



Comparative effect of Humic acid application methods and rates on seed yield and yield components of mungbean and some soil micronutrients in arid region of Saudi Arabia

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Abstract

Proper management and use of resources is well necessary to obtain sustainable and economic results especially in marginal land areas like arid lands of Saudi Arabia. To attain the above mention feathers a field experiment was carried out at the Agriculture Research Station of King Abdulaziz University to evaluate the comparative effect of humic acid application methods and rates on seed yield and yield components of mungbean and some soil micronutrients in arid region of Saudi Arabia. A two factor factorial under randomized complete block design was used in this experiment with four replications. Two methods of humic acid application (solid vs liquid) and Three treatments of humic acid (HA 20, 20kg/ha; HA 40, 40kg/ha and HA 60, 60kg/ha) along with control (HA 0) were applied. Results indicate that application of humic acid in solid form resulted in significant improvement in yield and yield components (shoot fresh weight, shoot dry weight, root fresh weight, root dry weight, hundred seed weight and seed yield). Regarding rates, increasing HA rates increased all yield and yield components. Significant increase in all yield components was observed at first three levels of humic acid rates (HA 0 kg ha⁻¹ To HA 40 kg ha⁻¹), while increasing humic acid rate from (40 to 60 kg ha⁻¹) all yield and yield components were statistically similar except seed yield. It is concluded that interaction of solid application method with increasing rates of humic acid upgraded yield and yield component of mungbean and enhance the micronutrients (Cu, Zn and Mn) status in soil solution under arid land region of Saudi Arabia.

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Introduction

Mungbean is a diploid ($2n = 2x = 22$) leguminous crop having genome size 560 Mb, which is widely cultivated as a food legume pulse dominantly in areas having tropical climate with moderate rainfall (Mondal *et al.*, 2012). Seeds of mungbean are highly nutritious containing about 24 % protein, 1.15 % fat, 16.3 % fiber, 3.32 % ash, and 62.62 % carbohydrate on dry weight basis and provide approximately 347 kcal energy (Afzal *et al.*, 2011).

The mineral profile is primarily composed of potassium (1,246 mg/100 g), phosphorous (367 mg/100 g), calcium (132 mg/100 g), and iron (6.74 mg/100 g). Mungbean protein is considered to be easily digestible. Being rich in quality proteins, minerals, and vitamins, it is an inseparable ingredient in the diets of a vast majority of world population (zahoor *et al.*, 2014). The dried grains of mung bean can be split or eaten whole after cooking and made into a soup or dhal (porridge). Mung bean is also eaten as sprouts. Green pods and seeds can be cooked as vegetables (Coelho *et al.*, 2016). It is also recommended as a medicinal diet in case of flatulence and to the sick. Being rich in vitamin B complex, it is regarded as preeminent remedy for beriberi. In addition, the dried green stalk and leaves of mung bean used as fodder (Ullah *et al.*, 2011).

Humic acid (HA) is a vital constituent and a fundamental part of soil organic structure (Nerdi *et al.*, 2016). It has been used by many scientists, agronomists and farmers for improving plant growth and soil conditions (khan *et al.*, 2010). In plants, humic acids have positive effects on plant nutrients, growth stimulant and enzyme activity and are considered as a "plant food". Humic substances are most approachable in high carbohydrate crops like wheat, rice, maize, potato, carrot etc. (Vanitha & mohandass, 2014). Humic acid contains 51% to 57% C, 4% to 6% N and 0.2% to 1% P and other micronutrients in minute quantity. Application of 1.0 kg ha^{-1} to the soil can bring improvement in soil physico-chemical conditions and appreciably increase the yields (up to 20%) of wheat, maize,

cotton, sugar beet and groundnut (Tahir *et al.*, 2011). Humic substances are complex organic compounds of high molecular weight and high stability.

