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RESPONSE OF MUNG BEAN TO BORON NANOPARTICLES AND SPRAYING STAGES (*VIGNA RADIATA* L.)

Nasreen Khalil Ibrahim* and Hameed Abed Khashan Al Farttoosi
Field Crops Department, College of Agriculture, University of Karbala, Iraq
Email : hameedabed76@yahoo.com

Abstract

The individual and composite effects of boron metal and nanoparticles were studied on growth and yield of mung bean by using the complete Randomized Block Design (RCBD) with three replications. This design depends on a sequence of experiments involving two factors. In the first factor, the boron metal and nanoparticles were sprayed with three concentrations (0, 90, and 180) mg.l^{-1}. The second-factor of spraying was carried out with three stages; the initial apparition of the buds in the first stage, the second stage with %50 flowering and the third of %100 flowering. These experiments were carried out during the spring season of 2018 in Ibn Al-Bitar Secondary school, the district of Al-Husseiniya, Holy Karbala, Iraq The findings of this research indicate that the spraying stages of boron nanoparticles and boron metal and the interference between them have significant differences, which could, therefore, have a number of explanations. Where, it was found boron nanopart- icles with 90 mg.l^{-1} concentrate to be a higher effect on increasing the harvest that features the highest rate of plant height, the number of pods, and total seed yield (98.80 cm, 70.33 pod.plant^{-1}, and 1.54 t.Ha^{-1}) respectively. Compared to those without treatment by boron nanoparticles featuring (86.73 cm, 40.67 pod.plant^{-1}, 0.78 t.Ha^{-1}) respectively On the other hand, the treatment with boron metal has exceeded the number of seeds in the pod which gave 10.53 seed.pod^{-1}in comparison with nano boron treatment 180 mg.l^{-1} which gave the lowest averages 8.50 seed. pod^{-1}. Additionally, the stages of spray have significant effect on the plant height, the number of pods, the number of seeds on pod and the seed yield. , The spraying phase was 100% superior to the rest of the stages also, the results indicate that there is significant interaction between the two factors of the study. It gave a 100% spraying stage with a treatment of 90% nano boron. The highest average rate of plant height, number of pods and total seed yield (102.07cm, 77.00pod.plant^{-1}, 1.75t.ha^{-1}) compared to the control treatment which gave (84.87cm, 36.33pod.plant^{-1}, 0.69t,ha^{-1}) at the beginning of the emergence of buds. There was a significant influence on the number of seeds it gave a 100% spraying stage with a treatment of 90% metal boron 11.30seed.pod^{-1}. compared to the control treatment which gave 7.87 seed.pod^{-1} at the beginning of the emergence of buds.

Keywords : *Vigna radiata*, Randomized Block Design, Nanoparticle.

Introduction

Green gram (*Vigna radiata* L. Wilczek) belong to the Legumes family that is cultivating as one of the principal crops since ages in our country. India is the primary green gram producer and contributes about 75% of the world's production (Tanuk *et al.*, 2012). It is characterized by a short growing season (120-90 days) and cultivated for the purpose of obtaining seeds of high nutritional value for humans and animals. This is because they are full of nutrients, an excellent source of the high-quality protein content of % 26-24 and easy for digestibility. The cultivated area of this crop in Iraq is 33027 acres with a production rate of 383.80 kg don^{-1} (Directorate of Agricultural Statistics, 2016). Generally, crops pulp suffers from the problem of high percentage falling of flowers reaching more than 75% which has a significant impact on the decrease of production. Therefore, attention should be paid to the micro-sedimentary elements, especially Boron, which is one of the important fertilizer elements needed by the plant in small quantities and indispensable An inorganic element in the plant has a role for the formation of cellular walls and facilitates the movement and transfer of photosynthesis of the leaves to the active areas in the plants such as sugars, as it is necessary for cell division, stimulation and inhibition of photosynthetic pathways (Ahmad *et al.*, 2009). Boron is important in the formation of the bark and the transfer of some active hormones that affect the growth and developing of the stem and root levels. Additionally, It has an encouraging role in the vitality and germination of pollen, flowering and increasing the level of carbohydrates transferred to the active areas of growth during the reproductive stage. Moreover, it plays a role in the speed of plant absorption of water and plants resistance of drought and also the relationship to regulate the absorption of calcium. In addition, it has importance to increase protein synthesis through its large role in the formation of nucleic acids. Boron is relatively immobile and cannot be easily transported to reproductive organs but continuous supply of boron is must during the flowering stage. Adequate boron is also required to ensure effective nodulation and nitrogen fixation in legumes (Noor and Hossain, 2007).

