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Effect of Foliar Feeding with Humic Acid and Adding method of Magnesium on Growth and Yield for *Mung Bean* (*Vigna Radiata* L.)

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Abstract. *A field experiment was conducted during the autumn season of 2020 in Ibn Al-Bitar Vocational Preparatory School in Al-Hussainiya District / Holy Karbala province Aim of determining the best concentration of humic acid and the best method for adding magnesium and their interaction in some of the vegetative growth traits of Mung bean(Vigna radiata* L.*).The experiment was conducted according to the Completely Random Block Design(CRBD). according to the order of factorial experiments, with three replications, and the number of experimental units 36 experimental units. The spraying was conducted during the stage of vegetative growth and flowering. second factorExperience included Sprinkle humic acid four concentrations(0,5,10,and15) g liters .Liters were sprayed during the vegetative growth phase and flowering: - Adding of magnesium inthree ways, ground adding according to the recommended amount of 80 kg M ha^{-1} (adding one time at the beginning of cultivationMO) and adding half the recommended ground quantity and half the recommended spraying amount (40 kg M ha^{-1} and 10 ml.L $^{-1}$ spray during the vegetative growth stageM1 and magnesium is sprayed according to the recommended amount of 20 ml.L^{-1}. It is divided into two batches (during vegetative growth and flowering) and which is symbolized by M2. Humic acid spray treatment the concentration of (10 g.L^{-1} (H2)gave highest averages in leaf area, leaf content of chlorophyll Spad, number of branches, plant height , root length and the seed yield .The main one reached (374.3 cm, 45.63 spad, 23.31 branch.plant^{-1} ,103.30 cm, 23.82 cm,0.780tons ha^{-1}) respectively. The method of spraying magnesium the concentration of (20 ml.L^{-1}) (M2) excelled and gave highest average leaf area (323.5 cm ^{2}) and the presence of a bi-interaction between the humic acid and magnesium addition method, as ground addition and spraying method (M1) with a concentration of 10 g.L^{-1}was excelled and it gave highest averages in the number of branches, plant height and main root length as it reached (24.87 plant.branch^{-1} ,106.30 cm, 24.93 cm) respectively. The ground addition of M0 excelled on the leaf chlorophyll content of Spad and gave the highest average of (45.63) Spad and the presence of significant interaction. As the ground application method with spraying (M1) with a concentration of (10) g.L $^{-1}$ (H2) excelled on the leaf chlorophyll content of Spad and gave the highest average (51.00) Spad. We conclude through the study that the best concentration of humic acid spray is 10 g .L^{-1}*H2, with the addition of half the amount of spray and the ground addition of magnesium*M1*, for its excelled in most of the vegetative growth traits of Mung bean.*

Keywords: *seed yield; humic acid; leaf area.*

1. INTRODUCTION

Mung bean is an important summer leguminous crop, and its seeds are used as food for humans because they contain protein, carbohydrates, oil, and fiber. Mung bean contains 51% carbohydrates, 26%

