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Response of Onion Yield and Its Chemical Content to NPK Fertilization and Foliar Application of Some Micronutrients

Karim Fikry Fouda
Soils Department, Faculty of Agriclture, Mansoura University, Monsoura, Egypt

THE PRESENT study was conducted at the Experimental Farm of the Faculty of Agric., Mansoura University. Six treatments were arranged in Randomized Complete Block Design with three replications as follows: 50% and 100% from the recommended doses (RD) of NPK, 300 Fe mg L^{-1} + 50% from RD of NPK, 50 Cu mg L^{-1} +50% from RD of NPK, 100 Zn mg L^{-1} + 50% from RD of NPK and Fe + Cu + Zn + 50 % from RD of NPK. Micronutrients were added as foliar application while NPK as soil addition. Obtained results indicated that all treatments under investigation significantly affected all traits. The highest values of vegetative growth parameters including fresh, dry weight of bulb and total yield as well as N, P, K, Cu, Fe and Zn, beside nitrate reductase activity in onion bulb recorded with using 50% NPK as soil addition and foliar application of (Fe + Zn + Cu). NO_3-N and NO_2-Nin onion bulb also recorded the highest mean values with the untreated plant (control). The highest availability values of N, P and K in the soil after harvesting were recorded in case of the addition of Fe + Cu + Zn + 50% RD from NPK.

Keywords: NPK fertilization, Micronutrients, Chemical content, Soil nutrients availability and Onion.

Onion plant (*Allium cepa* L.) is a species of the Alinaceae family that has a great economic importance and the second most important vegetable crop in the world (FAO, 2006 and Mishra *et al*., 2013). Onion bulb is a rich source of minerals like phosphorus and calcium. It also contains protein and vitamin C, quercetin and flavonoids. Quercetin helps to eliminate free radicals in the human body, to inhibit low density lipoprotein oxidation (an important reaction in the atherosclerosis and coronary heart disease), to protect and regenerate vitamin E and to inactivate the harmful effects of chelate metal ions (Scott, 2007). In Egypt, onion ranks fourth after cotton, rice, and citrus as an export crop. The total cultivated area was 36153 fed (15184.3 ha) in 1999 and the total production was 305201 tons (CAPMS, 2000).

Micronutrients are just as important as the macronutrients in respect of their functions in plants. The micronutrients required by plants include iron (Fe), zinc (Zn) and copper (Cu). Availability of micronutrients (except Mo) generally decreases as soil pH increases. Therefore, availability of Zn, Mn and Cu declines rapidly as soil pH rises (Umma, 2012). Although the requirement of a micronutrient is small compared to a macronutrient, nevertheless micronutrient deficiency can limit the crop growth and production. Micronutrients have a great role in the fertilizer program to achieve higher and sustainable crop yields. Foliar application of micronutrients such as Fe, Zn, Mn and B could be beneficial as to prevent nutrient deficiency and to avoid soil problems that affect their availability. Kamel (2001) reported that spraying onion plants with solution containing 300 mg L^{-1} of micronutrients chelate (Fe-EDHA, 6% Fe; Mn-EDTA, 12% Mn and Zn-EDTA, 14% Zn) four times significantly increased total yield and total contents of all studied nutrients. El-Tohamy *et al.* (2009) revealed that essential oil, growth and yield of onion plants significantly increased by the application of Fe, Zn and Mn compared to control plants. The results showed that the high concentration of Fe and the low concentrations of both Zn and Mn had the best effects compared to the other concentrations. Durgude et al. (2013) reported that the highest total uptake of total nitrogen and iron by onion was found in foliar treatment of 0.5 % $FeSO_4$.

