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# VARIETAL RESPONSES OF WHEAT ( *Triticum aestivum* L. ) TO MICRONUTRIENTS FOLIAR APPLICATION

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## ABSTRACT

Two field trials were conducted during the consecutive seasons of 1997/1998 and 1998/1999 at the Agricultural Experimental Station , National Research Centre (NRC), Cairo, at Shalakan, Qualiubia Governorate, Egypt , on three wheat varieties namely Sids 1, Sakha 69 and Gemaiza 3, to investigate the nutrient status, growth and yield responses to micronutrients foliar application . That was to gain information about the effeciency in aquisition and utilization of nutrients .The results showed that , spraying micronutrients compound (Wuxal suspension micro-Zn contained Fe 1.35 % , Mn 2.7 % and Zn 4.0% ) resulted in improving plant nutritive status, leading to increasing the growth in terms of shoot dry weight , grain yield and total carbohydrate and protein content in grains of all varieties under investigation , in comparison with non- treated plants . In addition, the results revealed that the positive response of the foliar applied micronutrients varied in degree between the three wheat varieties . Sakha 69 variety gave the highest grain yield at the rate of micronutrients 3.0 ml/l , and Sids 1 variety produced the highest percentage of total carbohydrates in grains at the same rate. Meanwhile, highest protein percentage in grains was obtained by Gemaiza 3 variety at the rate 1.5 ml/l . Significant interaction effect between micronutrients application and varieties for all studied characters except the plant height was found . These results might reflect the different responses due to genetic factors of the three wheat varieties to micronutrient application . Furthermore, the present study suggests that micronutrients foliar application can be used to improve nutrient status and yield production of all varieties .

## INTRODUCTION

The total production of wheat in Egypt is still insufficiet to cover the local consumption . Thus, the shortage is covered through importation . Increasing the vertical production through introducing new varieties with high yield potential is needed to overcome the gap between local production and demand . The growth of wheat plants was found to be affected with nutrient availability , which is one of the important factors contributing to plant growth , and relevant economic yield . Deficiency of micronutrients , particularly Fe, Mn and Zn form one of the major yield limiting factor in Egypt . This is because of high pH and low organic matter contents in soil (El-Fouly 1983 and 1986 and Alexander, 1986) . Therefore, foliar application of micronutrients was promising for increasing yield under local conditions . Improving wheat growth and yield due to micronutrients foliar application was reported by many authors ( Firgany *et al.*, 1983 ; El-Fouly *et al.*,1990 and1997 and Abdalla *et al.*, 1992 ) . Wheat varieties differ in their uptake and use of nutrients ( Brown *et al.*,1972 ; Brown,1979 ; Kannan & Pandy, 1982 and Sharaan and Abd-El-Samie, 1999) . Higher varietal tolerance to micronutrients deficiencies is needed and recommended . Growing tolerant varieties would appear tooffer

cheaper and a more satisfactory solution than changing soil properties (Brown *et al.*,1972 ; Bruetsch & Estes ,1976 ; Mengel , 1982 and Saric, 1982 ) .

This work was undertaken to investigate the nutrient status, growth and yield responses to micronutrient foliar application of some Egyptian wheat varieties. That was to gain information about the efficiency in acquisition and utilization of essential mineral nutrients.

## MATERIALS AND METHODS

Two field trials were conducted during the consecutive seasons of 1997/1998 and 1998/1999 at the Agricultural Experimental Station , National Research Centre (NRC), Cairo, which is located at Shalakan, Qualiubia Governorate, Egypt . The split plot design was applied to carry out the field trials ; each as factorial experiment of two factors with three replicates .These factors were arranged in a descending order, based on the objective of the study, as follows :

*Micronutrient treatments : three treatments as foliar application (0.0, 1.5 and 3.0 ml /l) by using Wuxal suspension micro-Zn which contained Fe1.35%, Mn 2.7% and Zn 4.0%.

* Varieties : three Egyptian wheat varieties namely, Sids 1 , Sakha 69 and Gemaiza 3 .