They are responsible for many of the beneficial effects in the soil and in the plant, commonly originated from highly decomposed organic matter (Primo *et al.*, 2011; Baldotto and Baldotto, 2014). There are certain reports about the mechanisms of action of HS on plants (Façanha *et al.*, 2002; Canellas *et al.*, 2009; Nardi *et al.*, 2012; Canellas and Olivares, 2014; Nardi *et al.*, 2016).

To attain valuable results from any input, it is well necessary to utilize that input in efficient manner. Saudi Arabian soils are sandy in nature with low water holding capacity and low organic matter. More over the climatic condition are semi arid to arid which tend to decrease the crop and soil productivity. Ibrahim *et al.*, (2013) suggested that a farmer should pay more attention to the practical application of organic based fertilizer in order to maintain effective nutrient soil interaction. Different method of humic acid application can be used like foliar spray soil spiking, fertigation, etc. Correct selection of application method among these leads to successful crop production along with soil sustainability.

Keeping in view the above facts this study was aimed to evaluate the comparative effect of two different application methods of humic acid in enhancing yield and yield components of mung bean and soil fertility with different application rates.

Material and methods

Experimental location and design

The experiment was conducted at the Agriculture experimental Station of King Abdulaziz 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 two factor factorial under complete randomized design with four replications

was used in this experiment with 32 plots corresponding to two methods of Humic acid with three different rates along with control.

Treatments

Two factors (Humic acid application methods and rates) constitute 8 treatments was 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. The application of solid humic acid was spiked in the soil of experimental area with different rates one week before sowing and the entire area of treated plot was mixed with the upper layer of 15 cm by hand hoeing. Regarding liquid humic acid application method, each rate was dissolved in equal amount of water and applied directly to the soil in three equal doses along the growing season. 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 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 mung bean crop were followed until harvesting.

Measurements of crop yield and yield components data

Shoot fresh weight, shoot dry weight, root fresh weight, root dry weight, 100 seed weight and seed yield at harvesting, was measured. The measurement and determination procedures were performed as described in Kumar *et al* (2012) where the Shoot fresh weight, shoot dry weight, root fresh

weight, root dry weight, 100 seed weight were recorded from 10 randomly selected plants from each plot. Seed yield were measured in 1m² from the middle of each plot and then converted to total seed yield t/ha.

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 was measured in 1:1 soil suspension, while EC (dS m⁻¹) was measured in 1:1 soil and extraction as described by Jackson (1973). Determination of copper, zinc and Manganese was done using absorption spectroscopy technique by atomic absorption spectrophotometer.

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 ($p \leq 0.05$; steel *et al.*, 1997).

Results

Effects of Humic acid application method and rates on yield and yield components

The ANOVA results (table 2) indicated the humic acid application methods, rates and their interaction effects illustrated that HA application methods significantly affect yield components (shoot fresh weight, shoot dry weight, root fresh weight, root dry weight and hundred seed weight) of mung bean crop at $P \leq 0.05$. More over, highly significant result was obtained ($P \leq 0.01$) seed yield. ANOVA indicated that highly significant effect ($P \leq 0.01$) of humc acid rates on all yield and yield components of mungbean.

Table 1. Initial Physical and chemical soil analysis before the starting of the experiment.

Parameters	Unit	Value
Sand	%	78
Silt	%	12
Clay	%	10
Textural class	-	Sandy loam
Saturation percentage	%	39
pH	-	8.4
EC	dSm ⁻¹	4.1
Organic matter	%	0.73
Total nitrogen	%	0.18
Available phosphorus	mg kg ⁻¹	12
Extractable potassium	mg kg ⁻¹	123
Cu	mg kg ⁻¹	1.5
Zn	mg kg ⁻¹	2.4
Mn	mg kg ⁻¹	8.4

Table 2. Analysis of variance for yield and yield components of Mung bean under different application methods and rates of humic acid.

Source	D.F	Shoot fresh weight	Shoot dry weight	Root fresh weight	Root dry weight	100 seed weight	Seed Yield
Rep	3	Ns	Ns	ns	Ns	Ns	Ns
HA types	1	.02*	.003**	.04*	.04*	.049*	0.01**
Error	3						
Rates	3	.00**	.00**	.00**	.00**	.00**	0.00**
Types*Rates	3	.021*	.002**	.02*	.004**	.04*	0.04*
Error	18						
Total	31						

NS : not significant at $p \leq 0.05$. , * , significant at $p \leq 0.05$ and ** , significant at $p \leq 0.01$.

