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Effect of Late Foliar Feeding with N and Micronutrients Nano Particles on Mungbean (*Vigna radiata* L. Wilczek) Growth, Yield and Chemical Constituents

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Abstract: Two field experiments were conducted during 2021 and 2022 summer seasons at a private farm, Tawfik El Hakim Village, Nubaria district, Behaira Governorate. The objective of the experiments was to study the effect of late foliar spray with some nutrients on growth, yield and seed chemical composition of VC1973A mungbean variety. The foliar applied treatments were urea at 1.5% and four key micronutrients Nano particles: Fe NPs (0.5%); Zn NPs (0.1%); Mn NPs (0.2%) and Cu NPs (0.05%). Micronutrient treatments were sprayed either alone or combined with urea at the early pod-setting stage. The results showed that foliar spray with N and micronutrient Nano particles alone or combined with urea improved growth characters. The data of yield and yield components revealed significant effects due to the combined application of micronutrient Nano particles with urea. Urea application at 1.5% combined with Nano-ZnO increased pod-number plant^{-1}. The highest seed yield per plant was recorded when the plants were foliar sprayed with Cu NPs and Mn NPs alone or Urea + Zn NPs. Meanwhile, the highest seed yield per feddan was achieved by foliar spraying with Cu NPs or Zn NPs alone as well as by the combined application with urea with Cu NPs, Mn or Zn. The greatest protein percentage in mungbean seeds was recorded due to the combined application of urea with Zn NPs, while the highest carbohydrate percentage was found due to combining urea with Cu NPs. Micronutrient concentrations in mungbean seeds were elevated more than in the control treatment due to foliar spray treatments but they did not reach the level of significance for Cu NPs, Zn NPs and Cu NPs. It can be concluded that foliar spray of urea combined with Cu NPs or Zn NPs may enhance mungbean growth, increase seed yield and improve the quality of seeds.

Key words: Micronutrients · Nano particles · Urea · Mungbean · Foliar feeding · Yield · Chemical constituents

INTRODUCTION

Mungbean (*Vigna radiata* L. Wilczek) is a newly introduced summer pulse crop in Egypt. It is a short duration crop (70-90 days) with relatively low fertilizer requirements [1]. The preliminary experimental work has proved that mungbean could be grown successfully in different regions of Egypt [2]. It is expected that the demand for mungbean may be increased because of its multipurpose utilization such as starch extraction, food rich in protein and as a supplement to wheat flour in bread making [3]. Moreover, mungbean can be consumed directly by cooking, or as sprouts as well as making popular foods when it is mixed with other cereals [1]. Mungbean is a symbiotic N-fixing legume and nitrogen fixation process increases to reach the maximum during the flowering and early pod-filling stage, however, it declines rapidly there after [4]. Mungbean plants has the

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determinate growth habit and are characterized by forming compensatory side branches after flowering, which are considered as new sinks that compete for the limited supply of the synthesized assimilates source [5]. Therefore, self-destruction phenomena in legumes may be excited in mungbean leaves, thus to avoid or delay leaf senescence an external or supplemental N-supply is needed [6]. Several investigators recommended foliar spray of N on soybean at the pod-filling stage [7]. Ghildiyal [8] sprayed mungbean plants with urea 1.5% at weekly intervals and found that the rate of photosynthesis in the urea, treated plants remained constant for 20 days after flowering, while it declined in the untreated plants. Moreover, Sekhon [9] found that foliar urea application during pod-filling (after 63 days from saving) of mungbean enhanced ammonia assimilation and the accumulation of amino acids. Furthermore, foliar applied N to mungbean was found to increase seed yields [10]. In addition, several investigators showed the positive response of mungbean yield and chemical composition to micronutrients, i.e. Zn and Fe and Cu [11, 12]