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protein, vitamins 3%, and 1% moisture [1]. The adding of nutrients by spraying is considered complementary to ground fertilization, since the Iraqi lands have a low percentage of organic matter, as well as a high percentage of calcium carbonate, and this leads to a decrease in most of nutrients, including magnesium [2]. Humic acid is considered one of the most important acids that play an important role in the processes of oxidation, reduction, and Photosynthesis [3].Foliar fertilization with humic leads to an increase in plant viability by retaining water, photosynthesis, and antioxidants of photosynthesis, and an increase in index of leaf area and length of main root, as humic contains a number of organic compounds that help in increasing the vegetative growth of the plant, increasing the yield and developing the root system [4]. It activates enzymes and inhibits other enzymes, increases plant resistance to harsh environmental conditions such as high temperature and salinity, increases the permeability of cell membranes and stimulates many biological reactions in the plant [5]. Humic acid affects the growth and development of plants directly and indirectly. The direct effects include a change in the metabolic processes of the plant that occurs after the absorption of humic acid. When these components enter the plant cell, many changes will occur in the cell membranes and the different components of the cytoplasm. It increases the permeability of the cell membranes and the ease of transport of nutrients to the sites that require their presence. It affects both the hydrophobic sites on the surfaces of the cellular membranes.This effect is related to the function of all active groups (hydroxyl and carboxyl) of humic acid, which causes increased absorption of the nutrients added by sprinkling [6] in addition to the fact that many researchers believe that the components (phospholipid of cell membranes) are electrically modified due to the presence of humic acid. the cell membrane becomes more efficient for transporting nutrients from outside the cell to the cell's cytoplasm [7]. As for indirect effects, they enter into the vegetative structure and its composition or they enter the amino acids that are among basic units of protein, as well as the production of energy, as is the case with the element phosphorous and its entry into (ATP), Nutrients have an important role in activating enzymes and microelements, and they have a role in the work of plant growth organizations, enzyme activity, fixation of atmospheric nitrogen and chlorophyll, the process of photosynthesis and respiration [8]. Magnesium is one of the macronutrients for plants and is lost through washing and magnesium has a necessary and important role in many vital plant activities, and it is a secondary and important nutrient because it is one of the primary components forming chlorophyll, and it contributes to the formation of protein [9] Use of foliar magnesium reduces fertilizer losses to a minimum, which plays in many biochemical and physiological roles, meaning chlorophyll formation, protein synthesis, enzyme activation, and energy transfer [10]. Ms of study aims to determine the best concentration of humic acid and best method for adding of magnesium and their interactions in the vegetative growth traits of Mung bean.

2. MATERIALS AND METHODS

A field experiment was conducted during autumn season 2020 at Ibn Al-Bitar Vocational School located in Al-Husayniyah district of the Holy Karbala province . To study the effect of foliar feeding with humic acid and the method of adding magnesium on the vegetative growth of Mung bean and their interaction. Humic acid was sprayed in four concentrations (without spraying (control), 5, 10 and 15) $g.L^{-1}$ (H0,H1.H2,H3).The spraying was conducted during stage of vegetative growth and flowering and methods of adding magnesium in the form of magnesium sulfate are as follows:

1- ground adding according to the recommended amount of 80 kg M ha^{-1} (adding one time at the beginning of cultivation)It is symbolized by the symbol (M0)

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2- Add half the recommended ground quantity and half the recommended spraying amount (40 kg M – 1 and 10 ml.L $^{-1}$ spray during the vegetative growth stage) It is symbolized by the symbol (M1).
3- Spraying magnesium according to the recommended amount, 20 ml.L^{-1} and in two batches (during vegetative growth and flowering) It is symbolized by the symbol (M2). Eexperiment was conducted according to Completely Random Block Design(CRBD). According to order of factorial experiments and with three replicates and the number of experimental units 36 experimental units. The cultivation was conducted on lines and the distance between one line and another was 0.50 m and between one pit and another 0.25 m, and 3-4 seeds were placed in each pit at a depth of 2-3 cm. Phosphate fertilizer was added at an average of 75 kg P_2O_5 ha^{-1} in the form of DAP (46% p2o5 and 18% N) when preparing the soil [2] with the addition of nitrogen fertilizer at an average of 40 kg.ha^{-1} in the form of urea (46% N) half the amount at Preparing the soil and the other half at the beginning of the emergence of buds, and the physical and chemical properties of the soil were analyzed as shown in Table 1.The soil was cultivated with Mung bean crop (the local cultivar) on 3/7/2020 on plot and the area of the experimental unit was 6 m 2 with dimensions of 3 x 2 m after the plant reached 15 cm, the plants were reduced to one plant in the pit [11]. humic acid was sprayed in four concentrations (without spraying, 5, 10, 15) g.L^{-1}, which is a water-soluble powder, and weighing each concentration separately. A 2-liter sprayer was used with the addition of distilled water and the spray was conducted during the vegetative growth and flowering stage, and methods of adding magnesium in the form of magnesium.