The interaction effect of rates and methods of humic acid application also found significant for all components.

Mean comparison of mungbean yield and yield components (Table 3) indicated that application of humic acid through soil spiking (solid HA Type) statistically perform better than liquid HA type in shoot fresh weight, shoot dry weight, 100 seed weight and seed yield, while performed statistically similar in case of root fresh and dry weights (Table 3). Increased application rates of humic acid (HA) increased all yield and yield components. Significant increase in all yield components was observed at first

three levels of humic acid rates (HA 0 kg ha⁻¹ To HA 40 kg ha⁻¹), while increasing humic acid rate from (40 to 60 kg ha⁻¹) all yield and yield components were statistically similar except seed yield (table 3).

Effects of application method and rates of humic acid on some soil micronutrients

The ANOVA results (table 4) indicated the humic acid application methods (HA types), rates and their interaction effects showed that HA application methods significantly affect the Zinc and copper concentration in the soil at $P \leq 0.01$, while manganese concentration was statistically unaffected. Regarding rates, analysis of variance results indicated that HA

rates highly significant effected ($\alpha= 0.01$) on all measured micronrients (table 4). Interaction effect of application methods (HA types) and rates of humic acid was significant on copper concentration at $P \leq 0.01$ but zinc and manganese were unaffected.

Results presented in figure (1) showed that solid application of humic acid perform better as compare to liquid application method in case of copper and zinc but remain statistically same for manganese in soil solution.

Table 3. Means of yield and yield components of Mungbean under different application methods and rates of humic acid.

Types	Shoot fresh weight/plant (g)	Shoot dry weight/plant (g)	Root fresh weight/plant (g)	Root dry weight/plant (g)	100 seed weight (g)	Seed Yield (t/ha)
Solid	53.77 a*	24.99 a	4.15 a	4.02 a	17.16 a	1.47 a
Liquid	48.70 b	21.86 b	3.98 a	3.85 a	16.78 b	1.39 b
LSD _{0.05}	3.60	2.31	0.37	0.22	0.38	0.27
Rates (kg ha ⁻¹)						
0	31.46 d	17.13 d	3.43 c	3.39 c	16.29 c	0.75 d
20	46.50 c	21.14 c	3.67 b	3.62 c	16.74 b	1.09 c
40	62.66 a	29.02 a	4.55 a	4.45 a	17.55 a	1.45 b
60	64.61 a	27.41 a	4.29 a	4.53 a	17.28 a	1.72 a
LSD _{0.05}	2.25	2.37	0.27	0.29	0.29	0.15

*; Means in each column with the same letter are not significantly different, NS : not significant at $p \leq 0.05$.

Table 4. Analysis of variance for soil micronutrients under different application methods and rates of humic acid.

Source	D.F	Zn Conc.	Cu Conc.	Mn Conc.
Rep	3	ns	ns	Ns
HA types	1	0.02*	.04*	.78 ^{ns}
Error	3			
Rates	3	0.00**	.00**	.00**
Types*Rates	3	0.77 ^{ns}	.004**	.95 ^{ns}
Error	18			
Total	31			

NS: not significant at $p \leq 0.05$. , *, significant at $p \leq 0.05$ and ** *, significant at $p \leq 0.01$.

Copper and manganese increased significantly with increased application of humic acid rate (2), Manganese concentration also increased at initial three levels but (in 40 & 60 kgh⁻¹) showed insignificant increase in their concentration. The highest response was observed in manganese folowed by zinc and copper, respectively for both methods and rates of humic acid as elaborated in the figure (1 and 2).

