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Influence of Mineral Fertilization Rates and Foliar Application of Some Micro Nutrients on Lettuce Plant

Fouda, K. F.
Soil Sci. Dept., Fac. of Agric., Mansoura Univ., Egypt

ABSTRACT

Effects of mineral fertilization (NPK) rates and foliar application of micro nutrients (Zn, Fe and Mo) on vegetative growth, yield and some nutrient contents of lettuce plant (*Lactuca sativa* L.) were studied at the Experimental Farm of Faculty of Agriculture, El-Mansoura University during the winter season of 2015. The experiment was conducted in split plot design with three replicates, which were simple possible combination between 3 rates of NPK (50, 100 and 150% of the recommended dose (RD) by the Ministry of Agriculture i.e. 60, 27.5 and 17.43 kg ha^{-1} for N, P and K, respectively) as main plots and 4 treatments of micro nutrients foliarly (0, 50 mgL^{-1} Mo, 100 mgL^{-1} Zn and 300 mgL^{-1} Fe) as sub plots. The results acquired from the study demonstrated that, fresh and dry weight as well as yield of lettuce plants increased significantly in response to rate of 100% RD from NPK. In addition; chlorophyll content, N, P, K concentrations, Mo content and NO_3-N concentration in outer, inner leaves and stem recorded the highest values due to 150% of NPK recommended dose (RD), whereas Zn, Fe and nitrate reductase activity were decreased with increasing rate of NPK fertilization. The highest mean values of the grown parameters of lettuce plant significantly increased due to the foliar application of Mo at rate of 50 mgL^{-1}. Zn, Fe and Mo contents in plant increased due to the foliar application of chelating-Zn at rate of 100 mgL^{-1}, chelating-Fe at rate of 300 mgL^{-1} and chelating-Mo at rate of 50 mgL^{-1}. As for NO_3-N concentration in outer, inner leaves and stem gave the highest values with foliar of chelating-Zn at rate of 100 mgL^{-1}.

INTRODUCTION

Lettuce (*Lactuca sativa* L.) is the most bronchial crop among the salad crops (Midan and Sorial, 2011). Lettuce is considered as a very good natural source of minerals and vitamins as it is used as a fresh green salad (Hanafy *et al.*, 2000). Also, leaves of lettuce are a rich as source of antioxidants, vitamins A and C, and phytochemicals which are anti-carcinogenic (Masarirambi *et al*., 2012). In Egypt, the cultivated area of lettuce is about 3110 hectares, which produce about 68644 megagram (Mg) (MALR, 2012). Lettuce is a shallow-rooted crop and requires a large amount of nitrogen fertilizer to produce high yield (Sukor, 2013).

NPK fertilizers are required greatly by crops for healthy development and crop quality. N is a remarkable nutrient for higher crop and intermediate head weight of lettuce (Hosseny and Ahmed, 2009). Moreover, nitrogen is the maximum limiting nutritional factor for yield production in semiarid and arid lands. Thus, application of nitrogen fertilizer to soils has become an important agricultural practice in arid regions (Al-Moshileh *et al.*, 2005). The increment in the N-fertilization rate can gaining a higher yield but jointly conveys a danger of deteriorating yield quality. Nitrate accumulation is the main problem facing lettuce production (Midan and Sorial, 2011). Tests of nitrate accumulation in Egyptian vegetables, including lettuce showed considerable higher values as compared to those found in vegetables grown in several European countries. The next element after N that limits the crop production in the tropical regions and indeed most regions of the world is phosphorus (Holford, 1997). Inadequate P supply will result in a decreased synthesis of RNA, the protein maker, leading to decreased growth. Grain yield is often severally reduced with P deficiency (Jones *et al*., 2003). Potassium is wanted in huge amount by a lot of crops and it is substantial for maintaining the osmotic potential and rigidity of plant cells; thus it plays a key part in water relations in the plant (Okoli and Nweke, 2015).

