukan (2008) reported that humic acid improve plant growth by Activating/or inhibiting certain enzyme activities, assimilating many elements, changing membrane permeability which affect protein synthesis and finally the activation of biomass production. Yildirim (2007) reported that using humic acid also increased leaf area and provided more photosynthetic materials which help in the grains filling that can increase yield through seed weight in wheat crop. El-Bassiony (2010) also reported that application of humic acid on bean crop increased chlorophyll content, protein, number of pods per plant by increasing extant of nutrient absorption. humic acid application has significantly affect the seeds per pod through increasing the leaf area, leaf area duration, photosynthesis and maintaining flowers in bloom stage(Khan *et al.*, 2012).

Effects of humic acid on soil parameters

Application of humic acid also improved soil properties and nutrient availability in our experiment. This improvement in soil properties and nutrient availability is attributed to reactive functional group of humic substances. Our results are confirmed by Han (2011) who reported that Application of humic acid along with inorganic fertilizer increases the efficiency of inorganic fertilizer which in turn aids to reduce its rate without disturbing the yield of crop. Mac Carthy *et al.* (2001) reported that humic acid application improves soil structure, increased nutrient uptake, yield and quality of different crops. Moreover, Humic substances are reported to help in nitrate uptake from soil and facilitate water use efficiency.

The similar results were observed in rape (Du *et al.*, 2007) and grapes (Peng *et al.*, 2001). It is demonstrated humic acid based fertilizers improved the nutrient use efficiency of the crop directly by influencing its accumulation and utilization of the nutrients for better plant growth reflecting in enhanced dry matter yield and improvement in various physiological and compositional changes in plants and soil.

Conclusion

The obtained results from this experiment showed significant improvement in growth component of mung bean crop.

It is evaluated that application of humic acid play vital role to increase the growth components of crop and also improve soil fertility status under western region of KSA. Optimum response from all growth components is observed at (HA 40) 40 kgha-1 of humic acid application. Regarding soil properties, pH of soil decreased with increased humic acid rate, while N, P and K content in soil increased. In conclusion, it is proved that application of humic acid along with inorganic fertilizer a key option for better growth and soil conservation especially in arid region which aid sustainable agriculture.

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Reference

Akinichi S, bueyuekkeskin T, Eroglu A, Erdogan BE. 2009. The effect of humic acid on nutrient composition in broad bean (*Vicia faba* L.) roots. Notulae Scientia Biologicae **1(1),** 81.

Bakry BA, Elewa TA, El-Kramany MF, Wali AM. 2013. Effect of humic and ascorbic acids foliar application on yield and yield components of two wheat cultivars grown under newly reclaimed sandy soil. International Journal of Agronomy and Plant Production, **4(6),** 1125-1133. http://dx.doi.org/20133204041.

Buyukkeskin T, Akinci S. 2011. The effects of humic acid on above-ground parts of broad bean (*Vicia faba* L.) seedlings under Al (3+) toxicity. Fresenius Environmental Bulletin, **20(3),** 539-548. https://www.researchgate.net/40832868

Canellas LP, Olivares FL. 2014. Physiological responses to humic substances as plant growth promoter. Chemical and Biological Technologies in Agriculture **1(1)**, 3.
http://dx.doi.org/10.1186/2196-5641-1-3

Daur I, Bakhashwain AA. 2013. Effect of humic acid on growth and quality of maize fodder production. Pakistan Journal of botany**45**, 21-25.
http://dx.doi.org/org/10.12692/ijb/5.2.99-105

Du H, Xue S, Sun Z. 2007. Effects of different application rates of humic acid compound fertilizer on leave nutrient accumulation and physiological mechanism of grape. Chinese Journal of Eco-Agriculture **15**, 49–51.
http://dx.doi.org/10.1080/01904167.2015.1109106

El-Bassiony AM, Fawzy ZF, Abd El-Baky MMH, Mahmoud AR. 2010. Response of Snap Bean Plants to Mineral Fertilizers and Humic Acid Application. Research Journal of Agriculture and Biomass Sciences **6**, 169-175.
http://dx.doi.org/20103157609

El-Bassiouny HS, Bakry M, Attia BA, Allah MMA. 2014. Physiological role of humic acid and nicotinamide on improving plant growth, yield, and mineral nutrient of wheat (*Triticum durum*) grown under newly reclaimed sandy soil. Agricultural Sciences, 2014.
http://dx.doi.org/10.4236/as.2014.58072

El-Hassanin AS, Samak MR, Moustafa NS, Khalifa AM, Inas MI. 2016. Effect of Foliar Application with Humic Acid Substances under Nitrogen Fertilization Levels on Quality and Yields of Sugar Beet Plant. International Journal of Current Microbiology and Applied Science, **5(11)**, 668-680.
http://dx.doi.org/10.20546/ijcmas.2016.511.078

Gao TG, Jiang F, Yang JS, Li BZ, Yuan HL. 2012. Biodegradation of Leonardite by an alkali-producing bacterial community and characterization of the degraded products. Applied Microbiology and Biotechnology, 2581–2590.
DOI: 10.1007/s00253-011-3669-5.