Nanotechnology can be identified as a science, technology carried out using materials, atoms, or molecules in dimensions ranged 1-100 nm [13]. The inclusion of nanoscience in agricultural applications such as bio pesticides and fertilizers contributes to rapid progress in the field of food safety and quality [14-17]. Nanotechnology can serve the agricultural sector by providing innovative strategies for increasing food production [18]. Nowadays, there is a growing interest in the beneficial application of Nano-fertilizers in consolidating crops to withstand biotic and abiotic stresses [19-22]. Nano-fertilizers are fertilizers produced in the nanoscale by chemical, physical or biological methods that enhance their characteristics and improve their performance compared to conventional fertilizers [23]. That drew attention toward the nutritional advantage of elevating micronutrients like Zn content in basic food crops [24]. It exists in the plant tissues as ions or as an essential component assimilating into protein and has a vital role in plants metabolism and biomass production. The micronutrients play a direct or indirect role in carbohydrate breakdown and are involved in protein synthesis [25, 26]. It is performed as a regulatory factor for many enzymes and incorporated in several activities along with chlorophyll and cytochrome synthesis [27-31]. Moreover, micronutrients especially zinc has a crucial function in plants' strategies against salinity, drought and pathogens [32-37]. Accordingly, the deficiency of these nutrients leads to several physiological process disruptions, reducing crop production and yield quality. Thus, the supply of field crops by Nano fertilizers is crucial for crop productivity [37]. Mungbean and other short duration legume nature is considered symbiotic N-fixing crops that depends on the N-fixed by nodules since their activity ceases at the later stage of growth and starvation to N occurs at later growth stages, therefore an external or supplemental N is needed to overcome the self-destruction phenomena which leads to rapid leaf senses. Therefore, the objective of this work is to study the effect of late foliar feeding with N and micronutrients Nano particles on mungbean (*Vigna radiata* L. Wilczek) growth, yield and chemical constituents.

MATERIALS AND METHODS

Two field experiments were conducted during 2021 and 2022 summer seasons at a private farm, Tawfik El-Hakim Village, Nubaria district, Behaira Governorate. The objective of the experiments was to study the effect of late foliar spray with some micronutrients Nano particles on growth, yield and seed chemical composition of VC1973A mungbean strain (*Vigna radiata* L. Wilczek). Mungbean (*Vigna radiata* L. Wilczek) strain of VC1973A (imported from (AVRDC, Taiwan) was used in both experiments. The physical and chemical analysis of the experimental soil was carried out according to [38] are presented in Table (1).

The experimental soil was ploughed twice, ridged and divided into experimental units each of 21 m^2 area (1/200 fed). The experimental design was a Complete Randomized Bock Design (CRBD) with four replicates. A uniform basal dressing of phosphatic fertilizer as calcium superphosphate 15.5% P_2O_5 at the rate of 150 kg fed^{-1} was applied during seed-bed preparation. Mungbean seeds were inoculated with the specific rhizobium strain (Prepared by the Microbiology Unit, NRC) and immediately sown in hills on both sides of the ridge at 15 cm space between hills. Sowing dates were May 27th and 30th in 2021 and 2022 seasons, respectively. A starter dose of N at the rate of 15 kg N fed^{-1} was applied at sowing in the form of ammonium nitrate (33.5% N). Two weeks later, the plants were thinned at two plants per hill to attain the theoretical number required (186×10^3 fed^{-1}). Weeds were controlled manually at 18 and 32 days after sowing. At the early pod formation (43 days after sowing, 2-3 pods/raceme, 2-3 cm length) the assigned plots were sprayed with the following treatments;

Table 1: Physical and chemical characteristics of experimental soil sites (Means to 30 cm depth)

A) Physical							
Coarse sand (%)	Fine sand (%)	Silt (%)	Loamy sand (%)	Texture class	WHC (%)	Particle density (g/cm^3)	SBD (g cm^{-3})
58.9	22.5	7.9	10.6	Loamy Sand	40.6	2.38	1.37