Mineral fertilizers are considered to be an important source of macro- and micro-elements in crop production. Continuous application of mineral fertilizers may adversely affect soil chemical composition, nutrient imbalance, soil degradation and crop yield. Nitrogen, phosphorus and potassium (NPK) are necessary for onion plant growth, maturity, bulb yield and quality. El-Desuki and Sawan (2001) concluded that NPK uptake and bulb quality increased with increasing level of NPK fertilizer up to 132:96:96 kg fed^{-1}. NO_3-N accumulation in the onion bulb gradually and significantly increased with increasing level of NPK fertilizer up to the highest level. Baddour (2014) used recommended dose of NPK which significantly affected the mean values of N, P and K % and Fe, Zn and Mn (mg kg^{-1}) as well as NO_3-N of onion bulb. Shaheen *et al.* (2007) recorded the highest values of K, Fe, Mn and Zn as well as the content of total protein, N, P, K, Mn, and Cu of onion recorded a good positive correlation with the increasing phosphorus levels addition. The present study was undertaken to study the effect of macro- and micro-nutrients on chemical composition of onion and their soil bioavailability.

Materials and Methods

The present study was conducted at the Experimental Farm of the Faculty of Agric., Mansoura Univ. with 6 treatments arranged in Randomized Complete Block Design with three replications as follows: 50% and 100% from recommended doses (RD) of NPK, 50% from (RD) of NPK + 300 mg L^{-1} Fe, 50% from (RD) of NPK + 50 mg L^{-1} Cu, 50% from (RD) of NPK + 100 mg L^{-1} Zn and 50% from (RD) of NPK + mixture of the same rates of (Fe + Cu + Zn). Micronutrients were added as foliar application while NPK as soil addition.

The soil texture of the experimental site is clayey (sand: 23.1%, silt: 30.1% and clay 46.8%), and having pH: 7.85, EC: 3.91 dS m^{-1}, $CaCO_3$: 3.78%, OM: 1.72%, N:P:K in mg L^{-1}; 52.1: 5.13: 197 were determined according to the standard methods reported by van Reeuwijk (2002). The experiment included onion cultivar (*Allium cepa* L.). Seedlings of the onion were transplanted on January 20th, 2015 at distance of 20 cm apart between the plants on one side of ridges (70 cm wide and 5 m long). The plot consisted of 3 ridges, making an area of about 10 m^2. NPK treatment was treated with

90, 60 and 48 kg fed^{-1} for onion as recommended doses of N, P and K by the Ministry of Agriculture and Soil Reclamation in the form of ammonium sulfate (20.5 % N), super phosphate (15 % P_2O_5) and potassium sulfate (48 % K_2O). Full dose of P was added to the soil before sowing while; N and K were added in two equal doses one after 15 days from sowing and the other two weeks later. The application of micronutrients; zinc 100 mg L^{-1}, iron 300 mg L^{-1} and copper 50 mg L^{-1} solution was sprayed 30 and 45 days from sowing. The source of micronutrient for Zn, Fe and Cu were EDTA. Onion handily yielded at 1st week of May and plants were collected in groups to dry for 10 days then onion yield components took place. The following parameters were recorded: fresh and dry weight of bulb (g/plant) and total yield (ton/fed). Elements of N, P, K were determined according to Mertens (2005a, b), NO_3-N, NO_2-N and nitrate reductase activity (Singh, 1988) as well as Fe, Zn and Cu (Kumpulainen *et al.,* 1983). Soil availability of N, P and K were measured in the soil samples after harvesting as reported by Reeuwijk (2002).

Data reported for chemical content of onion plant and soil availability were assessed by analyses of variance (ANOVA), Duncan and the least significant difference (L.S.D) method was used for any significant differences at the $P< 0.05$ levels between the means of treatment values to the methods described by Gomez and Gomez (1984). All the analyses were conducted using software computer CoSTATE.