Hafez MM, Shafeek MR, Mahmoud AR, Ali AH. 2015. Beneficial Effects of Nitrogen Fertilizer and Humic acid on Growth, Yield and Nutritive Values of Spinach (*Spinacia olivera* L.). Sciences, **5(02),** 597-603.

Han ZH. 2011. Apple Cultivation with Drawf Rootstock and High Density- theory and Pratice. Science Press, Beijing.
http://dx.doi.org/10.1590/S010029452011000500006

Khan A, Khan MZ, Hussain F, Akhtar ME, Gurmani AR, Khan S. 2012. Effect of humic acid on the growth, yield, nutrient composition, photosynthetic pigment and total sugar contents of peas (*Pisum sativum* L.). Journal of the Chemical Society of Pakistan, **35,** 206-211.

Kumar R, Singh MP, Kumar S. 2012. Effect of salinity on germination, growth, yield and yield attributes of wheat. International Journal of Scientific & Technology Research **1**, 19-23.

Mac Carthy P, Clapp CE, Malcom RL, Bloom PR. 2001. Humic substances in soil and crop sciences: selected readings. American Society of Agronomy and Soil Science Society of America, Madison, W.I.
http://dx.doi.org/19911950504

Mohajerani S, Fazel, MA, Madani H, Lak S, Modhej A. 2016. Effect of the foliar application of humic acid on red bean cultivars (*Phaseolus vulgaris* L.). Journal of Experimental Biology and Agricultural Sciences **4(5),** 519-524.
http://dx.doi.org/10.18006

Moraditochaee M. 2012. Investigation energy indices of corn production in north of Iran. Journal of Agricultural and Biological Science **7(5),** 376-379.

Peng Z, Men M, Xue S, Xue B, Bi S. 2007. Effects of humic acid compound fertilizers on the nitrogen utilization and the following rape. Chinese Journal of Eco-Agriculture **15,** 51–53.
http://dx.doi.org/10.1080/01904167

Saruhan V, Kusvuran A, Babat S. 2011. The effect of different humic acid fertilization on yield and yield components performances of common millet (*Panicum miliaceum* L.). Science Research Essays **6,** 663-669.
http://dx.doi.org/10.5897/SRE10.1153

Selim EM, El-Neklawy AS, El-Ashry SM. 2010. Beneficial effects of humic substances on soil fertility to fertigated potato grown on sandy soil. Libyan Agriculture Research Center Journal International, **1(4),** 255-262.

Seydabadi A, Armin M. 2014. Sugar beet (*Beta vulgaris* L.) response to herbicide tank-mixing and humic acid. International Journal of Biosciences **4(12),** 339-345.

Shafeek MR, Helmy Y, Nadia YI, Omer M, Fatma AR. 2013. Effect of foliar fertilizer with nutritional compound and humic acid on growth and yield of broad bean plants under sandy soil conditions. Journal of Applied Science Research **9,** 3674-3680.
http://dx.doi.org/10.18006/2016.4(5).519.524

Steel RGD, Torrie JH, Dicky DA. 1997. Principles and procedures of statistics- A biometrical approach. 3rd Ed. Mc Graw-Hill, New York, NY. http://dx.doi.org/10.1016/0020-7101(81)90057-X

Ulukan H. 2008. Effect of soil applied humic acid at different sowing times on some yield components in wheat (*Triticum* spp.) hybrids. International Journal of Botany **4(2),** 164-175.
http://dx.doi.org/10.3923/ijb

Vijayakumar R, Arokiaraj A, Martin DP. 2011. Micronutrients and their relationship with soil properties of natural disaster proned coastal soils. Research Journal of Chemical Sciences **1(1)**, 8-12.

Xi J, He M, Lin C. 2010. Adsorption of antimony (V) on kaolinite as a function of pH, ionic strength and humic acid. Environmental Earth Sciences, **60(4),** 715-722.
http://dx.doi.org/10.1007/s12665-009-0209-z

Yildirim E. 2007. Foliar and soil fertilization of humic acid affect productivity and quality of tomato. Acta Agriculturae Scandinavica Section B-Soil and Plant Science **57,** 182-186.
http://dx.doi.org/10.1080/09064710600813107