The micronutrient treatments were considered as main-plots; then, the varieties were randomly allocated in the sub-plots of each main-plot .Soil surface (0-30 cm depth ) layer was taken as an representative sample for analysis . Physical and chemical analysis of soil was determined as shown in Table 1 .Wheat grains were planted at last week of November for the two seasons . Prior to planting , the NPK fertilization was soil applied in the experimental site of each season ( as recommended by the Extention Service in Egypt .Two sprays of micronutrients were carried out, the first was at tillering stage (45 days after planting) and the second was at stem extention stage (15 days after the first spray) . Plant samples (shoots) were taken 15 days after the second spray from all treatments. Plant samples were washed with a sequence of tap water, 0.01 N HCL , acidified bidistilled water and bidistilled , and were oven-dried at 70 $^0$C .

**Macro and micronutrients determination in shoots :**

The plant material was ground in a stainless steel mill .Total N was determined by using micro-kjeldahl method (Allen,1953) . P, K, Mg, Na, Ca, Fe, Mn, Zn and Cu were determined using wet digestion method according to Chapman and Pratt (1978).

**Dry weight determination :**

Plant samples (shoots ) were taken 15 days after the second spray . The plants were oven-dried at 70 $^0$C , and the dry weights were calculated.

**Table (1): Physical and chemical characteristics of soils**

| Physical characteristics | Nutrients content |
|---|---|

| | 1st season | 2nd season | | | 1st season | 2nd season |
|---|---|---|---|---|---|---|
| Sand (%) | 12.8 | 12.8 | P | mg/100g | 1.2 0 | 1.56 |
| Silt (%) | 28.0 | 26.0 | K | mg/100g | 27.15 | 24.8 |
| Clay (%) | 59.2 | 61.2 | Mg | mg/100g | 56.68 | 58.0 |
| Texture | clay | clay | Na | mg/100g | 31.20 | 34.2 |
| pH | 8.33 | 8.41 | Fe | ppm | 5.0 0 | 6.8 0 |
| E.C.(mmhos) | 0.54 | 0.77 | Mn | ppm | 3.50 | 3.6 0 |
| Ca CO3 (%) | 2.02 | 2.0 | Zn | ppm | 1.10 | 1.50 |
| O.M. (%) | 1.3 | 1.4 | Cu | ppm | 2.50 | 2.02 |

**pH (1:2.5 soil : water ): Jackson (1973 )**
**E.C.(1:2.5 soil :water ) : Jackson (1973 )**
**Ca CO3: Black (1965 )**
**O.M.: Walkley and Black (1934)**
**P: Olsen *et al* (1954 )**
**K , Mg and: Jackson (1973 )**
**Fe , Mn , Zn and Cu: Lindsay and Norvell (1978)**

**Yield determination :**

At ripening stage, harvesting was done for whole area of each treatment . Plant height (cm) and grain yield (ardab/feddan) were recorded .

**Determination of total carbohydrates in grains :**

Total carbohydrate percentage in grains was measured colorimetrically according to ( Dubois *et al*., 1956) .

**Determination of protein content in grains :**

Total nitrogen in grains (%) was determined according to ( Allen, 1953) . Protein percentage in grains was calculated by the following equation:
% protein = % total N content x 6.25

**Data analysis :**

Data were statistically analyzed using Costate Statistical Package (Anonymous, 1989).

## RESULTS AND DISCUSSION

**Soil characteristics :**

Results presented in Table (1) show that the soil had clayey texture and characterized by high pH , low organic matter , E.C. and CaCO3 . Contents of available P, K and Mg were moderate and low for Fe, Mn, Zn and Cu. The high soil pH together with low organic matter content reduce the availability of micronutrients ; especially Fe, Mn and Zn to plants ( Amberger, 1991) Therefore, spraying such nutrients proved to be a good tool in correcting their deficits ( Alexander, 1986 and El- Fouly *et al.*,1990 and 1997).

**1-Effect of micronutrients :**

**Growth and yield:**

Data in Table (2) show that growth in terms of shoot dry weight and grain yield of the three wheat varieties was significantly increased by

micronutrients at the rates 1.5 and 3.0 ml/l in both seasons comparing with non-treated plants . No significant differences between the two treatments for the dry weight , meanwhile spraying by 3.0 ml/l gave the highest significant increment for grain yield . The increments of shoot dry weight and grain yield due to micronutrients application varied from variety to the other . Sakha 69 variety surpassed the other varieties in grain yield, its maximum grain yield reached 32.4 ardab/feddan , meanwhile the lowest grain yield was recorded by Sids 1 variety (26.7 ardab/feddan) . Data show that no significant differences in plant height of the tested varieties as a results of micronutrient treatments . The results indicated that, foliar application increased growth and yield through improvement of the plant nutritive status which affected physiological performance. Several investigators reported that micronutrients foliar application greatly affected growth and yield of wheat plant , (Firgany *et al.*, 1983 ; Abdalla *et al.*, 1992) .