Result and Discussion

It is evident from Table 1 that NPK and micronutrient treatments revealed clear significant differences of vegetative growth parameters. The listed data showed that 50% from RD of NPK + (Fe + Zn + Cu) treatments recorded the highest values of plant height, fresh and dry weight of onion plant foliage comparing with the control treatment without adding any fertilization. The rate of the increasing was 33.44, 30.57 and 30.95% for plant height, fresh and dry weight, respectively. These results indicated that (Fe + Zn + Cu) micronutrients when used with NPK fertilizers interaction supplied plant nutrients and provided, better growing conditions which helped for getting proper vegetative growth.

The increase in yield might be due to applying nitrogen improving the vegetative growth and increase in net assimilation rate and accelerating the photosythates in storage organs of bulbs resulting in an increased diameter and weight of the bulb (Sharma, 1992). In addition, the effect of P and K on growth components could be explained through its roles, which is extremely important as a structural part of many components, notably nucleic acid, and phospholipids. In addition phosphorus plays an indispensable role in energy metabolism; the high energy of hydrolysis of phosphate and various organic phosphate bonds being used to induce chemical reaction. The stimulating effect of NPK combination on the above mentioned characteristics were confirmed by Jilani *et al.* (2003) who found that NPK doses resulted in the tallest plant height and maximum number of leaves per plant, compared with control treatment (00:00:00 NPK). These results are in harmony with Yaso and Abdel Razzak (2007), Kandil *et al.* (2013), Kamble & Kathmale (2015) and El Dardiry *et al.* (2015).

TABLE 1. Plant height, fresh and dry weight of onion plant foliage as affected by NPK application and some micronutrients

Treatments	Plant height (cm)	Fresh weight (g/plant)	Dry weight (g/plant)
Control	45.52e	41.54e	3.49e
50% from RD of NPK	49.04d	43.80d	3.69d
100% from RD of NPK	58.29b	52.06b	4.39b
50% from RD of NPK+ Fe 300 ppm	55.41c	49.49c	4.17c
50% from RD of NPK+ Cu 50 ppm	50.61d	45.20d	3.81d
50% from RD of NPK+ Zn 100 ppm	53.49c	47.77c	4.03c
50% from RD of NPK+ (Fe+Zn+Cu)	60.74a	54.24a	4.57a
LSD $_{\text{at 5\%}}$	**2.25**	**2.01**	**0.17**

The increase in yield by mixing of micronutrients as Cu, Zn and Fe might be due to it is essential for plant metabolism; it is one of the constituents of certain oxidizing reduction enzyme, therefore, its role in plant metabolism and participation in oxidation-reduction action. It checks certain diseases and improves the growth of plant. As for zinc, El Gamelli (2000), Bose *et al.* (2009) and Alam *et al.* (2010) stated that the plant height and fresh weight of leaves were positively affected by application of micronutrients. Fresh, dry weight and total yield of onion plant as affected by application of NPK and microelements were represented in Table 2. The resulted data mentioned that the highest values were recorded at 50% from RD of NPK + (Fe + Zn + Cu) comparing with using the control with no addition which recorded the lowest values of the mentioned parameters. The increase in yield might be due to applying nitrogen which improving the vegetative growth and increase in net assimilation rate and accelerating the photosythates in storage organs of bulbs resulting in an increased diameter and weight of the bulb (Sharma, 1992). This results were in harmony with Yaso & Abdel Razzak (2007), Kandil *et al.* (2013), Kamble and Kathmale (2014) and El Dardiry *et al.* (2015), they found that Giza 20, Giza Red and Texas Early Yellow Grano X Giza 20 cultivars were significantly better in most of the studied characters in both seasons. They also added that, mineral fertilization of onion with 214.2 kg N + 71.4 kg P_2O_5 + 57.1 kg K_2O ha^{-1} (85.7 N, 28.6 P_2O_5, 22.8 K_2O kg fed^{-1}, in same sequences) surpassed other studied fertilization treatments and resulted in highest values of most studied characters in both seasons.

