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ORIGINAL ARTICLE

THE EFFECT OF SPRAYING ORGANIC ACIDS, NANO AND TRADITIONAL IRON IN THE GROWTH AND YIELD OF THE MUNG BEAN (*VIGNA RADIATE* L.)

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Abstract: This field experiment was conducted in 2020 at the Research Station of College of Agriculture, University of Anbar (Anbar Province, Iraq) in order to investigate the effect of spraying of different organic acids on the mung bean properties. The treatments are: control (without addition A0), the humic acid (H), the amino acid of valine (V) and the auxin (growth regulator) of indole acetic acid (I) with concentrations of 100 mg.L^{-1} for each one. The second factor is the addition of iron spray formulas with different concentration (0, 20 mg.L^{-1} Nano-Iron (NI), 20 mg.L^{-1} chelating NI and 100 mg.L^{-1} metal iron in the form of iron oxide take the symbol (Fe_0, Fe_N, Fe_{NC} and Fe_T) sequentially. The factorial experiment of randomized completely block design (RCBD) with three replications was used. The results showed significant increase in all studied traits due to H and different Fe forms. The interaction between treatments H and Fe_N achieved the highest values of plant's height (PLH), total grains yield (TGY) and the iron concentration in grains (ICG) with increasing percentage of 66.2, 65.2 and 253.6%, respectively in comparison with control treatment Fe_0 A_0. The highest values of leaf area (LA), dry weight of green part (DWGP), iron concentration in leaves (ICL) and protein concentration in grains (PCG) were recorded at Fe_N I treatment with increasing percentage of 83.2, 52.9, 349.2 and 163.8% successively compared to control treatment Fe_0 A_0. Moreover, the highest value of fertilization efficiency (FE) was 63.5% in the treatment of Fe_N H compared to control Fe_0 A_0.

Key words: Foliar application organic acids, Iron oxide, Nano iron oxide, Green gram.

Cite this article

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1. Introduction

The mung bean is one of the magnitude field crops belonging to the fabaceae family. It is an important crop for its large nutritional importance because it contains a high protein concentration ranging from 19-29%, carbohydrates from 62-65%, oil 1-1.5% and fibres 3.5-4.5%. It is one of the crops with a high need for nutrients, including the iron element, which is one of the essential and necessary micronutrients for plant growth, as the iron element is an important element for the plant because of its large and effective role in the vital processes of the plant where it activates the enzyme processes in the plant and enters into the formation (Ferredoxin) in the plant which is a very important compound in the electronic transport chain in addition to being one of the components of the nitrogenise enzyme necessary in the process of stabilizing atmospheric nitrogen as well as its lack leads to defect in the process of photosynthesis within the body of the plant in addition to its role in the RNA and DNA formation process and its active role in the protein formation process. Despite the importance of this element, most Iraqi soils suffer from a shortage of it, due to its high content of calcium carbons more than 25% and the alkali pH interaction of them, which increases the processes of adsorption and deposition of this element as well as the low content of organic matter, all of these factors combined worked to reduce

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the availability of this element. In order to overcome the problems of ground addition from stabilization and deposition, it has resorted to the use of several strategies and alternatives, including the use of leaf nutrition and to make the most of these nutrients and has been provided with substances that increase their absorption, including organic acids, which are an organic bio-catalyst like amino and humic acids that affects plant growth development and increase the yield, as they behave similar to the work of hormones [Sallume *et al.* (2020)]. Nanotechnology has recently entered agriculture in its various sectors, with Nano fertilizers being an important tool in this area to improve crop growth by increasing productivity and increasing nutrient efficiency while reducing the cost of growing crops. Furthermore, many researchers have pointed to the positive effects of organic acid spraying and all forms or concentration of iron fertilizers whether it was traditional or Nano in most measured plant yield and growth indicators [Tan (2004), Galal *et al.* (2016)]. Therefore, the target of this study is to compare the effect of spraying addition of Nano and traditional iron on the plant with the presence and absence of organic acids in some characteristics of plant growth and yield and find out what kind of organic acid which has achieved the plant's maximum response to absorbing different iron images and also gave the best values in growth and yield indicators to study the impact of these treatments on the efficiency of fertilizer use for its importance in the economic evaluation and fertilizer productivity.

2. Materials and Methods

The study location and irrigation method

The study was conducted at the Research Station at the University of Anbar - College of Agriculture in the Agricultural Season 2020-2021 in Anbar province - Ramadi District - Al-Hamdhiya area. The seeds of mung bean (Indian-cultivar) were implanted on 19/7/2020 in loamy soil as it was analyzed for chemical properties according to Page *et al.* (1982) and physical by Black (1965) as shown in Table 1. Surface irrigation was used according to plant requirements. The amount of water needed for each plot is equipped with 4-inch polyethylene pipes to unify the amount of water prepared for each plot.