2.1. Studied traits

2.1.1.Vegetative growth traits and yield

1- The leaves area (cm^2): The leaves area was measured according to the formula [12]. The leaves area was taken in the stage of pod formation:

$$LA = L \times W \times 0.66$$

Where: LA = leaf area (cm2)

L = leaf length (cm)

W = maximum sheet width (cm)

The triple leaf area was multiplied by the number of leaves per plant to calculate the total leaf area
2 - Chlorophyll content in leaves (spad) The percentage of chlorophyll in the leaves was measured by the device (KONICA MINOLTA of origin China) by taking three measurements for one leaf at the end, middle and at the base of the leaf and for three plant leaves, bottom, middle and end leaves of five plants randomly for each experimental unit, and the average was extracted for each experimental unit.
3- Number of branches (plant. branch $^{-1}$): The number of branches post-harvest was calculated from the five plants that were taken to measure the length of the plant, then the average was extracted for each experimental unit.
4-Plant height (cm): The height post-harvest was taken from five plants randomly for each experimental unit, starting from the base of the stem to the end of the main stem by means of a tape measure, and the mean was calculated for each experimental unit.

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5- Length of the main root (cm): The root length of five plants was calculated randomly for each experimental unit, starting from the point of connection of the root with the stem to the end of the main root by means of a tape measure, and the average was calculated for each experimental unit.

6- seed yield (ton ha^{-1}): Calculating the seed yield by measuring the weight of the seeds using a sensitive scale after the harvest . the yield was calculated from the harvest of the experimental unit plants in addition to the five plants that were used in calculating the relevant traits previously.

2.2. Statistical analysis

The data were statistically analyzed for the experiment according to the Randomized Complete Block Design (R.C.B.D) by adopting three replicates by arranging the factorial experiments and using the statistical program (GenStat 2009), using the lowest significant difference test, L.S.D, at a probability level of 0.05 [13].

Table 1. Some chemical and physical properties of experiment field soil for the year 2020

Units	Values	Traits	
----------	7.95	**PH**	
$DS.m^{-1}$	2.3	**Electrical conductivity (Ec)**	
$mg.kg^{-1}$	81.7	**ammonium availability (NH4)**	
$mg.kg^{-1}$	29.1	**nitrate availability(NO3)**	
$mg.kg^{-1}$	18	**Phosphorous (P)**	
$mg.kg^{-1}$	47.6	**Dissolved potassium (K)**	
%	0.9	**Organic matter**	
----------	Clay	**Soil Texture**	
%	25	**sand**	**Soil Separates**
	15	**Silt**	
	60	**Clay**	

The soil of the field was analyzed in the laboratory of the Agricultural Directorate of the Holy Karbala province.

3. RESULTS AND DISCUSSON

3.1. leaf area (cm^2)

The results in Table (2) indicate that there were significant differences according to the different methods of adding magnesium and spraying humic acid and their interaction. The results indicate that the

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method of spraying magnesium (M2) was significantly superior, and it gave the highest average of (323.5) cm^2, while the method of ground addition gave the lowest average of (281.9 cm^2).The reason may be due to the role of magnesium in increasing the absorption of chlorophyll, which was positively reflected in the increase in the foliar area and in agreement with what was mentioned [14]. indicated that the use of foliar fertilization of the element magnesium (50 ppm $MgSO_4$), has achieved an increase in the leaf area. It is noted from the results of the table the excelled of humic acid at a concentration of (H2), and it gave the highest average of (374.3 cm^2), while the control treatment without spraying (H0) gave the lowest average of (222.9 cm^2).The reason may be due to the role of humic acid in increasing the absorption of nutrients in the stomata and is consistent with what they found [15] who indicated that the treatment of Bean and cowpea vegetarians with humic acid increased the leaf area. The results also indicate the presence of significant interaction, and the excelled of the ground addition and spraying method (M1) with humic acid H2 at a concentration of (10 $g.L^{-1}$) and gave the highest average of (388.6 cm2), while the ground addition treatment (M0) with the control treatment (H0) gave the lowest average (213.6 cm2).