B) Chemical								
PH	EC (dS/m)	HCO_3 (meq/l)	OM (%)	CEC (meq/100g)	NO_3 (mg/kg)	N (mg/kg)	P (mg/kg)	K (mg/kg)
8.16	0.27	0.74	4.29	34.5	52	2826	1737	1996

- Control (water spray)
- Urea 1.5%
- Fe NPs 0.5%
- Mn NPs 0.2%
- Zn NPs 0.1%
- Cu NPs 0.05%
- Urea 1.5% + Fe NPs 0.5%
- Urea 1.5% + Mn NPs 0.2%
- Urea 1.5% + Zn NPs 0.1%
- Urea 1.5% + Cu NPs 0.05%

The above mentioned chemicals were dissolved in 200 liter of tap water, per feddan. Teepol 1% was applied as a surfcant to insure the homogenty of the spray solution. Foliar spray treatments were applied early in the morning to avoid leaf scorches. A randomized vegetative sample was taken at 15 days after spraying to record some growth characters, each sample consisted of four guarded hills (8 plants) from each experimental unit. Plant height, number of branches and leaves as well as total dry matter per plant were determined. Mungbean plants matured (95% of the pods were black) after 93 and 90 days from sowing in 2020 and 2021 seasons, respectively. At harvest, ten plants from each plot were taken; the pods were counted and weighed to obtain pod number and weight per plant. Then, the pods were shelled to separate the seeds and number of seeds per pod, 100-seeds weight and seed weight per plant were determined. The two central ridges were harvested from each plot to calculate seed yield per feddan. A random sample of seeds of both seasons was collected and pooled, dried and grounded. Total nitrogen was determined using the micro Kjeldahl apparatus according to [39] Total N values were multiplied by 6.25 to obtain protein percentages in mungbean seeds. Total carbohydrates were determined according to [40]. Micronutrient determinations were carried out by wet ashing digestion and were measured by using atomic absorption apparatus according to [41]. The obtained data were subjected to the proper statistical analysis according to [42]. Since the trends were similar in both seasons, the homogeneity test was carried out according to Bartlet's test and the combined analysis of the data was applied. Treatment means were compared using Duncan's Multiple Range test at 5% level.

RESULTS

Data presented in Table (2) show that micronutrient application in the form of Nano particles as foliar spray caused significant effects on mungbean plant height, the number of branches and leaves as well as total dry weight per plant. Foliar spray with Cu NPs or Zn NPs alone or Zn NPs combined with urea gave the tallest plants. Mungbean plants had a greater number of branches per plant when the plants were sprayed with urea or Zn NPs alone while the combination of urea with Mn NPs, Zn NPs and Cu NPs produced the greatest number of leaves per plant. The results also show that mungbean plants were able to accumulate greater dry matter content than the control treatment when it was foliar sprayed with Zn NPs alone or in combination with urea. Moreover, the data also show the hat combined application of urea with the micronutrient had a synergistic effect on dry matter content.

Data given in Table (3) show that foliar spray treatments reveal significant effects on mungbean yield and yield components. Foliar spray with Mn NPs alone or Zn NPs combined with urea produced the highest number of pods per plant. While the other treatments were similar in this criteria. Also, the application of Zn NPs alone or urea combined with Cu NPs, Mn NPs, Zn NPs, or Cu NPs produced heavier pod-weight per plant without significant differences. Meanwhile, the effect of these elements was insignificant when each element was applied alone. All foliar spray treatments were similar without significant differences and exceeded the control treatment in number of seeds per pod. The highest 100 seeds weight was obtained when mungbean plants were sprayed with Cu NPs. However, the data show severe reduction in 100-seeds weight when Cu NPs was combined with urea. From the same table, it can be realized that foliar spray with Cu NPs, Mn NPs and Zn NPs alone or combined with urea gave higher seed yield per plant compared with the control treatment. Evidently, the data show that when foliar spray was carried out with Cu NPs and Mn NPs alone or with urea + Zn NPs, higher seed yield per plant was obtained. The results of seed yield per feddan show significant differences among foliar spray treatments.