Discussion

Results showed that both yeild and yield components as well as soil micronutrients significantly respond to methods and rates of humic acid application. Solid

application method perform better than liquid application method, so it may be due to the sandy nature of the soil of the experimental area which promote the leaching of soil nutrients (macro and micro) from root zone causing nutrient depletion. As a result, low productivity and fertility was recorded compare to solid application method which increased the persistance and contact time of humic acid in soil. Baldi *et al*, (2010) demonstreted that soil structure and texture play very imortant role in ntrient mobility and interaction with soil crop system. They further reported that efficiency of inputs in light textured soils can be increased by increasing their persistants in soil system either using slow releasing

methods or applying in split doses. Yang *et al.*, (2013) observed that longer existence of fertilizer especially organic fertilizer in the soil increase water and nutrient holding capacity which leads to better

crop production along with sustainable resources. So application of humic acid by soil spiking method proved better performance than liquid application method in western region of Saudi Arabia.

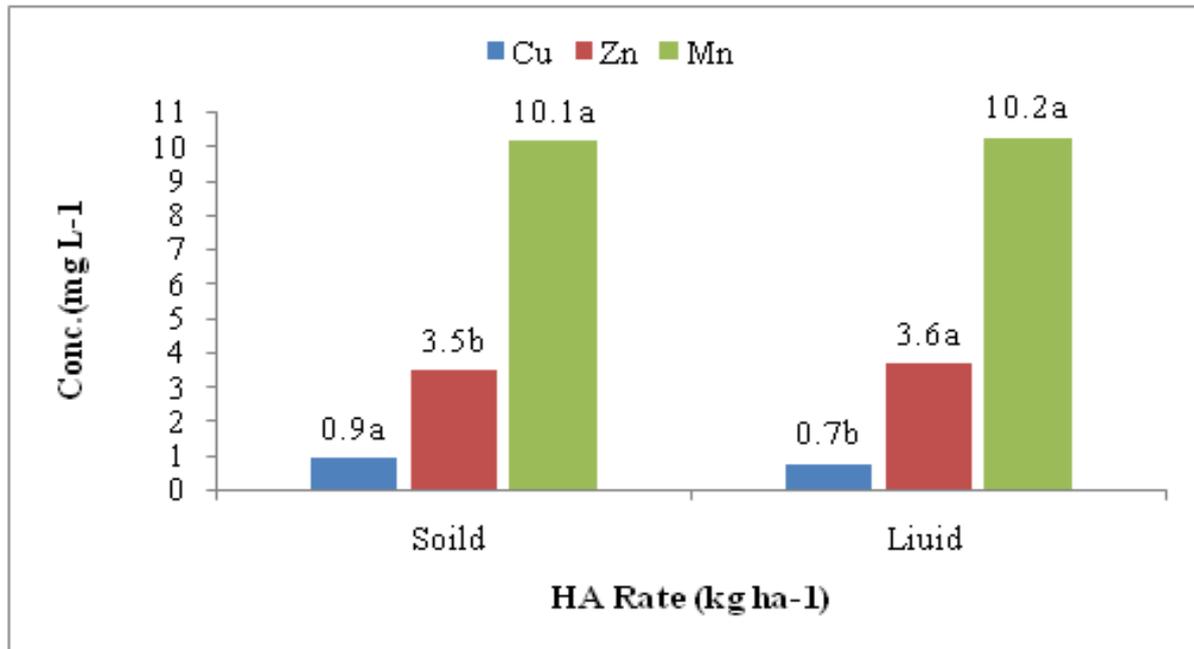


Fig. 1. Effect of humic acid application methods on micronutrients (Cu, Zn and Mn) concentration.

Role of humic acid in yield and yiled components enhancment

The improvement in yield and yield components by increasing humic acid application rate could be attributed to the enormous roles of humic acid in

plant growth. Humic acid (HA) is a vital constituent and a fundamental part of soil organic structure (Nerdi *et al.* 2016). It has been used by many scientists, agronomists and farmers for improving plant growth and soil conditions (khan *et al.*, 2010).