Table 2. The effect of humic acid concentrations and the method of magnesium addition and their interaction on the leaf area (cm^2)

Adding magnesium methods	Humic acid concentration (g.L-1)				Average of magnesium
	0	5	10	15	
ground adding (M0)	213.6	252.7	350.8	310.4	281.9
ground adding + M1 spraying	219.5	226.1	388.6	353.3	296.9
Spraying (M2)	235.6	291.3	383.4	383.8	323.5
LSD 0.05	4.640				2.320
Humic acid average	222.9	256.7	374.3	349.2	
LSD 0.05	2.679				

3.2. Chlorophyll content of leaves (Spad)

The results in Table (3) indicate that there are significant differences according to the difference in the method of magnesium addition and the concentrations of humic acid and their interaction. The ground method of adding magnesium (M0) gave the highest average of (45.63Spad), while the method of foliar spraying of magnesium (M2) gave the lowest average of (41.27).The reason may be due to the basic and most common function of magnesium in plants is its role as a central atom of the chlorophyll molecule in the complex of photoreceptor plastids consistent with what he mentioned [16].To study the effect of different levels of magnesium (0,3,6) kg, mg ha^{-1}-, and excelled (6 $kg.ha^{-1}$) on increasing the content of chlorophyll in the leaves. Results in the table also indicate that the concentration of humic acid (H2) gave the highest average of (49.48) Spad, while the control treatment without spraying (H0) gave the lowest average of (41.14) Spad. The reason may be due to the effect of humic acid on the growth and development of the plant, directly and indirectly, and the positive correlation between the addition of humic and the growth and development of the plant, the direct effects include a change in the metabolic

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processes of the plant that occurs after the absorption of humic acid when these components enter the plant cell. Many changes will take place in the cell membranes and various components of the cytoplasm, which leads to an increase in the leaf content of chlorophyll. [17] and [15] who indicated that treating bean and cowpea vegetarians with humic acid led to an increase in the leaf content of Chlorophyll. The results in Table (3) indicate the presence of significant interference, as the method of ground addition with spraying (M1) with a concentration of (H2) outperformed and gave the highest average of (51.00) Spad while giving a ground addition treatment with spray (M1) The control treatment without spraying was the lowest average of (40.27) Spad.

Table 3. Effect of humic acid concentrations and the method of magnesium adding and their interaction on the leaves content of chlorophyll

Adding magnesium methods	Humic acid concentration (g.L-1)				Average of magnesium
	0	5	10	15	
ground adding (M0)	40.72	45.30	48.47	48.04	45.63
ground adding + M1 spraying	40.27	45.43	51.00	49.92	45.41
Spraying (M2)	42.43	46.35	50.19	41.27	41.27
LSD 0.05	2.144				1.072
Humic acid average	41.14	45.70	49.48	44.74	
LSD 0.05	1.238				

3.3. The number of branches (branch. plant $^{-1}$)

Table (4) showed that there are no significant differences according to the method of adding magnesium, the presence of significant differences in the application of humic acid, and the presence of significant interaction between the method of adding magnesium and humic.It is noticed from the results of the table that the concentration of (H2) was higher and the highest average was (23.31 branch. plant $^{-1}$), while the control treatment without spraying (H0) gave the lowest average of (14.44 branch. plant $^{-1}$). The reason may be that humic acid stimulates the action of vitamins inside cells, and your diet has the ability to form complexes with vitamins. When vitamins become associated with humic acid for cells, in this case, the process of cells' use of these vitamins by cells will be easier, which increases the number of branches in the plant, and this is in agreement with [18] who indicated that the treatment of the cowpea plant with humic resulted in an increase in the number of branches plant. The results indicate the presence of significant interference and the excelled of the ground addition and spraying method (M1) gave the highest average of (24.87 branch. plant $^{-1}$), while the ground addition treatment (M0) with the control treatment (H0) gave the lowest average of (13.27 branch. plant $^{-1}$).The reason may be due to its major role in many physiological processes of the plant through its main function in forming phloem, which increases the number of branches in the plant. This is in agreement with [14] who indicated that the use of foliar fertilizer of magnesium (50 ppm MgSO4), has achieved an increase in the vegetative growth characteristics of Mung bean crop, including the number of branches per plant.