Table 2: Effect of foliar spray of urea and micronutrients Nano particles on mungbean growth characteristics

Treatment	Plant height (cm)	No. of branches plant^{-1}	No. of leaves plant^{-1}	Total dry weight (g) plant^{-1}
Control	66.3 f	3.9 d	12.0 de	36.1 g-i
Urea 1.5%	80.5 de	7.3 c	18.3 a	40.3 fg
Fe NPs	97.5 a	8.6 bc	14.8 b-e	59.5 a
Mn NPs	84.8 cd	8.1 a-c	14.8 b-e	43.0 ef
Zn NPs	96.3 ab	10.9 a	15.9 a-c	50.5 cd
Cu NPs	82.5 de	6.6 c	14.1 c-e	34.1 i
Urea 1.5% + Fe NPs	90.0 bc	10.5 ab	11.7 e	56.3 ab
Urea 1.5% + Mn NPs	76.0 e	7.8 bc	15.2 a-d	50.8 cd
Urea 1.5% + Zn NPs	93.2 ab	8.9 a-c	17.5 ab	53.8 bc
Urea 1.5% + Cu NPs	92.5 ab	8.6 a-c	16.4 ac	46.4 de

Values for each mean within a column, followed by the same letter, are not significantly different at P = 0.05

Table 3: Effect of foliar spray of urea and micronutrients Nano particles on mungbean yield characteristics

Treatment	No. of pods plant^{-1}	Pod weight plant^{-1} (g)	No. of seeds pod^{-1}	Seed yield plant^{-1} (g)	100-Seeds weight (g)	Seed yield fed^{-1} (kg)
Control	18.8 c	14.9 b	10.9 c	5.1 d	3.5 f	873 e
Urea 1.5%	19.5 c	21.0 ab	14.0 ab	6.0 cd	4.6 c	928 d
Fe NPs	18.8 c	21.9b ab	15.0 ab	9.1 a	4.9 b	1238 a
Mn NPs	25.8 ab	20.9 ab	13.8 b	8.1a-c	4.3 e	955 d
Zn NPs	22.3 bc	23.8 a	15.3 a	6.8 a-d	4.6 d	1190 ab
Cu NPs	19.6 c	21.9 ab	14.0 ab	5.3 d	5.0 a	951 d
Urea 1.5% + Fe NPs	18.4 c	26.5 a	14.4 ab	8.9 a-b	4.3 e	1146 b
Urea 1.5% + Mn NPs	18.4 c	27.9 a	14.6 ab	7.1 ad	4.6 c	1093 c
Urea 1.5% + Zn NPs	27.5 a	28.1 a	14.4 ab	8.4 a-c	4.3 e	1158 b
Urea 1.5% + Cu NPs	20.1 c	25.9 a	14.4 ab	6.5 c-d	3.3 g	953 d

Values for each mean within a column, followed by the same letter, are not significantly different at P=0.05

Table 4: Effect of foliar spray of urea and micronutrients Nano particles on mungbean chemical constituents