**Table (2) : Plant dry weight , main stem length and grain yield of three wheat varieties as affected by micronutrients spraying .**

| | MN treatments ml /L | First season Varieties ( V ) | | | | Second season Varieties ( V ) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Sids 1 | Sakha 69 | Gemaiza 3 | Mean | Sids 1 | Sakha69 | Gemaiza 3 | Mean |
| Dry weight ( g/plant ) | 0.0 | 4.82 | 3.57 | 4.48 | 4.29 a | 5.95 | 5.13 | 4.49 | 5.18 a |
| | 1.5 | 5.51 | 5.27 | 6.21 | 5.66 b | 6.16 | 7.09 | 6.24 | 6.49 b |
| | 3.0 | 5.64 | 5.25 | 5.52 | 5.47 b | 6.94 | 5.28 | 6.00 | 6.07 b |
| | Mean | 5.32 b | 4.70 a | 5.40 b | | 6.35 b | 5.84 a | 5.58 a | |
| Main stem length ( cm ) | 0.0 | 102.0 | 97.8 | 98.2 | 99.3 a | 105.0 | 100.0 | 101.6 | 102.2 a |
| | 1.5 | 102.0 | 100.8 | 101.7 | 101.5 a | 106.7 | 105.5 | 103.3 | 105 .0a |
| | 3.0 | 103.5 | 100.2 | 102.8 | 102.1 a | 110.0 | 103.3 | 106.7 | 106.6 a |
| | Mean | 102.4 a | 99.6 a | 100.9 a | | 107.2 a | 102.8 a | 103.9 a | |
| Grain yield (ardab / feddan ) | 0.0 | 24.3 | 27.9 | 27.7 | 26.6 a | 27.4 | 29.5 | 27.5 | 28.1 a |
| | 1.5 | 26.7 | 32.3 | 29.7 | 29.6 b | 28.2 | 31.4 | 30.1 | 29.8 b |
| | 3.0 | 28.5 | 31.8 | 31.6 | 30.6 c | 29.8 | 32.4 | 29.2 | 30.5 c |
| | Mean | 26.5 a | 30.7 b | 29.7 b | | 28.5 a | 31.1 c | 28.9 b | |

**Values followed by same letters are not significantly different at 5%**
**MN = Micronutrients treatments**
**V = Varieties**

**LSD 0.05 : ( First season )**

**Dry weight: MN=0.2 V = 0.1 MN * V = 0.3**
**Main stem: MN=N.S V =N.S MN * V = N.S**
**Grain yield: MN = 1.0 V =1.5 MN * V = 1.7**

**LSD 0.05 : ( Second season )**

**Dry wieght: MN = 0.5 V = 0.4 MN * V = 0.8**
**Main stem: MN = N.S V = N.S MN * V = N.S**
**Grain yield : MN = 0.7 V= 0.4 MN * V =1.4**

**Nutrients uptake :**

The uptake of macronutrients N,P,K,Mg,Na and Ca ( Table 3 ) and micronutrients Fe, Mn, Zn and Cu ( Table 4) was significantly increased in response to micronutrient treatments comparing with control in all tested varieties . Similar results were obtained by El- Fouly *et al.*,1990 and 1997. It

was clear that micronutrients application led to more efficiency of plants to utilize macronutrients of soil (Hahr,1987 ; Abdalla & Mobarak,1992 ; Abdalla *et al.*,1992 and Nofal *et al.*, 1999 ) . Such a result might be attributed to some possible reasons including that this small quantities of micronutrients led to better balance between micro and macronutrients in treated plants . Meanwhile, micronutrients have possibly increased activities of metabolic processes in plant ( Mengel & Kirkby, 1987). Accordingly, physiological performance of such plants was improved ; as manifested by increased efficiency of roots in absorping macronutrients from the soil . The results showed that the rate of micronutrients which led to high increment of nutrient uptake varied from variety to the other .