Micronutrients are essential and important for plant growth and development that use at lower values than macronutrients such as nitrogen, phosphorus and potassium. These micronutrients include iron, zinc, copper, molybdenum, boron manganese and chlorine (Hargert *et al.*, 1999). Growers are often faced with deficiency of micronutrients such as Fe, Zn, and Mo. Growers think that those micro nutrients are found as traces in the common use macronutrient fertilizers and/or in organic fertilizer. Although the traces of those micronutrients may be enough for plant needs, the conditions of the soil (i.e. high pH, presence of $CaCO_3$) may negatively affect the availability of these elements for plant uptake (Fageria *et al*., 2002). Therefore, foliar application of micronutrients is usually practiced. Plant micronutrients are required by plants in a very low concentration for adequate growth and reproduction. However, micronutrients are of equal importance to macronutrients for plant nutrition. According to Kirkby and Römheld, (2004) these lower concentrations of micronutrients are fundamentals for growth and development, acting as constituents of cell wall and membranes, as constituents of enzymes, of activation of enzymes and in photosynthesis.

The goal of the current experiment is to determine the effect of traditional NPK fertilizers as well as the foliar spraying with some micronutrients (Fe, Zn and Mo) on vegetative growth, yield and some nutrient contents of lettuce plant.

Keywords:NPK rates, micronutrients, foliar application and lettuce plants.

MATERIALS AND METHODS

A field experiment was conducted in a clayey soil at the Experimental Farm of Faculty of Agriculture, El-Mansoura University during the winter season of

2015 to study the effect of mineral fertilization NPK rates and foliar application of micro nutrients (Zn, Fe and Mo) on vegetative growth, yield and nutrient contents of lettuce plant (*Lactuca sativa* L.). Soil properties of the experimental site are presented in Table 1.

Table 1. Soil properties of the experimental soil.

Property		Value
	Coarse sand	4.75
	Fine sand	19.79
Particle size distribution (%)	Silt	28.93
	Clay	46.53
	Textural class	Clayey
EC dSm^{-1}(Soil paste extract)		3.96
pH (1:2.5) Soil water suspension		7.76
Saturation percent (SP) %		63.1
Organic matter (OM) gkg^{-1}		17.4
$CaCO_3$ gkg^{-1}		36.3
Potassium chloride extractable N ($mgkg^{-1}$)		52.3
Sodium bicarbonate extractable P ($mgkg^{-1}$)		5.18
Ammonium acetate extractable K ($mgkg^{-1}$)		191.2

Twelve treatments were arranged in split block design with 3 replicates, which were the simple possible combinations between 3 rates of NPK (50, 100 and 150% of the rates recommended dose by the Ministry of Agriculture i.e. 60, 27.5 and 17.43 kg ha^{-1} for N, P and K, respectively) as main plots and 4 treatments of micronutrients foliarly (0, 50 mgL^{-1} Mo, 100 mgL^{-1} Zn and 300 mgL^{-1} Fe) as sub plots. Accordingly, the overall number of the experiential plot was 36 plots.

Seeds of lettuce, c.v dark green. were intersperse on August 5th, seedlings were transplanted on September 15th during the season, at 30 cm a part between every seedling and the other on both sides of edges (3m long and 70 cm wide). Each plot comprised of 3 edges making an area of around 8.5 m^2.

In this implementing mineral fertilizers were used as ammonium nitrate (33.5% N), calcium super phosphate (6.7% P) and potassium sulphate (39.8% K). Nitrogen fertilizer was added in two equal doses instantly before the 1st and 2nd irrigations, whereas the phosphorus fertilizer was added during soil preparation for sowing and potassium fertilizer was added before the first irrigation.

The micronutrients were sprayed two times, 30 and 40 days after seeding, respectively. However, it was used as foliar in chelating form known under the commercial name of Agro-Fe at a rate of 300 mgL^{-1}, Agro-Zn at a rate of 100 mgL^{-1} and Agro-Mo at a rate of 50 mgL^{-1} as recommended by AGRICO International Co., Egypt, (www.agricointernational.com). Aqueous spraying solutions of micro-elements were freshly prepared and few drops of wetting agent were added to spraying solution. All sprays were done in the morning using a hand pressure sprayer and covering the plant foliage with spraying solution.