Experimental design and crop management

A factorial experiment was executed according to the randomized completely blocks design (R.C.B.D.)

Table 1: Some physical properties and chemical analyses of field soil before agriculture*

Trait		Unit	Value
pH 1:1		-----	7.7
EC 1:1		$dS.m^{-1}$	2.4
SOM		%	0.69
$CaCO_3$		%	5.0
Bulk density		$Mg.m^{-3}$	1.57
CEC		$Cmole.kg^{-1}$ soil	20.1
Dissolved cations	Ca^{2+}	$meq.L^{-1}$	7.5
	Mg^{2+}		5.0
	Na^{+}		8.7
	K^{+}		2.1
Dissolved anions	SO_4^{2-}	$meq.L^{-1}$	12.8
	HCO_3^{-}		2.0
	Cl^{-}		10.0
Available nitrogen		$mg.kg^{-1}$ soil	56.0
Available phosphorus		$mg.kg^{-1}$ soil	12.5
Available potassium		$mg.kg^{-1}$ soil	286.0
Available iron		$mg.kg^{-1}$ soil	2.73
Particle size distribution PSD	Sand	$mg.kg^{-1}$ soil	42.4
	Silt		44.0
	Clay		13.6
Texture class		Loamy soil	

with three replications. The first factor is organic aids with 100 mg.L^{-1} for each one as the following:

1. A_0: treatment without any addition (control).
2. H: humic acid treatment.
3. V: valine (amino acid) treatment.
4. I: indole acetic acid (auxin- growth regulator) treatment.

The second factor is spraying application of iron element with different concentrations and forms as the following:

1. Fe_0: mg.L^{-1} concentration (control treatment).
2. Fe_N: 20 mg.L^{-1} of NI treatment.
3. Fe_{NC}: 20 mg.L^{-1} of Nano chelating iron treatment.
4. Fe_r: 100 mg.L^{-1} of mineral iron (ferrous oxide form) treatment.

The total sum of treatments and their interaction produced 48 experimental units.

The organic acids were dissolved using distilled water, but the iron forms were dissolved with a diluted acid solution and then the required concentrations were prepared. The experimental unit consisted of six lines of 2 meters length per line and the distance between every two lines is 30 cm and the distance among the plants is 25 cm. The number of plants for the experimental unit was 48 plants. One meter distance was left among the experimental units to ensure that the spray solution splash does not move from one experimental unit to another. The treatments were sprayed on three times as the first spray was 50 days after the start of the implantation and the second spray was 15 days after the first spray and the third spray 15 days after the second spray. Whereas, the control treatment was sprayed by water only.

The same amount of fertilizers was applied on the ground for all treatment. The scattering method was used to add fertilizers of macronutrients according to the recommendation. The first is nitrogen with 40 kg N.ha^{-1} fertilizer in two batches, the first one at implantation and the second after 40 days of cultivation, the second is phosphorus was added at a level of 80 kg P. ha^{-1} and the third is potassium was added at 40 kg K.ha^{-1} and they are both added at the beginning of cultivation. The service of crop was operated when required.

The harvesting and measured indicators

The plants were harvested on 14 October 2020, showing signs of maturity and taking measurements of vegetable growth and the yield of mung bean as follows:

Indicators of vegetative and radical growth

To calculate the indicators of vegetative growth, a random sample of (10) plants was taken from the middle line after leaving a number of guard plants surrounding the sample during the growing season and the measurements included: plant height (PLH) (cm), number of branches per plant (NBPP) (branch.$plant^{-1}$), leaf area (LA) (cm^2.$leaf^{-1}$), dry weight of the vegetative part (DWV) (g.$plant^{-1}$) and leaf content of chlorophyll (LCC) (SPAD unit).

Elements analysis

The samples included both leaves and grains were dried in an oven at a temperature of 65^oC. Then milled and 0.2 g were taken from each sample and digested to estimate iron concentrations in leaves and grains according to the method mentioned in Lindsay and Norvell (1978). Iron was measured using an atomic absorption spectrometer, while nitrogen concentration in grains was estimated using the Keldahle device and in accordance with the method used by Page *et al.* (1982).