			Yield fed^{-1} (kg)		Micronutrient concentration mg kg^{-1}			
Treatment	Protein (%)	Total Carbohy- dates (%)	Protein	Carbohydrates	Fe	Zn	Mn	Cu
Control	22.6 cd	52.9 b	197.4 e	461.9 e	39.26 a	3.10 a	1.19 bc	0.81 a
Urea1.5%	23.6 bc	57.8 a	218.9 d	536.2 d	28.94 a	5.83 a	1.31 bc	1.18 a
Fe NPs	22.9 c	57.8 a	283.4 a	715.4 a	53.06 a	6.33 a	1.73 a	1.02 a
Mn NPs	26.2 ab	57.2 a	250.2 cd	546.3 cd	50.84 a	6.13 a	1.57 ab	1.00 a
Zn NPs	21.3 d	53.1 b	253.4 ab	631.8 ab	60.72 a	5.84 a	1.70 a	1.09 a
Cu NPs	21.4 d	57.5 a	203.4 d	546.5 d	27.88 a	5.32 a	1.04 c	0.90 a
Urea 1.5% + Fe NPs	23.1 bc	59.5 a	264.8 b	682.0 b	70.08 a	5.84 a	1.72 a	1.21 a
Urea 1.5% + Mn NPs	24.4 ab	56.7 a	266.7b	619.7 b	39.78 a	4.84 a	1.27 b-c	0.72 a
Urea 1.5% + Zn NPs	25.5 a	57.1 a	295.3 a	661.3 ab	31.33 a	6.43 a	1.40 a-c	0.94 a
Urea 1.5% + Cu NPs	24.0 b	57.5 a	228.6 d	547.7 d	57.73 a	5.73 a	1.22 bc	0.94 a

Values for each mean within a column, followed by the same letter, are not significantly different at P=0.05

The highest seed yield per feddan was attained by foliar spray of mungbean plants with Fe NPs or Zn NPs alone without significant differences. Moreover, the data also show obvious increments in seed yield per feddan resulted from the combined application of Fe NPs, Mn NPs or Zn NPs with urea.

Table (4) and Fig. (2) shows that the highest protein percentage in mungbean seeds was detected when the plants were sprayed with Mn NPs, urea + Zn NPs and by urea + Mn NPs. However, the lowest protein percentage was found as a result of foliar spray Cu or Zn NPs alone. Urea + Cu NPs resulted in significant increase in protein percentage. All micronutrient Nano particles combined with urea gave greater protein and carbohydrate yields fed^{-1} than the foliar spray of these elements alone. Such results emphasize the beneficial effect resulted from combining urea with Mn NPs, Zn NPs or Cu NPs in increasing protein percentage in mungbean seeds. From the same table the data show that except for foliar spray treatment with Zn NPs alone, no significant differences among treatments on total carbohydrates percentage in mungbean seeds were detected. The highest carbohydrate content in mungbean seeds resulted from the combined applications of urea + Cu Nps.

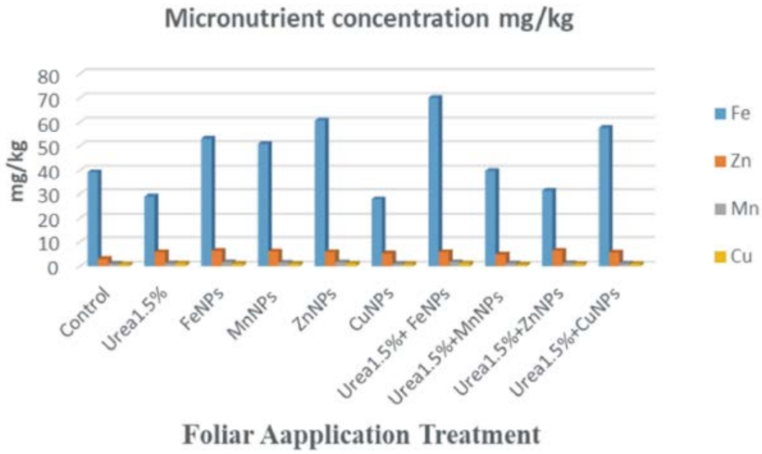

Fig. 1: Effect of late foliar feeding with N and micronutrients Nano particles on micronutrient concentration mg kg^{-1} of mungbean seeds