At marketing stage; 90 days after transplanting of lettuce seedlings, 5 plants were indiscriminate taken from every plot. The plant samples were discrete into dark and light green leaves as well as stems. The separated parts of the plant were weighed and then NO_3-N, NO_2-N content (mg kg^{-1}), nitrate reductase activity and chlorophyll contents were determined in the fresh weight of plant parts. Also, lettuce plants for each plot were collected, weighed and calculated as fresh yield (Mg ha^{-1}). Subsamples of whole plants were often dried at 70^{o}c till a constant weight. The dried samples of lettuce plant were thoroughly ground using a micro-mill grinder and stored for chemical analysis of N, P and K as well as Zn, Fe and Mo.

- **Soil analysis:**

∗ The electrical conductivity of the soil paste extract, pH value, $CaCO_3$ and organic matter contents were decided according to Sahlemedhin and Taye (2000).

- Particle size distribution, available Nitrogen, Phosphor and potassium in the soil were decided according to the methods of Haluschak, (2006), Reeuwijk, (2002), respectively.

- **Plant analysis:**

∗The grounded plant materials were subjected to wet digestion solution with a mixture of 1:1 H_2SO_4 and $HClO_4$ acid according to method described by Page *et al.,* (1982). Concentrations of N, P, K, Fe, Zn and Mo were determined in the digest of plant.

- **Chemical content and fruits quality:**

∗ Total Nitrogen, Phosphor and potassium were decided according to the methods described by Mertens, (2005a and b), Agrilasa, (2002), respectively.

∗ For determining Zn, Fe and Mo, the concentration of these elements were measured by an atomic absorption spectrometer (Kumpulainen *et al.,* (1983).

∗ Chlorophyll content was determined using the method described by Gavrilenko and Zigalova (2003).

∗ Nitrate content, nitrate reductase enzyme activity, were determined according to Singh (1988) *and* Hageman and Reed, (1980), respectively.

Data of statistically analyzed were acquired due to the technique of analysis variance (ANOVA) and the least significant difference (LSD) method was done by compare the deference between the means of treatment values according to the methods depict by Gomez and Gomez, (1984). All statistical analyses were performed using analysis of variance technique by means of Co-STATE Computer Software.

RESULTS AND DISCUSSION

- **Growth and yield parameters:**

Fresh, dry weight and yield of lettuce plants as affected by NPK fertilization and micro nutrients as well as their interactions are recorded in Table 2. These growth and yield parameters increased significantly in response to rate of 100% RD from NPK. This may be due to the substantial role of nitrogen in plants, where it is found in nuclic acids, proteins and co-enzymes. Phosphorus also has a role in N_2 fixation, reinforce nodulation of plant and mounting photosynthesis process, whilst potassium activates some enzymes and K^+ ions play an substantial role in targen control of stomatal guard cells of leaves and as well raise photosynthesis. These results are harmonious with finding of Gairola *et al*., (2009); Mirdad, (2009); Kawthar *et al*., (2014); Singh *et al*., (2014); Hossain *et*

al., (2014) and Nemadozi, (2015) who demonstrated that fresh yield, dry matter yield, chlorophyll contents and leaf area index (LAI) were significantly raised by increasing the NPK application. However, application at the higher rate (150%) of NPK reduced values of the parameters. Regarding the effect of micronutrients on fresh, dry weight and yield, data in Table (2) indicate that, the mean values of the parameters for lettuce plant were significantly increased due to the foliar application of the different micronutrients, i.e. Zn, Fe and Mo treatments. Comparing with the control treatment, fresh, dry weight and yield were increased by 19.47, 9.85 and 25.53% for the treatment of Mo with fresh, dry weight and yield, respectively. The increment in plant growth parameters may be brought by the presence of the foliar spraying of the micronutrients which acts as constituents of cell wall and membranes (Kirkby and Römheld, 2004). These results agree with those of Fawzy, (2007) on lettuce; Shaheen *et al*., (2011); Abd El-Samad *et al*., (2011) on onion and Shaheen *et al*., (2012) on lettuce.