3. Results and Discussion

The results of Table 2 show the presence of significant effects to add organic acids as H (100 mg.L^{-1}) applied as spray achieved a rise in most measured morphological growth properties and this can be due to the role of H in increasing cell elongation and increase cellular division, as H causes increased plant growth rate and give the best conditions division cells [Bhiah and Al-Zurfi (2020)]. The significant effect was clear for all the formulas and compositions of the added ferrous element. It has also been obvious to the plant as compared to the treatment of non-spraying, which can be explained by the role of iron and its participation in many processes that occur in the plant such as photosynthesis, amino acid production and enzymes that lead to increased cellular divisions and antioxidant enzymes As well as the role of iron in increasing gibberellins (GA) synthesis in plants [Rui *et al.* (2016)] which has affected the elasticity of plants' cell membranes and thus their expansion. The Nano-iron spraying treatment of 20 mg.L^{-1} was superior to all other iron formulas, which could be due to its characterization by increased speed of bioactivity, large surface area and small size of Nano-particles that increase the speed of reactions leading to the production of growth materials, stimulate enzymatic activity and increase the production of secondary metabolism compounds in leaves, leading to increased plant growth [[AL-Snafi (2015) and Abed and Sallume (2020)].

The highest values of PLH and NBPP reached increasing percentages 66.2% and 89.1%, respectively at the interaction treatment of Fe_N H, compared to Fe_0 A_0 treatment which has the lowest values for the above mentioned traits. The results of the statistical analysis in Table 3 showed the presence of significant effects to add organic acids as H achieved in the trait of ICG as well as a noticeable increase in the TGY and in the FE for the concentration 100 mg.L^{-1} which is highest significant value compared to the control treatment and this can be attributed to the effect of H through its role in increasing the conductivity of stomatas and thus increase the absorption of elements used in the spraying on the plant. In addition to increasing the permeability of cell membranes, H directly affects cellular membranes where permeability increases, making it easier to transport nutrients to areas where they require availability, affecting both hydrophobic and hydrophilic areas in cellular membrane surfaces, which is linked to the function of effective hydroxyl groups and causes the carboxyl found in H to absorb more added nutrients [Chen and Aviad (1990)].

The same table illustrates the significant effect of

Table 2: The effect of spraying organic acids and iron element formulas and concentrations in some properties of vegetative growth.

Treatments Organic acids	Iron forms	PLH (cm)	NBPP (branch.plant^{-1})	LA (cm^2.plant^{-1})	DWV (g.plant^{-1})	LCC (SPAD)
A_0	Fe_0	47.47	4.30	13.16	19.73	47.9
	Fe_N	76.17	8.07	23.18	28.68	54.18
	Fe_{Nc}	73.73	7.33	18.05	24.67	52.05
	Fe_T	62.40	5.73	18.05	21.74	46.02
H	Fe_0	63.23	5.47	17.13	21.22	52.69
	Fe_N	78.93	8.07	23.39	29.76	52.42
	Fe_{Nc}	78.53	8.13	23.18	24.77	51.63
	Fe_T	66.63	6.60	17.83	24.38	48.83
V	Fe_0	55.60	5.23	12.29	21.13	48.60
	Fe_N	78.27	8.00	21.76	29.15	51.84
	Fe_{Nc}	76.50	7.80	22.99	27.07	53.19
	Fe_T	65.43	6.13	15.50	21.97	47.00
I	Fe_0	60.20	5.17	15.46	21.57	46.36
	Fe_N	76.03	8.03	24.11	30.17	50.78
	Fe_{Nc}	75.60	7.43	21.98	24.14	52.09
	Fe_T	60.70	6.03	17.67	23.78	46.32
L.S.D = 0.05		4.583	0.940	3.241	1.604	4.253
Average for organic acids	A_o	64.94	6.36	18.11	23.71	49.84
	H	71.83	7.07	20.38	25.03	51.39
	V	68.95	6.79	18.13	24.83	50.16
	I	68.13	6.67	19.80	24.92	48.89
L.S.D = 0.05		2.291	0.470	1.620	0.802	2.126
Average for iron forms	Fe_0	56.63	5.04	14.51	20.92	48.68
	Fe_N	77.35	8.04	23.11	29.44	52.30
	Fe_{Nc}	76.09	7.68	21.55	25.16	52.24
	Fe_T	63.79	6.13	17.26	22.97	47.04
L.S.D = 0.05		2.291	0.470	1.620	0.802	2.126

all spraying applied iron forms on increasing the ICI and ICG which may be due to the spraying operation of iron. While the rise of protein content may be attributed to the important role of iron in participating to many biological processes that occur in the plant, including photosynthesis and increased production of amino acids [Phogat *et al.* (2016)].