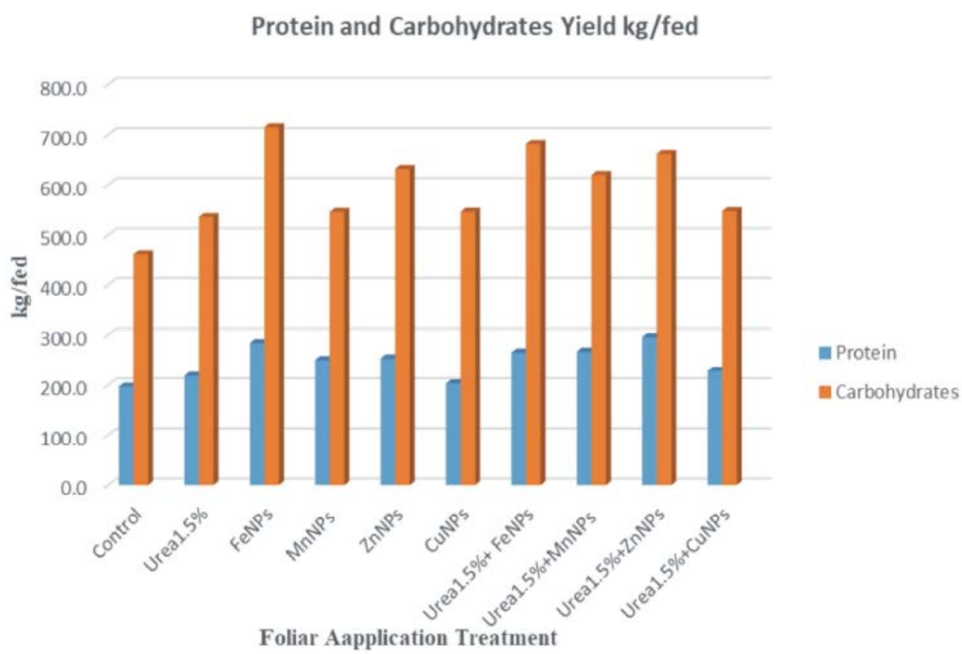

Fig. 2: Effect of late foliar feeding with N and micronutrients Nano particles on protein and carbohydrates yield kg fed^{-1} of mungbean seeds

Data in Table (4) and Fig. (1) reveal insignificant differences Fe, Zn and Cu concentrations of mungbean seeds due to the foliar spray treatments compared to the control treatment, however, such magnitude was not true for Mn concentration. Foliar spray of urea alone gave the lowest Fe concentration in mungbean seeds. However, a synergistic effect was recorded between the urea + Fe NPs as well as urea alone which lead to the increase of Cu concentration in mungbean seeds. The same table also shows that, foliar spray treatments increased Zn concentration in mungbean seeds as compared with the control treatment. The highest concentration of Zn was recorded due to urea + Zn NPs treatment.

Regarding micronutrient uptake (Table 5 and Fig. 3) in mung bean seeds the data reveal that all foliar spray treatments increased micronutrient uptake in mungbean seeds, the highest micronutrient uptake in mungbean seeds resulted from the treatment of foliar spray of Urea 1.5% + Fe NPs.

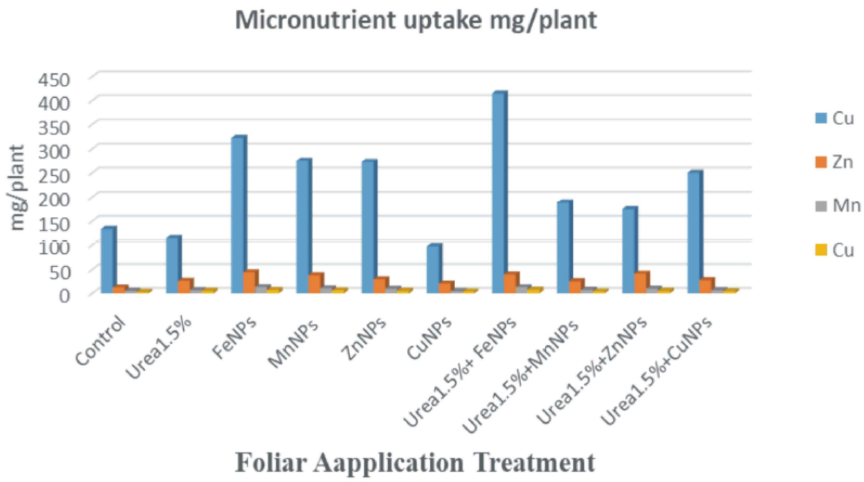

Fig. 3: Effect of late foliar feeding with N and micronutrients Nano particles on micronutrient uptake (mg plant^{-1}) of mungbean