As for the interaction effect between the previously mentioned treatments, data also proved that; the highest mean values of fresh, dry weight and yield for lettuce plant were realized for the plants treated with Mo + 100% RD from NPK, while the lowest one was connected with an application of 50% RD from NPK.

Table 2. Growth parameters and yield of lettuce plants as affected by application of macro (NPK) and micro nutrients (Zn, Fe and Mo) as well as their interactions.

Micronutrient treatments(B)	FW g plant^{-1}					DW g plant^{-1}					Yield Mg ha^{-1}				
NPK treatments (A)	Without	Zn	Fe	Mo	Mean	Without	Zn	Fe	Mo	Mean	Without	Zn	Fe	Mo	Mean
50% of the RD	619.87	668.43	684.50	703.67	669.12	44.09	45.89	46.40	47.03	45.85	24.47	26.66	27.44	28.13	26.67
100% of the RD	634.83	735.07	770.83	810.53	737.82	44.64	48.36	49.54	50.82	48.34	25.18	31.73	33.22	34.32	31.11
150% of the RD	651.17	718.47	753.03	787.70	727.59	45.24	47.56	48.92	50.18	47.98	25.89	31.20	33.42	33.75	30.82
Mean	635.29	707.32	736.12	759.01		44.66	47.27	48.29	49.06		25.18	29.86	31.03	32.07	
LSD $_{at\ 5\%}$	A: 4.24, B=5.88, A×B:10.18					A:0.18, B:0.15, A×B:0.25					A:0.04, B:0.04, A×B:0.07				

RD: Recommended dose **FW: Fresh weight** **DW: Dry weight**
Zn: at a rate of 100 mgL^{-1} **Fe: at a rate of 300 mgL^{-1}** **Mo: at a rate of 50 mgL^{-1}**

- **Chemical composition:**
- **Chlorophyll content:**

Data presented at Table 3 clearly showed that the effect of several concentrations of NPK fertilization, micronutrients treatments and their interactions on photosynthetic pigments.

Data at the same Table generally directed, that there was a rising in chlorophyll a, b, and a+b with increasing NPK fertilization. The alteration in pigments was significantly raised by increasing NPK rates. The significant increases were found in plants grown under the high NPK rate (150%) of RD i.e. 0.639, 0.466 and 1.105 mg.g^{-1} FW of chlorophyll a, chlorophyll b and chlorophyll a+b, respectively. The satisfactory effects of mineral fertilizers enforcement on the content of chlorophyll may be refer to its memorable role in the chlorophyll pigment synthesis or chlorophyll molecule in the plant tissues. These findings are conformable to those reported by Saif-El-Deen (2000); Nabih (2002) and Abd-Elfattah, (2012).

Also, data in Table 3 show the effect of micronutrients of Zn, Fe and Mo at various concentrations on chlorophyll content. It was noticed that, micronutrient treatments markedly decreased chlorophyll a, b, and a+b, in lettuce plants comparing with the untreated plants. The decrease in total chlorophyll recorded 0.27, 2.63 and 9.61% for Mo, Fe and Zn, respectively. Leaf chlorophyll preservation and photosynthesis durability in stress of fertilization are physiological tolerance indices (Pessarakli, 1993). Therefore, the using of nutrient solution containing Fe, Mo and Mg, which are the main components of chlorophyll under this conditions can be prevented this organelle decreases, (Amirani and Kasraei, 2015).

With regard to the interaction effect between macro and micronutrients on chlorophyll content of lettuce plants, it can be noticed that chlorophylls content significantly rose in NPK plants foliared with micronutrients compared to their control. It can be seen that the plants grown under 150%RD NPK and foliated with 50 mgL^{-1} Mo achieved the highest chlorophyll a, b, and a+b as compared with other treatments.

Table 3. chlorophyll content of lettuce plants as affected by application of macro (NPK) and micro nutrients (Zn, Fe and Mo) as well as their interactions.