**Table (3): Macronutrients uptake (mg/plant) in shoots of three wheat varieties as affected by micronutrients spraying .**

| Element | MN treatments | First season | | | | Second season | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Varieties ( V ) | | | | Varieties ( V ) | | | |
| | ml /L | Sids 1 | Sakha 69 | Gemaiza 3 | Mean | Sids 1 | Sakha 69 | Gemaiza 3 | Mean |
| N | 0.0 | 57.84 | 44.27 | 60.52 | 54.21 a | 160.3 | 118.0 | 112.3 | 130.21a |
| | 1.5 | 87.61 | 65.84 | 89.99 | 81.14b | 172.4 | 196.9 | 137.2 | 168.82b |
| | 3.0 | 96.44 | 91.35 | 80.64 | 89.47 c | 194.3 | 158.4 | 132.0 | 164.56b |
| | Mean | 80.63 c | 67.15 a | 77.05 b | | 175.78c | 157.77 b | 127.17 a | |
| P | 0.0 | 4.34 | 3.04 | 4.48 | 3.95 a | 10.7 | 7.7 | 6.7 | 8.37 a |
| | 1.5 | 5.51 | 4.48 | 6.20 | 5.39 b | 11.7 | 10.5 | 10.6 | 10.93 b |
| | 3.0 | 5.81 | 6.30 | 5.52 | 5.57 c | 15.1 | 9.0 | 10.8 | 11.63 b |
| | Mean | 5.22 b | 4.60 a | 5.40 c | | 12.51 b | 9.08 a | 9.36 a | |
| K | 0.0 | 107.97 | 82.11 | 98.63 | 96.24 a | 136.8 | 97.5 | 98.8 | 111.02a |
| | 1.5 | 135.55 | 121.14 | 136.4 | 131.0b | 147.8 | 163.2 | 143.3 | 151.48c |
| | 3.0 | 142.66 | 126.00 | 127.07 | 131.9b | 159.3 | 121.4 | 120.0 | 133.57b |
| | Mean | 128.7c | 109.75 a | 120.70 b | | 147.9b | 127.37 a | 120.74 a | |
| Mg | 0.0 | 7.71 | 5.54 | 8.07 | 7.05 a | 9.5 | 6.7 | 5.8 | 7.33 a |
| | 1.5 | 8.82 | 8.43 | 11.16 | 9.47 b | 9.9 | 10.6 | 9.9 | 10.13 c |
| | 3.0 | 9.59 | 9.97 | 10.49 | 10.02 c | 12.5 | 7.4 | 8.4 | 9.43 b |
| | Mean | 8.70 b | 7.92 a | 9.91 c | | 10.63 b | 8.23 a | 8.03 a | |
| Na | 0.0 | 13.49 | 7.14 | 11.66 | 10.76 a | 5.40 | 4.60 | 3.60 | 4.53 a |
| | 1.5 | 13.22 | 10.00 | 11.16 | 11.46 b | 6.16 | 7.10 | 5.60 | 6.28 b |
| | 3.0 | 15.23 | 9.97 | 8.84 | 11.34 b | 9.70 | 10.00 | 7.20 | 8.96 c |
| | Mean | 13.98 c | 9.04 a | 10.54 b | | 7.08 b | 7.23 b | 5.47 a | |
| Ca | 0.0 | 2.41 | 1.79 | 2.69 | 2.30 a | 2.40 | 1.50 | 2.20 | 2.03 a |
| | 1.5 | 3.31 | 2.64 | 3.10 | 3.01 b | 2.50 | 2.90 | 3.10 | 2.83 b |
| | 3.0 | 3.39 | 3.15 | 3.31 | 3.28 c | 2.80 | 2.60 | 3.00 | 2.79 b |
| | Mean | 3.03 b | 2.53 a | 3.03 b | | 2.53 b | 2.32 a | 2.78 c | |

**Values followed by same letters are not significantly different at 5%**
**MN = Micronutrients treatments**
**V = Varieties**