TABLE 2. Fresh, Dry weight of bulb and total yield as affected by NPK application and some micronutrients

Treatments	Fresh weight of bulb (g/plant)	Dry weight of bulb (g/plant)	Total yield (ton/fed)
Control	113.54e	10.12e	8.02e
50% from RD of NPK	116.67d	13.13d	10.34d
100% from RD of NPK	138.68b	15.61b	12.29b
50% from RD of NPK+ Fe 300 ppm	131.83c	14.84c	11.68c
50% from RD of NPK+ Cu 50 ppm	120.41d	13.55d	10.67d
50% from RD of NPK+ Zn 100 ppm	127.26c	14.32c	11.28c
50% from RD of NPK+ (Fe + Zn + Cu)	144.49a	16.26a	12.81a
LSD $_{at\ 5\%}$	**5.36**	**0.61**	**0.48**

Data presented in Table 3 showed the interaction effect of soil addition of NPK fertilization and foliar application of micronutrient on N, P and K concentrations and its uptake (Fig. 1) of onion plant comparing with the untreated plants. All present treatment significantly affected N, P and K concentrations and its uptake, using NPK fertilization increased traits with increasing up to 100% RD. Adding some micronutrients + 50% RD increased N, P and K% and its uptake followed by 100% NPK. It means that the highest best chemical quality N, P and K% of onion bulbs was associated with the plants which received 50% from RD of NPK + mixture of some micronutrients with the levels under study.

This might be attributed to the chemical NPK form with more availability and solubility for plant absorption. Moreover, increasing the levels of NPK in root zone caused an increase in its absorption by plants, consequently increased the ability of plant roots to uptake more nutrients in plant tissues. Many investigators had a good accordance with that which obtained in this script; Diriba-Shiferaw *et al.* (2014), El Dardiry *et al.* (2015) and Singh & Ram (2015).

TABLE 3. Nitrogen, phosphorus and potassium concentration as affected by NPK application and some micronutrients

Treatments	Nitrogen (%)	Phosphorus (%)	Potassium (%)
Control	1.61g	0.165g	1.88g
50% from RD of NPK	1.87d	0.176e	2.03f
100% from RD of NPK	2.23b	0.214b	2.40b
50% from RD of NPK+ Fe 300 ppm	2.12c	0.206bc	2.32c
50% from RD of NPK+ Cu 50 ppm	1.93d	0.187d	2.13e
50% from RD of NPK+ Zn 100 ppm	2.04c	0.198c	2.23d
50% from RD of NPK+ (Fe + Zn + Cu)	2.32a	0.225a	2.50a
LSD $_{at\ 5\%}$	**0.09**	**0.009**	**0.07**