Micronutrient treatments (B)	Chlorophyll A mg g^{-1} FW					Chlorophyll B mg g^{-1} FW					Total chlorophyll mg g^{-1} FW				
NPK treatments (A)	Without	Zn	Fe	Mo	Mean	Without	Zn	Fe	Mo	Mean	Without	Zn	Fe	Mo	Mean
50% of the RD	0.625	0.573	0.581	0.634	0.603	0.452	0.399	0.409	0.461	0.430	1.077	0.971	0.990	1.095	1.034
100% of the RD	0.643	0.591	0.600	0.651	0.621	0.472	0.415	0.428	0.478	0.448	1.115	1.006	1.028	1.129	1.070
150% of the RD	0.662	0.607	0.619	0.670	0.639	0.486	0.434	0.446	0.496	0.466	1.148	1.041	1.065	1.166	1.105
Mean	0.643	0.590	0.600	0.641		0.470	0.416	0.428	0.468		1.113	1.006	1.028	1.110	
LSD $_{at\ 5\%}$	A:0.020, B:0.004, A×B:0.007					A:0.005, B:0.003, A×B:0.005					A:0.005, B:0.005, A×B:0.016				

See footnote of Table 2

- **Nitrogen, phosphorus and potassium concentrations:**

Data recorded in Table 4 show the effect of NPK fertilization as soil addition on nitrogen, phosphorus, potassium in lettuce plants. Results reveal that nitrogen, phosphorus and potassium contents of lettuce plant significantly increased by increasing the rate of NPK fertilization. The highest mean values were increased due to applying NPK at 150% of the RD.. Such increases may be due corresponding increases in available contents of N,P and K in soil. These results are similar to those of Gairola *et al*., (2009); Mirdad, (2009) Hossain *et al*., (2014); Kawthar *et al*., (2014); Singh *et al*., (2014); and Nemadozi, (2015) they all stated that N, P and K concentrations increased with raising rates of NPK fertilization.

Data in Table 4 clearly that the effect of micronutrient treatments on the contents of nitrogen, phosphorus and potassium. It is clearly showed that nitrogen, phosphorus and potassium contents of lettuce plant significantly were decreased due to foliar application of different micronutrients as compared with the untreated plants. It could be concluded that, foliar spraying by some micro-elements such as Zn, Fe and Mo for lettuce plant, resulted in increases in contents of N, P and K in tissues of lettuce as compared with those of control treatment. These results are in agreement with those of Shaheen *et al.,* (2006) on Okra; Shaheen *et al*., (2011); Abd El-Samad *et al*., (2011) on onion and Shaheen *et al.,* (2012) on spinach.

The interaction effect between NPK fertilization and micro nutrients (Fe, Zn and Mo) show that N, P and K contents were significantly affected by adding Fe, Zn and Mo. This occurred regardless of rate of the applied NPK fertilization. The highest values of N, P and K contents were generally attained in plant treated with 50 mgL^{-1} Mo and grown under 150% RD from NPK fertilization.

Table 4. N, P and K concentrations of lettuce plants as affected by application of macro (NPK) and micro nutrients (Zn, Fe and Mo) as well as their interactions.

Micronutrient Treatments(B)	N concentration %					P concentration %					K concentration %				
NPK Treatments (A)	Without	Zn	Fe	Mo	Mean	Without	Zn	Fe	Mo	Mean	Without	Zn	Fe	Mo	Mean
50% of the RD	2.600	2.100	2.190	2.720	2.400	0.248	0.202	0.210	0.256	0.229	2.97	2.32	2.43	3.08	2.70
100% of the RD	2.810	2.280	2.370	2.890	2.590	0.267	0.214	0.222	0.275	0.245	3.19	2.54	2.63	3.29	2.92
150% of the RD	2.980	2.440	2.530	3.070	2.760	0.284	0.230	0.240	0.294	0.262	3.41	2.74	2.87	2.52	2.88
Mean	2.800	2.270	2.360	2.790		0.266	0.215	0.224	0.265		3.19	2.53	2.64	2.90	
$LSD_{at\ 5\%}$	A:0.03, B:0.04, A×B:0.06					A:0.03, B:0.03, A×B:0.06					A:0.04, B:0.04, A×B:0.06				

See footnote of Table 2

Table 5. Zn, Fe and Mo concentrations of lettuce plants as affected by application of macro (NPK) and micro nutrients (Zn, Fe and Mo) as well as their interactions.