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Table 4. Effect of humic acid concentrations and the method of adding magnesium and their interaction on the number of branches (branch. plant $^{-1}$)

Adding magnesium methods	Humic acid concentration (g.L-1)				Average of magnesium
	0	5	10	15	
ground adding (M0)	13.27	18.47	22.93	18.07	18.18
ground adding + M1 spraying	14.73	20.73	24.87	15.40	18.93
Spraying (M2)	15.33	22.07	22.13	15.33	18.72
LSD 0.05	1.862				n.s
Humic acid average	14.44	20.42	23.31	16.27	
LSD 0.05	1.075				

3.4. Plant height (cm)

The results in Table (5) indicate that there were no significant differences according to the method of adding magnesium, the presence of significant differences in the application of humic acid, and the presence of significant interaction between the method of adding magnesium and humic.It is noted from the results of the table the humic acid at an concentration of (10 g.L^{-1}) (H2) excelled and gave the highest average of (103.30 cm), while the control treatment without spraying (H0) gave the lowest average of (88.60 cm).The reason may be that humic acid increases cell division and elongation of cells, improves cell balance, and the highest growth rate and best conditions for cell division occur, which leads to an increase in plant height and this is in agreement with [19].Significant increase when spraying humic acid with concentrations (0, 0.5 and 1 ml.L^{-1}) on pea plants during the phase of elongation in the average plant height and excelled on the concentration (1 1 ml.L^{-1}).The results also indicate the presence of significant interaction, and the method of ground addition and spraying (M1) excelled and gave the highest average of (106.30 cm), while the ground addition treatment (M0) with the control treatment (H0) gave the lowest average of (85.10 cm).The reason is that the resulting increase in this trait is due to the role of adding magnesium as a spray in stimulating the important enzymes in stabilizing the (CO_2) molecule in the process of photosynthesis, and this in turn leads to an increase in the production of processed foodstuffs that have a positive role in the plant, including plant height and consistent with [14] that the addition of magnesium had a significant effect on increasing plant height in Mung bean yield.

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Table 5. The effect of humic acid concentrations and the method of magnesium addition and their interaction on plant height (cm)

Adding magnesium methods	Humic acid concentration (g.L-1)				Average of magnesium
	0	5	10	15	
ground adding (M0)	85.10	92.37	103.87	93.47	93.70
ground adding + M1 spraying	88.80	94.83	106.30	87.90	94.46
Spraying (M2)	91.90	97.40	99.73	85.80	93.71
LSD 0.05	2.373				n.s
Humic acid average	88.60	94.87	103.30	89.06	
LSD 0.05	1.370				

3.5- Length of the main root (cm)

The results in Table (6)showed that there were no significant differences according to the method of adding magnesium, the presence of significant differences in humic acid spraying, and the presence of significant interaction between the method of adding magnesium and humic..The results of the table indicate that the concentration of (10 $g.L^{-1}$) (H2) was superior and gave the highest level of (23.82 cm), while the control treatment without spraying (H0) gave the lowest average of (17.87 cm).The reason may be that humic acid leads to an increase in the amount of nutrients absorbed by the roots, by increasing the length and bifurcation of the root complex [7] and [20] and agree with [3] that the addition of three levels of humic (0, 2, and 3) kg ha^{-1} For green beans, the treatment of humic acid (3 kg H1-) was superior to giving the highest root length.The results also show the presence of significant interaction, and the method of ground addition and spraying (M1) outperformed and gave the highest average of (24.93 cm), while the ground addition treatment (M0) with the control treatment (H0) gave the lowest average of (16.33 cm).The reason is that the synergistic effect of magnesium on phosphorus, which is mostly responsible for the growth and development of the primary root [21], in turn increases the length of the main root and agrees [22] Magnesium led to an increase in the length of the root.