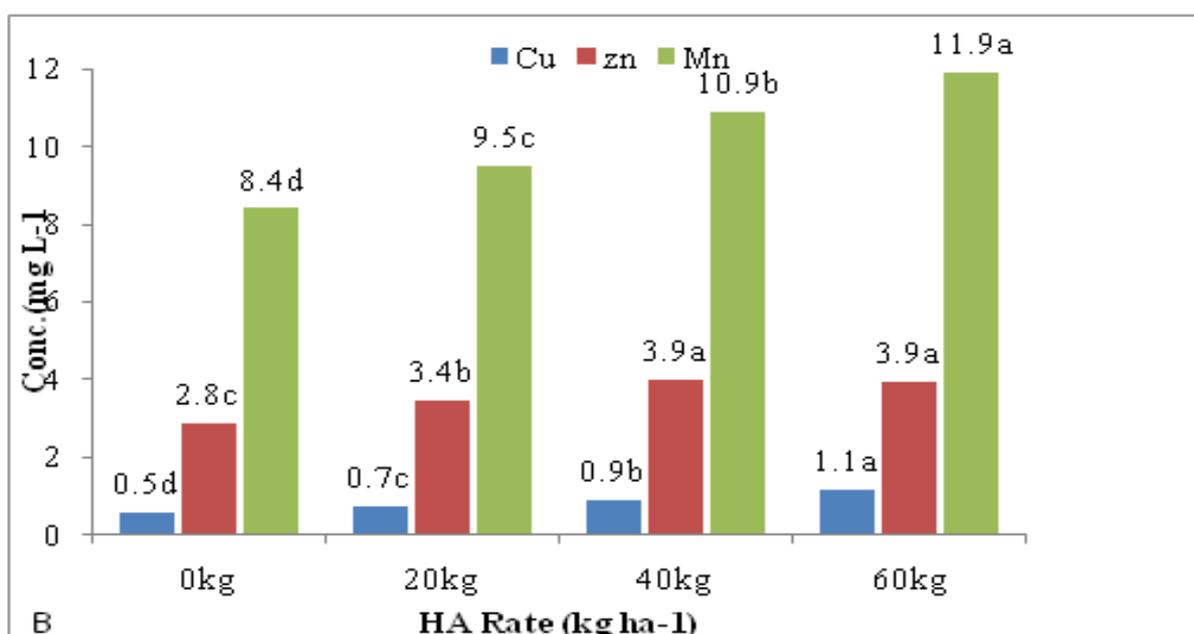


Fig. 2. Response of soil micronutrients (Cu, Zn and Mn) concentration to different humic acid rates.

In plants, humic acids have positive effects on plant nutrients, growth stimulant and enzyme activity and are considered as a “plant food”. Humic substances are most approachable in high carbohydrate crops like wheat, rice, maize, potato, carrot etc. (Vanitha and mohandass, 2014). 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).

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. Effect of humic acid on plant growth may be direct or indirect. Directly it accelerates the plant respiration process, increases chlorophyll content, boost up hormonal growth response and improve membrane penetration in plants (Daur & bajashwain, 2013).

Effect of humic acid on soil properties

It is also demonstrated from different researchers that humic acid application in proper amount increases the efficiency of nutrients present in the soil and also replenish the deficiency without disturbing the soil properties and yield of crop (Han, 2011) It is also reported that humic acid application improve soil structure, increased nutrient uptake, yield and quality of different crops (MacCarthy *et al.* 2001).

Conclusion

The obtained results from this study showed significant effect of application method and rates of humic acid on yield and yield component of mung bean crop and some micronutrients status in soil. Solid application method perform better than liquid application method for yield and yield component as well as micronutrients in arid land region of Saudi

Arabia. Increasing humic acid application rates also improved yield and yield components (shoot fresh weight, shoot dry weight, root fresh weight, root dry weight and hundred seed weight) of mung bean. Concentration of Copper, zinc and manganese increased significantly with increased rates of humic acid by using solid application method. In conclusion, application of humic acid through solid application method (soil spiking) is good option for mungbean yield and soil fertility especially in arid region.

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