The iron is an important component for plant growth, chlorophyll synthesis, transpiration-reduction operation in plant tissues and synthesizing of plant cytokines that are important for plant photosynthesis. In addition, it plays an important role in nitrogen absorption and increased leaf area and directly affects the protein production process. It may also be due to the fact that Nano-iron is highly efficient in penetrating cell membranes since the NPS used is smaller than 100 nm and is able to cross the cell wall to functional work centres and is necessary for chlorophyll synthesis and photosynthesis, promote energy transfer, metabolism, cell division, increase their number, increase leaf and stem area, thickness of the crust and vessel diameters [Nair *et al*. (2010)]. Furthermore, Nano-iron increases the efficiency of H-ATPase enzyme in the plasma membrane of sentinel or guard cells, which increases the opening of stomata nearly five times their normal state, enhancing CO_2 entry and increasing the efficiency of nutrition-synthesis and its reflection on the mung beans' yield and its indicators [Kim *et al.* (2015)].

The results of the same table also show the significant effect of the interaction between the two

Table 3: The effect of spraying organic acids and iron element formulas and concentrations in some properties of the yield and quality.

Treatments Organic acids	Iron forms	ICL ($mg.kg^{-1}$)	ICG ($mg.kg^{-1}$)	PCG (%)	TGY ($mg.kg^{-1}$)	Yield FE (%)
A_0	Fe_0	76.4	117.1	8.26	1.73	0.00
	Fe_N	338.0	334.4	21.29	2.88	66.11
	Fe_{Nc}	209.9	277.9	15.56	2.60	50.46
	Fe_T	120.0	241.9	14.10	2.27	31.11
H	Fe_0	56.1	150.5	9.54	2.24	29.13
	Fe_N	342.8	414.4	19.92	2.86	65.38
	Fe_{Nc}	241.8	344.3	14.14	2.59	49.52
	Fe_T	159.0	248.0	14.51	2.21	27.57
V	Fe_0	62.9	144.9	7.81	2.12	22.50
	Fe_N	322.4	413.3	21.60	2.77	59.99
	Fe_{Nc}	230.1	321.2	15.53	2.62	51.20
	Fe_T	174.5	251.5	16.25	2.19	26.48
I	Fe_0	68.1	121.5	7.26	2.09	20.58
	Fe_N	343.2	315.1	21.79	2.81	62.64
	Fe_{Nc}	275.5	319.5	13.67	2.56	47.51
	Fe_T	135.1	230.5	14.03	2.07	19.45
L.S.D = 0.05		47.88	89.52	2.797	0.152	8.972
Average for organic acids	A_o	186.1	242.9	14.80	2.37	36.92
	H	199.9	289.3	14.53	2.48	42.90
	V	197.5	282.7	15.30	2.42	40.04
	I	205.5	246.6	14.19	2.38	37.55
L.S.D = 0.05		23.94	44.76	1.398	0.076	4.486
Average for iron forms	Fe_0	65.9	133.5	8.22	2.05	18.05
	Fe_N	336.6	369.3	21.15	2.83	63.53
	Fe_{Nc}	239.4	315.7	14.72	2.59	49.67
	Fe_T	147.2	243.0	14.72	2.19	26.15
L.S.D = 0.05		23.94	44.76	1.398	0.076	4.486

study factors. The treatment of interaction achieved the highest values when spraying H with NI. While the Fe_NH interaction treatment achieved the highest values in TGY and ICG with increasing percentages of 65.2% and 253.6%, respectively compared to the control treatment Fe_0A_0. Whereas the treatment of Fe_NH achieved the highest FE value (63.53%) compared to the Fe_0A_0 transaction that recorded the lowest value. The treatment of interaction Fe_NI had the highest values of ICL and PCG with increasing percentages of 349.2, 163.8, successively compared to Fe_0A_0 treatment.

4. Conclusion

The results of this study showed that H spraying significantly exceeded for the studied properties. Moreover, the spraying of all the formulas and iron compositions achieved a significant increase in most measured properties. The NI was the more effective treatment on all studied properties, nevertheless, the interaction between sprayed H (100 $mg.L^{-1}$) and sprayed NI (20 $mg.L^{-1}$) had the best effect on the values of vegetative growth properties and also on ICL, ICG, FE and TGY where the increase was 65.2% compared to control treatment.

5. Recommendations

1. It is recommended to spray H on mung bean crop with 100 $mg.L^{-1}$ concentration associated with NI of 20 100 $mg.L^{-1}$ without addition of chelating agent under the same conditions of study area.
2. It is possible to use foliar application of iron on the vegetative part without need to spray chelating agents.

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