Micronutrient treatments(B)	Zn concentration mg kg^{-1}					Fe concentration mgkg^{-1}					Mo concentration mg kg^{-1}				
NPK treatments (A)	Without	Zn	Fe	Mo	Mean	Without	Zn	Fe	Mo	Mean	Without	Zn	Fe	Mo	Mean
50% of the RD	19.50	23.63	10.13	21.37	18.66	45.27	35.67	59.63	56.43	49.25	0.89	0.28	0.37	1.33	0.72
100% of the RD	18.27	22.27	11.37	20.10	18.00	47.63	38.80	58.17	54.20	49.70	0.98	0.46	0.59	1.64	0.92
150% of the RD	13.07	16.87	12.20	15.47	14.40	43.20	41.03	53.17	51.47	47.22	1.11	0.68	0.78	1.98	1.14
Mean	16.94	20.92	11.23	18.45		45.37	38.50	56.99	52.89		0.99	0.47	0.58	1.45	
$LSD_{at\ 5\%}$	A:0.62, B:0.49, A×B:0.88					A:0.38, B:0.66, A×B:1.14					A:0.03, B:0.03, A×B:0.07				

See footnote of Table 2

- **Zinc, iron and molybdenum concentrations:**

Data presented in Table 5 show that lettuce plants treating with fertilization of NPK affected Zn, Fe and Mo concentrations in lettuce plants.

It is obvious from the presented data that treating lettuce plants with NPK fertilization as soil addition significantly affected Zn, Fe and Mo content. Zn and Fe decreased with increasing NPK fertilization. Mo concentration increased and recorded the highest values due to applied of NPK at the high rate (150%) of the RD. The acid affect of NPK fertilizers might be minimized the soil pH and, subsequently facilitated the absorption of nutrients by the roots of lettuce plant.

Also, results in Table 5 show the effect of foliar spray with micro nutrient treatments (Zn, Fe and Mo) on Zn, Fe and Mo contents of lettuce plants. It is clearly showed that spraying lettuce plants with micro nutrient treatments significantly increased all studied micronutrient treatments. These findings are similar to those reported by Kołota *et al.* (2006).

The interaction effect between NPK fertilization and micronutrients (Fe, Zn and Mo) show a promotive effect on Zn, Fe and Mo in lettuce plants. The highest mean values of Mo was recorded under 150% NPK from RD, whereas the highest mean values of Zn and Fe recorded with 50% NPK from RD.

- **Nitrate concentration and nitrate reductase activity:**

Data introduced in Table 6 demonstrate that treatment lettuce plants with NPK fertilization significantly raised NO_3-N concentration and reduce the nitrate reductase activity. In general, the most suitable treatment for improving NO_3-N concentration in out, inner leaves and stem was 150% NPK from RD. These results are in approval with Abd-Elfattah, (2012). Nitrate reducates activity recorded the highest values with 50% RD.

It is obvious from the presented data that spraying lettuce plants with all tested micronutrients (Fe, Zn and Mo) decreased significantly NO_3-N

concentrations in out, inner leaves and stem. However the superior treatment that gave the highest values of NO_3-N concentration was foliar spray with Zn at a rate of 100 mgL^{-1}, which recorded 215, 87 and 137 mgL^{-1} in out, inner leaves and stem, respectively. Nitrate reductase activity recorded the highest values with foliar spray with Mo at a rate of 50 mgL^{-1}. This result are in agreement with Wojciechowska and Kowalska, (2011) who found an increase in nitrate reductase activity with using foliar application of Mo, while the NO_3-N concentration was decreased Shaheen *et al.,* (2012).

The interaction effect between the NPK fertilization and micronutrients (Fe, Zn and Mo) show a promotive effect on NO_3-N concentration and nitrate reductase activity. NO_3-N concentrations in out, inner leaves and stem recorded the highest mean values with 150% RD without foliar application, whereas nitrate reductase activity recorded the highest mean values with 50% NPK from RD with foliar application of 50 mgL^{-1} Mo.