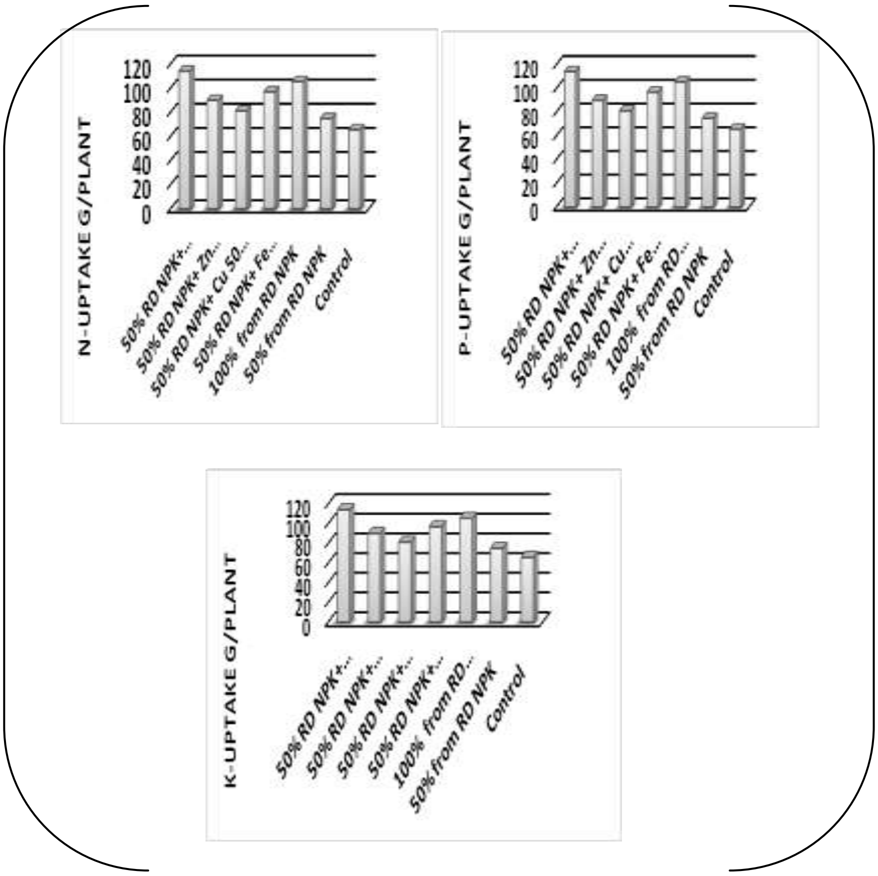

Fig. 1. Nitrogen, phosphorus and potassium uptake g/plant as affected by NPK application and some micronutrient

The results in Table 4 revealed that the effect of all treatments under study significantly affected contents of Zn, Fe and Cu and its uptake mg/plant as illustrated in Fig. 2., in bulb of onion. The contents of Zn, Fe and Cu in bulb onion recorded a good positive correlation with application of NPK and micronutrients. In addition, the differences between adding of all treatments comparing with using NPK in single form and the untreated plants were great enough to be significant at 5 % level. It means that, the best chemical content of onion bulbs was associated with the plants which received 50% NPK plus (Fe + Zn + Cu).

Significant increases in contents of Zn, Fe and Cu and its uptake in bulb onion due to the foliar application of micronutrients Fe, Zn and Cu confirm that foliar fertilizers are absorbed right at the site where they are used and are effective sources of traits and better nutrient uptake by onion bulb under foliar fertilization.

Zinc, iron and copper contents in onion bulb was maximum in the treatments where (Fe + Zn + Cu) was applied with 50% NPK. Zinc, iron and copper uptake deserves special attention because our soils are deficient in micronutrients and are largely immobile. As a result of limited soil availability, zinc, iron and copper is applied as a foliar spray. Foliar fertilization of crops has been considered a precious supplement to the application of nutrients under adverse soil and environmental situations, low soil nutrients bioavailability, hard top soil, and decreased root activity during the reproductive growth stage of plants (Alkaff and Hassan, 2003). It facilitates timely translocation of deficient nutrients to plant system through leaf tissues (Chattopadhyay *et al.,* 2003). Foliar fertilization enhances nutrient use efficiency of crops (Fageria *et al.,* 2009).

TABLE 4. Zinc, iron and copper content in onion plants as affected by NPK application and some micronutrient

Treatments	**Zinc (mg L^{-1})**	**Iron (mg L^{-1})**	**Copper (mg L^{-1})**
Control	8.31g	26.01g	2.98g
50% from RD of NPK	8.54f	27.14f	3.09f
100% from RD of NPK	8.96e	30.64c	3.72c
50% from RD of NPK+ Fe 300 ppm	9.36d	32.02b	3.47d
50% from RD of NPK+ Cu 50 ppm	9.72c	29.44d	3.87b
50% from RD of NPK+ Zn 100 ppm	10.04b	28.30e	3.28e
50% from RD of NPK+ (Fe + Zn + Cu)	10.45a	33.16a	4.04a
LSD $_{at\ 5\%}$	**0.15**	**0.20**	**0.11**