Table 5: Effect of foliar spray of urea and micronutrients Nano particles on micronutrient uptake (mg plant^{-1}) of mungbean seeds

	Micronutrient uptake (mg plant^{-1})			
Treatment	Fe	Zn	Mn	Cu
Control	134.1 d	12.2 d	5.1d	3.0 c
Urea 1.5%	115.7 d	26.9 b	6.6 c	5.0 b
Fe NPs	322.8 ab	44.4 a	13.1 a	6.7 a
Mn NPs	275.4 b	38.3 a	10.6 a	5.8 a
Zn NPs	273.2 b	30.3 ab	9.6 ab	5.3 ab
Cu NPs	97.6 e	21.5 c	4.6 d	3.4 c
Urea 1.5% + Fe NPs	414.6 a	39.9 a	12.7 a	7.7 a
Urea 1.5% + Mn NPs	189.0 c	26.5 b	7.5 b	3.7 c
Urea 1.5% + Zn NPs	174.9 c	41.4 a	9.8 ab	5.6 a
Urea 1.5% + Cu NPs	250.2 b	28.7 b	6.6 c	4.4 bc

Values for each mean within a column, followed by the same letter, are not significantly different at P=0.05

DISCUSSION

The response of mungbean growth characteristics to foliar spray treatments could be attributed to the nature of mungbean as a symbiotic N-fixing crop depends on the N-fixed by nodules since their activity ceases at the later stage of growth and starvation to N is occurred at later growth stages, therefore an external or supplemental N is needed to overcome the self-destruction phenomena which leads to rapid leaf senses; as described by [6]. Such interpretation is in good agreement with the results obtained by Abd El-Lateef (10) who sprayed mungbean plants with urea 1.5% at weekly intervals and found that the rate of photosynthesis in the sprayed plants remained constant up to 20 days after flowering and increased dry matter in the urea treated plants while it was declined in the untreated plants. Similar results were obtained by [43]. Also, the positive effect of certain micronutrients on the dry matter accumulation of mungbean plants was reported by [11].

From the obtained results it is clear that mungbean plants have good response to foliar spray with urea and micronutrients either alone or in combination especially urea + Cu NPs or Zn NPs. Such response to foliar applied urea and micronutrients could be attributed to the stimulatory effect of these elements on plant growth and in turn the increase in dry matter accumulation which lead to better yield. The stimulatory effect of foliar application of nitrogen on growth and yield of mungbean could be attributed to the high demand of N at the pod-filling stage where only 50% of the total seed N is found in the vegetative tissues [44]. Therefore it seems that the external foliar applied N is a good supplement for N requirements to mungbean at this growth stage. Several reports pointed out to the positive response of mungbean yield to foliar spray with either urea [8, 10] or micronutrients [12].

The results of Mondal *et al.* [43] indicated that foliar application of N or N plus micronutrients including foliar application of N or N plus micronutrients increased leaf area, specific leaf weight, chlorophyll content, total dry mass, flower number and reproductive efficiency, yield attributes and yield over the control. This increased, yield attributes and yield over the control. This increment appeared to be the highest in N plus micronutrients treatment plus micronutrients treatment although did not differ from the foliar application of only N.