Table 6. NO_3-N concentration in out, inner leaves and stem as well as nitrate reductase activity of lettuce plants as affected by application of (NPK) and micro nutrients (Zn, Fe and Mo)as well as their interactions.

Micronutrient treatments (B)	NO_3-N (outer leaves) mg kg^{-1}					NO_3-N (inner leaves) mg kg^{-1}				
NPK treatments (A)	**Without**	**Zn**	**Fe**	**Mo**	**Mean**	**Without**	**Zn**	**Fe**	**Mo**	**Mean**
50% of the RD	176	158	143	93	143	76	69	62	47	64
100% of the RD	274	235	196	107	203	105	93	81	50	83
150% of the RD	310	253	214	126	226	113	98	89	57	89
Mean	253	215	184	125		98	87	77	57	
LSD $_{at\ 5\%}$		A:6.44, B:7.56, A×B:13.09					A:3.91, B:5.37, A×B:9.30			
Micronutrient treatments (B)	NO_3-N (stem) mg kg^{-1}					Nitrate reductase activity				
NPK treatments (A)	**Without**	**Zn**	**Fe**	**Mo**	**Mean**	**Without**	**Zn**	**Fe**	**Mo**	**Mean**
50% of the RD	121	109	98	69	99	0.132	0.142	0.153	0.192	0.155
100% of the RD	167	146	129	77	130	0.083	0.102	0.120	0.175	0.120
150% of the RD	174	155	139	89	139	0.070	0.091	0.113	0.167	0.110
Mean	154	137	122	88		0.095	0.112	0.129	0.167	
LSD $_{at\ 5\%}$		A:4.61, B:4.35, A×B:7.53					A:0.003, B:0.004, A×B:0.007			

See footnote of Table 2

CONCLUSION

The results of the current study indicated that the application of 100% NPK from RD and foliar application of 50 mgL^{-1} Mo was more effective on the vegetative growth, chemical composition and yield components of lettuce plants

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تاثير إضافة مستويات من الأسمده المعدنيه و الرش ببعض العناصر الصغرى علي نبات الخس

كريم فكرى فودة

قسم الأراضى - كلية الزراعة - جامعة المنصورة – مصر.

تاثير إستخدام مستويات مختلفة من الأسمده المعدنيه و الرش بالعناصر الصغرى على النمو الخضرى والمحصول والتركيب الكيماوي لنبات الخس تم دراستها فى مزرعة كلية الزراعة جامعة المنصوره خلال موسم 2015. صممت التجربة فى صورة قطاعات منشقة في ثلاث مكررات لدراسة تأثير ثلاث مستويات من التسميد المعدنى (50، 75، 100% من الموصي به من وزارة الزراعة من أسمده النيتروجين والفوسفور والبوتاسيوم) كمعاملات رئيسية وكذلك أربعة معاملات من العناصر الصغرى (صفر، 50، 100، 300 ملليجرام/لتر، موليبدنم، زنك ، حديد على التوالى) كمعاملات منشقة. أظهرت النتائج تحت الدراسة أن كلاً من الوزن الطازج والجاف وكذلك المحصول حدثت بها زيادة معنوية عند إستخدام 100% تسميد معدنى من الموصي به و كذلك محتوى الكلوروفيل و النسبة المئوية للنيتروجين والفوسفور والبوتاسيوم و النترات فى الأوراق الداخلية والخارجية والساق .زاد المولبيدنم زيادة معنوياً عند إستخدام 150 % من الموصي به ، على عكس محتوي النبات من الزنك والحديد ونشاط انزيم إختزال النترات والتى انخفضت محتواها معنوياً بزيادة التسميد المعدنى. زادت قيم متوسطات الصفات تحت الدراسة جميعها زياده معنويه عند استخدام 50 ملليجرام/لتر موليبدنم رشاً على النباتات ، ماعدا محتوي الحديد و الزنك فقد زاد عند إضافة كل منهما بمعدل إضافته ، أما بالنسبه لمحتوي النبات من النترات فى الأوراق الداخلية والخارجية والساق فقد أعطت أفضل النتائج عند إستخدام 100 ملليجرام/لتر من الزنك رشاً على النباتات.