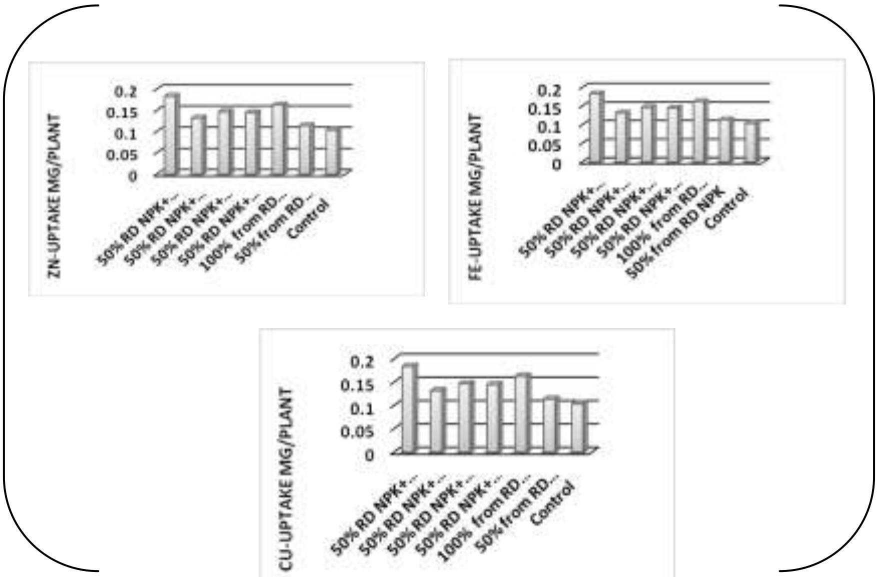

Fig.2. Zinc, iron and copper uptake (mg/plant) as affected by NPK application and some micronutrient

Contents of nitrate, nitrite and nitrate reductase activity in onion bulb were recorded in Table 5. Nitrate concentration measured in onion extracts ranged from 75.09 to 91.5 mg kg^{-1} of fresh weight. The highest level of nitrate 91.5 was observed in extracts treated with 100% from RD comparing with other treatments and the lowest value was recorded with the untreated plants. MAFF (1987) reported that nitrate contents in vegetable crops vary enormously, ranging from 1 to 1000 mg kg^{-1} of fresh weight. According to this classification onion belongs to division I; crops containing low nitrate concentration (> 250 mg kg^{-1}) of fresh weight.

On the other hand, nitrite concentrations ranged from 0.76 to 1.5 mg kg^{-1}. Plants contained the highest value (1.5 mg kg^{-1}) when treated with 100% NPK from RD and gave the lowest level of accumulation when treated with the untreated plants. These levels were in the safe extent (10 mg kg^{-1} FW) and do not cause any toxic effects. As for nitrate reductase activity recorded the highest mean values with 50% RD plus (Fe + Zn + Cu) comparing with using 100% NPK from RD which recorded the lowest values. The results are in good agreement with those reported by Zaki *et al.* (2014) was observed that high accumulation of nitrate and nitrite was observed in extracts of both cultivars when treated with 100% RD while, treatments with 50% RD decreased the contents of nitrate and nitrite.

TABLE 5. Nitrate, nitrite and nitrate reductase activity as affected by NPK application and some micronutrients

Treatments	**NO_3-N (mg kg^{-1})**	**NO_2-N (mg kg^{-1})**	**Nitrate reductase activity (mg min^{-1} g^{-1} FW)**
Control	75.06g	0.76g	1.91a
50% from RD of NPK	89.53b	1.37d	1.14f
100% from RD of NPK	91.50a	1.50a	0.99g
50% from RD of NPK+ Fe 300 ppm	80.40e	0.99e	1.66c
50% from RD of NPK+ Cu 50 ppm	86.60c	1.28c	1.33e
50% from RD of NPK+ Zn 100 ppm	83.93d	1.14d	1.48d
50% from RD of NPK+ (Fe + Zn + Cu)	76.40f	0.83f	1.86b
LSD $_{\text{at 5\%}}$	**1.69**	**0.07**	**0.11**