The effect of foliar application of N and N plus micronutrients on yield attributes and yield was significant but had not shown such significant effects on harvest index and grain protein content. This result is consistent with that of Mondal [45] who reported the influence of foliar application of N and N plus micronutrients on number of pods, seeds pod^{-1}, 100-seed weight and seed yield was higher in bold seeded genotype than small seeded one. The seed yield was higher in N and N plus micronutrients than control due to production of higher number of pods plant^{-1}, seeds pod^{-1} and 100-seed weight being the highest in the treatment of N plus micronutrients.

The results of Shojaei and Makarian [46] indicated that Nano and non-Nano zinc foliar application increased number of pod plant^{-1}, seed pod^{-1}, 1000-seed weight and total dry weight in water stress and non-water stress treatments significantly. Foliar application of 10 g l^{-1} Nano sized zinc oxide particles compared to control increased mungbean yield 6.6, 3.6 and 5.4 percent in non-water stress, water stress in flowering and pod setting stages treatments respectively. They concluded that foliar application of zinc as Nano particles can enhance the yield of mungbean more than zinc oxide under water stress conditions. Also, Marzouk *et al*. [47] reported that foliar application with zinc Nano-fertilizer increased the studied characteristics significantly compared with other Nano micronutrients. Also, the highest values of crude protein, total soluble solid content P, K, Mn, Fe and Cu percentages in snap bean were recorded by the foliar spraying of zinc Nano-fertilizer compared with the other treatments. On the other hand, the lowest values were obtained by control. and the highest significant increase of crude protein, total soluble solids, P, K, Mn, Fe and Cu percentages were recorded when snap bean treated with foliar spray of zinc Nano-fertilizer treatment compared with the other treatments. Regarding the chemical composition of mungbean seeds Abd El Lateef *et al*. [11] reported that protein percentage in mungbean seeds was not affected by either soil or foliar applications and ranged between 20.6 to 22.9%. However, protein yield kg ha^{-1} significantly increased when the plants were fertilized with 76 Kg P_2O_5 ha^{-1} and foliar sprayed with N. In addition, soil application of P and foliar spray treatment showed significant effects on carbohydrate percentage and carbohydrate yield ha^{-1}of mungbean seeds. The obtained results are in agreement with those obtained by Abd El Lateef [10] who found a slight increase in mungbean seed protein content resulting from urea 1.5% spray. Also, Sing *et al.* [12] obtained increases in protein content in mungbean seeds by Zn NPs application while (13) came to a similar conclusion with Cu NPs application. The obtained results are in agreement with those obtained by [12] who found a slight increase in mungbean seed protein content resulted from urea 1.5% spray. Also, Malewar *et al.* [14] obtained increases in protein content in mungbean seeds by Zn NPs application while [13] came to a similar conclusion with Cu NPs application. Micronutrient concentrations in mungbean seeds were elevated more than in the control treatment due to foliar spray treatments but it did not reach the level of significance for Fe, Zn and Cu. It could be concluded from this study that mungbean productivity responds to combined soil application of P at 57 Kg P_2O_5 ha^{-1} and late foliar applied N at the early pod formation stage. Foliar spray of urea combined with Fe or Zn may increase seed yield and improve the quality of seeds [11].

In general, it could be concluded from this study that foliar application with urea in association with micronutrients especially Cu NPs and Zn NPs may enhance growth and increase the productivity of mungbean also usefully improve the quality of seeds. From the obtained results it is clear that mungbean plants have a good response to foliar spray with urea and micronutrients either alone or in combination especially urea + Cu NPs or Zn NPs. Such response to foliar applied urea and micronutrients could be attributed to the stimulatory effect of these elements on plant growth and in turn the increase in dry matter accumulation which lead to better yield.

CONCLUSION

From the obtained results it seems that the association of urea with some micronutrients may increase the concentrations of these elements in mungbean seeds especially Cu NPs and Zn NPs. These effects may be due to the accelerating micronutrient uptake in the presence of nitrogen sources. These results emphasize the stimulatory effect of including urea with micronutrients Nano particles in improving the growth and yield of legumes, especially mungbean.

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