Nanotechnology is one of the promising methods in improving the use efficiency of fertilizers. Nano-particles are atomic or molecular aggregates in size in the nano-scale range of 1-100 nm (Rai, 2010). Nano-fertilizers have some beneficial effects on the increase in the NUE (Nutrient Use Efficiency), enhanced yield and reduced soil pollution (Naderi and Danesh, 2013). Application of nanoparticles has been proved to be effective in enhancing seed germination and seedling growth (Pandey *et al.*, 2010). Nanotechnology is a smart system that delivers a precise amount of nutrient and other agrochemicals required by plants, minimizing the use of pesticides and antibiotics (Sharon *et al.*, 2010). Also, it can enhance growth and yields of the plant by supplying one or more nutrients, whereas nanomaterial enhanced fertilizers improve the performance of conventional fertilizers, but it does not provide crops with nutrients directly. Nano-fertilizers compared with the conventional ones, are expected to significantly improve growth and yields of crops. These nano-fertilizers are being developed of their slow release and efficient dosages for plants (Singh, 2012). Nano-particles facilitate the absorption of water and nutrients by roots and enhance antioxidant enzyme activity such as catalase and superoxide dismutase. Thus, nano-particles can improve plants tolerance against different stresses (Harrison, 1996). Therefore, the use of the boron nanoparticles could be a promising technique, which, has never ever been used with Green-gram and this is the target of this research.

Materials and Method

A field experiment of this project was carried out during the spring season of 2018 in Ibn Al-Bitar Secondary school, the district of Al-Husseiniya, Holy Karbala, Iraq. This study investigates the individual and combined effect of boron metal and nanoparticles and the stages of their impact spraying on the growth and yield of the mung beans *Vigna radiata* L. The experiment was conducted with two factors; in the first factor, Boron metal and nanoparticles were added and with the concentrations (0, 90 and 180) mg.$^{-1}$ for each. The other factor includes three stages of spray; with the initial apparition of the flower buds, with 50% flowering and finally with 100% flowering with three replications, according to the Complete Randomized Block Design (RCBD).

After plowing the soil twice and dividing into four parts with dimensions (3 m length x 75 cm width) for each part with a distance 25 cm between them, Phosphate fertilizer was added by 75 kg, P_2O_5 Ha^{-1} and DAB (P46) N18 with the first batch of nitrogen fertilizer 40 kg, N Ha^{-1} (Shawqi, 2012).

The experimental unit was planting by placing three seeds in each hole with 5-6 cm deep and then it is reduced to one plant in the hole when the plants reach to 15 cm. The nano-chlorinated Boron, which is a fully water-soluble powder consisting of 9% of the boron, was used with two concentrates 90 mg/l^{-1} and 180 mg/l^{-1}. The weight of each concentration was placed individually in a sprayer with a 1 liter capacity and completed by adding distilled water. Comparison between the treatment with adding the distilled water only and the treatment with using boron mineral with the same concentrations of boron nanoparticles was carried out. Boron metal was symbolized with B1 for concentration 90 mg and B2 for 180 mg. Whereas, for boron-nanoparticles, N1 was the symbol for 90 mg concentration and N2 for 180 mg concentration. These quantities of concentrations were divided into three levels of spraying in three stages of plant growth which are; the initial apparition of the buds in the first stage, the second stage with 50% flowering and in the third stage with %100 flowering for above-mentioned concentrations for the two types of boron. The process of spraying was conducted in the early morning.

The measured characteristics are as following:

1- Length of the plant (cm).
2- Number of pods (pod. plant^{-1}).
3- Number of seeds (seed. pod^{-1}).
4- Total yield (t. ha $^{-1}$).