The effect of different treatments was found significant effect on soil available N, P and K after harvest of onion (Table 6). The significantly highest available N, P and K (70, 10.1 and 277.1 mg L^{-1}) were recorded by treatment 50% from RD of NPK + (Fe + Zn + Cu) comparing with the control which recorded the lowest values. Increased availabilities of N, P, and K may also result from changes in soil nutrient turnover rates due to altered ecosystem properties. Soil nutrient turnover rate consist of decomposition, mineralization, weathering, chemical complexation, adsorption or nutrient uptake by crops and soil organisms (Marrs, 1993). The results are in good agreement with those reported by

Kamble and Kathmale (2015) they found that the significantly highest available nitrogen (213 kg ha^{-1}), phosphorus (14.42 kg ha^{-1}) were recorded in 125 % recommended dose of NPK to onion appears to be improving soil fertility.

TABLE 6. Soil availability of N, P and K as affected by NPK application and some micronutrient

Treatments	Nitrogen ($mg\ L^{-1}$)	Phosphorus ($mg\ L^{-1}$)	Potassium ($mg\ L^{-1}$)
Control	45.3g	4.3g	172.5g
50% from RD of NPK	47.5f	5.1e	189.3f
100% from RD of NPK	64.5b	10.0a	260.9b
50% from RD of NPK+ Fe 300 ppm	60.7c	8.0b	239.5c
50% from RD of NPK+ Cu 50 ppm	52.0e	6.1d	209.4e
50% from RD of NPK+ Zn 100 ppm	55.6d	7.0c	228.7d
50% from RD of NPK+ (Fe + Zn + Cu)	70.0a	10.1a	277.1a
$LSD_{at\ 5\%}$	**3.08**	**0.25**	**5.56**

Conclusion

NPK and some micronutrients (Fe + Zn + Cu) can be used in field to enhance the crop nutrient absorption and to have a good quality of onion and decrease accumulation of nitrate and nitrite. It can be concluded that using 50% NPK from recommended dose and mixture of micronutrients (Fe + Zn + Cu) influenced the economic yield and high quality of onion plant.

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استجابه محصول البصل وتركيبه الكيماوى للتسميد المعدنى مع الرش ببعض العناصر الصغرى

كريم فكرى فودة
قسم الأراضى – كلية الزراعة – جامعة المنصورة – المنصورة – مصر .

اجريت دراسه حقليه فى المزرعه الخاصه بكليه الزراعه – جامعه المنصوره .عباره عن 6 معاملات خلال 3 مكررات مصممه فى قطاعات كامله العشوائيه كما يلى : 50٪، 100٪ سماد معدنيNPK من الموصى به، حديد 300 جزء فى المليون+ 50٪ سماد معدنى، نحاس 50 جزء فى المليون + 50٪ سماد معدنى، زنك 100 جزء فى المليون + 50٪ سماد معدنى، خليط من العناصر الصغرى السابقه +50 ٪ سماد معدنى .

اوضحت النتائج ان جميع المعاملات تحت الدراسه اثرت معنويا فى جميع الصفات المدروسه بينما سجلت اعلى متوسطات القيم لكل من صفات النمو ، الوزن الطازج والجاف للابصال والمحصول الكلي لنبات البصل كذلك النسبه المئويه للنيتروجين ، الفوسفور ، البوتاسيوم كذلك محتوى البصل من الحديد، الزنك، النحاس و نشاط انزيم النيتريت ريداكتيز عند اضافه خليط من العناصر الصغرى +50٪ سماد معدنى بينما محتوى النبات من النيترت والنترات سجلت اعلى القيم مع معامله الكنترول. اما بالنسبه لمحتوى التربه من العناصر الصالحه نيتروجين، فوسفور وبوتاسيوم بعد حصاد البصل سجلت اعلى قيم عند استخدام خليط من العناصر الصغرى +50٪ سماد معدنى من الموصي به.