**LSD 0.05 : ( First season )**

**N : MN = 3.0 V = 1.9 MN * V = 5.3**
**P : MN = 0.2 V = 0.1 MN * V= 0.4**
**K : MN = 5.9 V = 5.0 MN * V =8.2**
**Mg : MN = 0.4 V = 0.2 MN * V=0.6**

**LSD 0.05 : ( Second season )**

**N:MN = 15.7 V = 9.4 MN * V=27.2**
**P:MN = 1.4 V = 1.3 MN * V =2.5**
**K: MN = 10.8 V = 13.9 MN *V=18.6**
**Mg:MN = 0.7 V = 0 .9 MN * V =1.2**

**Na : MN = 0.5 V = 0.3 MN * V=0.8** **Na:MN = 0.6 V = 0.5 MN * V = 1.0**

**Ca : MN = 0.1 V = 0.1 MN * V = 0.2** **Ca MN = 0.2 V= 0.2 MN * V = 0.4**

**Total carbohydrates and protein in grains :**

The application of micronutrients increased the total carbohydrate percentage (Fig. 1) and protein (Fig.2) in grains of the three wheat varieties . Sids 1 variety gave the highest percentage of carbohydrate at the rate of 3.0 ml/l , meanwhile , Gemaiza variety produced the highest protein percentage at the rate of 1.5 ml/l .This results might be attributed to the specific function of micronutrients in plant metabolism and hence their biochemical role in carboxylating enzymes or carbonic anhydrase CAA (Abdel-Rahman *et al*., 1997 and El- Fouly *et al*., 1998 )

**Table (4): Micronutrients uptake (ug/plant) in shoots of three wheat varieties as affected by micronutrients spraying .**

| Element | MN treatments ml /L | First season Varieties ( V ) | | | | Second season Varieties ( V ) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Sids 1 | Sakha69 | Gemaiza3 | Mean | Sids 1 | Sakha 69 | Gemaiza 3 | Mean |
| Fe | 0.0 | 1085 | 904 | 1076 | 1022 a | 3717 | 2052 | 2021 | 2597 a |
| | 1.5 | 1229 | 1585 | 1750 | 1525 b | 4310 | 3463 | 3586 | 3786 b |
| | 3.0 | 1466 | 1703 | 1767 | 1645 c | 4858 | 2904 | 4050 | 3937 b |
| | Mean | 1260 a | 1400 b | 1531c | | 4295 c | 2806 a | 3219 b | |
| Mn | 0.0 | 241 | 214 | 224 | 227a | 274 | 215 | 202 | 230 a |
| | 1.5 | 276 | 316 | 310 | 301 b | 357 | 391 | 343 | 364 c |
| | 3.0 | 310 | 315 | 249 | 291 b | 437 | 246 | 318 | 333 b |
| | Mean | 276 b | 282 b | 261a | | 356 b | 284 a | 288 b | |
| Zn | 0.0 | 72 | 90 | 89 | 84 a | 173 | 190 | 144 | 169 a |
| | 1.5 | 84 | 132 | 124 | 113 c | 209 | 298 | 268 | 258 c |
| | 3.0 | 87 | 131 | 110 | 110 b | 222 | 195 | 216 | 211 b |
| | Mean | 81 a | 118 c | 108 b | | 201 a | 227 b | 209 a | |
| Cu | 0.0 | 24 | 36 | 45 | 35 a | 36 | 26 | 25 | 29 a |
| | 1.5 | 28 | 53 | 62 | 47 c | 40 | 40 | 37 | 39 b |
| | 3.0 | 28 | 53 | 56 | 46 b | 52 | 34 | 33 | 40 b |
| | Mean | 27 a | 47 b | 54 c | | 43 b | 33 a | 32 a | |

**Values followed by same letters are not significantly at 5%**
**MN = Micronutrients treatments**
**V = Varieties**

**LSD 0.05 : ( First season )**
**Fe:MN = 77.2 V = 102.8 MN * V =133.7**
**Mn:MN =10.3 V = 7.4 MN * V =17.9**
**Zn:MN =3.3 V = 2.5 MN * V =5.8**
**Cu MN = 1.6 V = 1.1 MN * V =2.8**

**LSD 0.05 : ( Second season )**
**Fe: MN = 290.4 V = 245.9 MN * V =503.1**
**Mn: MN =28.6 V = 38.4 MN * V =48.7**
**Zn: MN =17.5 V = 14.8 MN * V =30.3**
**Cu: MN = 3.4 V = 2.8 MN * V =5.9**