Statistical analysis: The data were statistically analyzed according to the design of the complete random complete Block Design with factorial experiment (R.C.B.D) using the statistical program (GenStat Vergen, 2009). The averages were compared using a test with a significant difference of L.S.D at a probability level of 0.05.

Results and Discussion

Plant Length (cm)

The height of the plant is one of the important qualities that have to do with the seed yield through the carrying of the number of pods in addition to carry the plant branches. Therefore, it is a source of crop and increases the process of photosynthesis due to exposure of solar radiation, that lead to increase the seed yield (Naderi *et al*, 2013).

The analysis of results showed significant differences in the effect of boron concentrations in the treatment as shown in table (1). The spray treatment of boron nanotubes when its concentration 90 mg.l^{-1}, led to the highest mean recording (97.80 cm). While the comparison to the treatment without nanomaterial gave a mean average of height (86.73 cm). This is because the positive role of boron in the movement of sugar which could easily attribute to some factors; to the cellular membranes after its association with boron, its effective growth in the plant, its role in cell division, and the formation of the bark, in addition to its relationship to the plant hormones that affect the growth of the growing peaks of stems and roots (El-Metwally *et al.*, 2018) (Makkdad, 2017). Furthermore, it has been noted from the same table a significant effect of the stages of spraying on plant length, The spraying phase was 100% superior to the rest of the stages, giving 95.45cm compared to the control treatment at the vegetative growth stage which recorded 89.80 cm. Also, the results indicate that there is significant interaction between the two factors. The spraying treatment exceeded 102.07 cm in the 100% flowering phase compared to the control treatment. at the beginning of the emergence of buds which gave the lowest averages 84.87 cm. These results are in agreement with the finding (El-Metwally *et al.*, 2018) (Makkdad, 2017).

Number of pods (pod.plant^{-1})

It can be seen from the table (2) a significant effect of the boron concentrations on the number of pods. The treatment of the boron nanoparticles concentration at 90 mg.l^{-1}, gives an average mean of 70.33 pods.plant^{-1} in comparison to control, which gave a mean average of 40.67 pods.plant^{-1}. This is due to the effect of boron in the promotion and increase of flowering in plants. Additionally, to increase the surface area of boron nanoparticles and increase its absorption that stimulates growth hormone (Cytokinin) which promotes the process of flowering and fertilization. While increasing the concentration of boron gives negative results on the number of pods it has been noted from the same table a significant effect. Furthermore, it has been noted from the same table a significant effect of the stages of spraying on number pods in plant. The spraying phase was 100% superior to the rest of the stages, giving 56.20pod.plant^{-1} compared to the control treatment at the vegetative growth stage which recorded 47.15 pod. plant^{-1}. Also, the results indicate that there is significant interaction between the two factors. The spraying treatment exceeded 77.00 pod.plant^{-1} in the 100% flowering phase compared to the control treatment. For another stage of spraying, at the beginning of the emergence of buds gave the lowest averages of 36.33 pod.plant^{-1}. These results are in agreement with the findings (El-Metwally *et al.*, 2018) (Makkdad, 2017).

Number of seeds in the pod (seed.pod^{-1})

Results of the table (3) indicate that there is a significant difference between the boron spraying factors in the number of seeds in the pod. The boron mineral treatment at 90 mg.l^{-1} concentrate gave the highest mean number of seeds reached up to 10.53seed pod^{-1} in compared to the nano boron treatment, which gave the lowest average number of seeds in pod 8.50 seed.pod^{-1}. This is due to the direct effect of boron on the growth of reproductive parts as it requires high levels of boron to grow naturally and especially the growth of callus in the walls of the cells of the vaccine tubes through a complex composition. Borate Callus Complex of tubing needs a high concentration of boron in the ovary for its important role as a chemical guide to the growth of the tube during the reproductive tissue in the direction of the ovary. This process called Chemotactic, which in turn directly affects the success of the process of fertilization in the flowers and the composition of seeds. and this is consistent with (Singh, 2012) (Patra, 2009) which were increased vitality showing a significant effect of boron in the number of seeds in the remaining pod. Furthermore, it has been noted from the same table a significant effect of the stages of spraying on number seeds in pod. The spraying phase was 100% superior to the rest of the stages, giving 10.26 seed .pod $^{-1}$ compared to the control treatment at the vegetative growth stage which recorded 8.68 pud.plant^{-1}. Also, the results indicate that there is significant interaction between the two factors. The spraying treatment exceeded 11.30 seed pod^{-1} in the 100% flowering phase compared to the control treatment. For another stage of spraying, at the beginning of the emergence of buds gave the lowest averages of 7.87 seed.pod^{-1}.