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Table 6. The effect of humic acid concentrations and the method of magnesium addition and their interaction on the length of the main root (cm)

Adding magnesium methods	Humic acid concentration (g.L-1)				Average of magnesium
	0	5	10	15	
ground adding (M0)	16.33	20.07	23.20	21.40	20.25
ground adding + M1 spraying	17.87	20.47	24.93	19.93	20.80
Spraying (M2)	19.40	21.33	23.33	19.20	20.82
LSD 0.05	1.010				n.s
Humic acid average	17.87	20.80	23.82	20.19	
LSD 0.05	0.583				

3.6. seed yield(ton ha^{-1})

It is clear from the results of table (7) that there areb no significant differences according to the method of adding magnesium and the presence of singnificant differences in spraying of humic acid ,and the presence of a significant interaction between the method of adding magnesium and humic . The results of the the joule also indicate that the concentration of (10g liter) (H2) exceeded and gave the highest level of (0.780 tons ha $^{-1}$), while the comparison treatment was given without spraying (H0)lowest average reached (0.685 tons ha $^{-1}$) the reason may be that humic acid is a complementary source of polyphenol , which acts as a respiratory chemical mediator and thes in turn leads to an increase in the biological activity of the plant, as the effectiveness of the enzymatic system increases[23] humic acid also increases the production of enzymes [24] the leads to an increase in the total seed yield and is consistent with [25] using tthree levels of humic acid foliar feeding and concentration (0,1,2 ml.L $^{-1}$) in the growth of the bean plant(Luzde otono class *Vicia faba L.*) and its production , the results showed the superiority of spraying humic acid with a concentration (2 ml.L $^{-1}$) as for the total seed yield of a plant ,it is noted from the results that there is a significant overlap, and the method of ground addition and spraying excelled (M1) it gave the highest average (0.780 tons ha $^{-1}$) while it gave the ground addition treatment (M0) with comparison treatment (H0) iowest average reached (0.647 tons ha $^{-1}$) the reason may be that the addition of magnesium plays an important role in the synthesis of chlorophyll , in addition, it has a key role in many physiological processes of the plant through its main function in the formation of the bark,as well as activating the enzyme in the process of protein biogenesis and phloem building by the effect of photosynthesis to ensure the growth of plant parts and this increases the number of pods , the number of pods, the number of seeds per pod and the weight of 100 seeds,and this leads to an increase in the total seed yield and is consistent with [26] in a field experiment ,adding different levels of magnesium extract(0,5,10,15) kg.mg.H^{-1} on the mung crop and planted for the agricultural season (2007) where does the focus lead (5) kg.mg.H^{-1} there was a significant increase in the number of seeds per pod,the number of pods.the weight of (1000seeds) , and the total seed yield.

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Table (7) The effect of humic acid concentrations and the method of magnesium addition and their interaction on the seed yield(ton ha^{-1})

Adding magnesium methods	Humic acid concentration (g.L-1)				Average of magnesium
	0	5	10	15	
ground adding (M0)	0.647	0.736	0.827	0.779	0.747
ground adding + M1 spraying	0.688	0.774	0.870	0.711	0.761
Spraying (M2)	0.719	0.800	0.834	0.690	0.761
LSD 0.05	0.032				n.s
Humic acid average	0.685	0.770	0.834	0.727	
LSD 0.05	0.018				

4. CONCLUSIONS

1- The foliar feeding with humic acid spray showed a significant response in most of the studied traits of the mung crop when spraying with a concentration of (10 g.L^{-1})(H2)
2- The method of ground application and spraying (M1) of magnesium achieved a significant increase in growth characteristics,yield and its components.
3- The method of ground addition of magnesium(M0) achieved a significant increase in the chlorophyll content of the leaves of spad.
4- There is a significant interaction that the method of ground addition with spraying(M1) with a concentration of leaves of chlorophyll spad.

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