**2- Effect of varieties :**

Data presented in Tables (2-4) and Figures(1-2) indicate that control (non- sprayed ) plants of the tested varieties differed in their dry matter

production, grain yield , nutrients uptake and percentage of total carbohydrates and protein content in grains .This results agree with Brown *et al*. (1972) and Kannan and Pandy (1982) who mentioned that, the genetic specificity is found in a great number of plant species, where the contents of different elements vary greatly between genotypes of the same plant species. When plants sprayed with micronutrients , the positive response of the foliar applied micronutrients varied in degree between the three wheat

Fig 1+2

varieties. These results might reflect the different responses , due to genetic factors of the three varieties to micronutrients application ( Brown *et al.*,1972 ; Bruetsch & Estes ,1976 ; Mengel , 1982 and Saric, 1982 ) . Varietal differences in growth , yield and nutrient content due to micronutrients spraying were reported by several investigators (Mobarak *et al.*,1992 and El-Bendary *et al.*,1992 ) .

**3- Effect of interaction :**

Concerning the interaction effect between micronutrients application and varieties (MNxV),data presented in Tables (2-4) and Figures (1-2) show significant interaction between micronutrients application and varieties ( MN x V) for all studied characters except plant height . These results also might reflect the different responses, due to genetic factors of the three varieties to micronutrients application

It might be concluded that the studied varieties markedly differed in their content from macro and micronutrients, total carbohydrates and protein as well as in their response to micronutrients foliar application . Furthermore, the present study suggests that micronutrients foliar application can be used to improve nutrient status and yield production of all varieties .

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**إستجابة بعض أصناف القمح للرش بالعناصر المغذية الصغرى**

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أجريت تجربتين حقليتين فى موسمين متتاليين ( 1997/ 1998 & 1998 /1999) بمحطة التجارب الحقلية الخاصة بالمركز القومى للبحوث التى تقع بمنطقة شلقان بمحافظة القليوبية لدراسة إستجابة بعض أصناف القمح المصرية للرش بالعناصر المغذية الصغرى . وكانت الأصناف المستخدمة هى : سدس 1 وسخا 69 وجميزة 3 ، أما السماد المستخدم للرش هو مركب فوكسال ميكرو- معلق الذى يحتوى على 53و1 % حديد ، 7و2 % منجنيز ، 0و4 % زنك . وكانت معاملات الرش هى 5و1 ، 0و3 مل/ لتر بالاضافة إلى المقارنة . وقد أظهرت النتائج أن الرش بالعناصر الصغرى أدى إلى زيادة معنوية فى محتوى النبات من العناصر الكبرى والصغرى مما أدى إلى زيادة معنوية فى النمو ( الوزن الجاف للأفرع ) ومحصول الحبوب وكذلك زيادة النسبة المئوية لكل من الكربوهيدرات الكلية والبروتين فى الحبوب مقارنة بالنباتات الغير معاملة ، وذلك فى الثلاث أصناف المختبرة ، كما إختلفت هذه الأصناف فى درجة الإستجابة للرش فقد تفوق الصنف سخا 69 فى المحصول عن الصنفين الاخرين حيث أعطى أعلى محصول للحبوب عند الرش بمعدل 0و3 مل/ لتر . أما أعلى نسبة مئوية من الكربوهيدرات الكلية فى الحبوب ظهرت فى الصنف سدس 1 عند الرش بمعدل 0و3 مل / لتر ، وأعطى الصنف جميزة 3 أعلى نسبة للمحتوى الكلى للبروتين فى الحبوب بالرش بمعدل 5و1 مل / لتر . كما أوضحت النتائج أن التداخل فى التأثير بين العناصر الصغرى والأصناف كان معنويا بالنسبة لجميع الصفات المدروسة ماعدا إرتفاع النبات

من هذه النتائج يمكن إستنتاج أن إختلاف إستجابة الأصناف للرش بالعناصر الصغرى قد يرجع إلى الإختلافات الوراثية بينهم . كما توضح النتائج إمكانية إستخدام الرش الورقى بالعناصر الصغرى لتحسين الحالة الغذائية والمحصول لهذه الأصناف .