Seed yield (t. ha^{-1})

The results of table (4) refer to a significant effect of boron metal and nanoparticles spraying, spray stage and interaction in yield. The nano boron spray treatment has exceeded the concentration of 90 mg.l^{-1} that led to the highest average recording of 1.54 t. Ha^{-1} compared with the control treatment that gave the lowest mean of this characteristic which was 0.87 t. Ha^{-1}. This is attributed to the superiority of the same treatment plants in the number of pods in the plant (Table 3). This result is in agreement with the findings (El-Metwally *et al.*, 2018) (Izadi and Sanave, 2018). Furthermore, it has been noted from the same table a significant effect of the stages of spraying on plant length, the spraying phase was 100% superior to the rest of the stages, giving 1.56 t.ha^{-1} compared to the control treatment at the vegetative growth stage which recorded1.05 t.ha^{-1}. Also a significant effect between the two factors of the study. The treatment of nano boron spray has exceeded the concentration of 90 mg.l^{-1} Which gave highest averages at 100% flowering 1.75 t.Ha^{-1} compared to the beginning of flowering buds stage which was 0.69 t, ha^{-1} .

Table 1 : Effect of boron metal and nanoparticles, the stages of spraying and the interaction between them on the length of the plant (cm).

Average effect of boron	Flowering 100%	Flowering 50%	The beginning of flowering buds	Stages of spraying / Concentration
86.73	88.63	86.70	84.87	Control
95.80	97.03	97.30	93.07	B1
92.40	94.40	92.67	90.13	B2
98.80	102.07	97.57	96.77	N1
89.80	95.10	90.13	84.17	N2
	95.45	92.87	89.80	Average spray effect
Interaction		Stages of spraying	Concentration of boron	$LSD_{0.05}$
7.807		3.491	4.507	

Table 2 : Effect of boron metal and nanoparticles and the stages of spraying and the interaction between them in the number pods in plant.

Average effect of boron	Flowering 100%	Flowering 50%	The beginning of flowering buds	Stages of spraying / Concentration
40.67	44.67	41.00	36.33	Control
58.33	66.31	55.28	53.40	B1
43.00	43.33	48.00	37.67	B2
70.33	77.00	69.67	64.33	N1
45.67	49.67	43.33	44.00	N2
	56.20	51.46	47.15	Average spray effect
Interaction		Stages of spraying	Concentration of boron	$LSD_{0.05}$
8.61		3.85	4.97	

Table 3 : Effect of boron metal and nanoparticles and the stages of spraying and the interaction between them in the number of seeds in pod

Average effect of boron	Flowering 100%	Flowering 50%	The beginning of flowering buds	Stages of spraying / Concentration
8.77	9.77	8.67	7.87	Control
10.53	11.27	10.60	9.73	B1
9.27	9.27	9.17	8.87	B2
10.17	11.30	10.23	8.97	N1
8.50	9.20	8.33	7.97	N2
	10.26	9.40	8.68	Average spray effect
Interaction		Stages of spraying	Concentration of boron	$LSD_{0.05}$
0.95		0.43	0.55	

Table 4 : Effect of boron metal and nanoparticles and the stages of spraying and the interaction between them in the Total yield of seeds ton ha^{-1}

Average effect of boron	**Flowering 100%**	**Flowering 50%**	**The beginning of flowering buds**	**Stages of spraying / Concentration**
0.78	0.94	0.71	0.69	Control
1.32	1.60	1.26	1.09	B1
1.42	1.66	1.38	1.22	B2
1.54	1.75	1.51	1.36	N1
1.08	1.33	1.01	0.90	N2
	1.46	1.18	1.05	Average spray effect
Interaction		Stages of spraying	Concentration of boron	$LSD_{0.05}$
0.39		0.17	0.23	

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