RESPONSE OF PEA PLANTS (Pisum sativum L.) TO SUPPLEMENT OF SULPHUR TO THE SOIL AND FOLIAR APPLICATION OF SOME MICRONUTRIENTS
Youssef, A. M. and A. S. S. Amer

ABSTRACT

Under field conditions, pea plants cv. Master B were cultivated in a clay loamy soil receiving sulphur at 0 or 50 kg / fed. and sprayed with Fe at 100ppm, Zn at 50ppm and Mn at 50ppm or a mixture of Fe, Zn and Mn at the previous concentrations as chelated forms. The foliar spray was repeated four times at 10 days intervals starting 45 days after planting. The experiments were carried out during the two successive winter seasons of 1998/1999 and 1999/2000.

1- Sulphur application to the soil significantly increased plant growth parameters (Plant height, no- branches and no-leaves per plant) and contents of Fe, Zn and Mn in leaf tissues. The treatment had no reduction of aborted ovules/pod and increased pod weight, no-pods/plant, total green pods yield, seed index, dry seed yield and protein content in dry seeds.

2- Foliar application with a mixture of Fe, Zn and Mn or Zn alone to pea plants resulted insignificant increase in plant growth characteristics. Contents of Fe, Zn and Mn in leaves followed the same pattern of changes as that mentioned before. Fresh pod yield and its components were increased. Additionally, seed index, dry seed yield and protein content in dry seed were also significantly greater than control.

3- The interaction of sulphur and mixture of Fe, Zn and Mn or Zn alone had significant increase in some plant growth characters as well as pod fresh yield and its components. Similar results were found for dry seed yield, seed index and protein content of these seeds.

The results indicate that sulphur supplement to the clay loamy soil can be used successfully for peas production in combination with foliar spray of micronutrients.

INTRODUCTION

The necessity of microelements application to plants is undoubtedly of great importance, specially after the decrease of these elements in Nile water (Nabhan, 1965). Moreover, the limited supply of manure used in vegetable growing nowadays and the intensive cropping of vegetables three time per year which remove more quantities of micronutrients from the soil. All these factors led us to give more attention to micronutrients application. Micronutrients play a very important role in vital processes of plants. They increase the chlorophyll content of leaves, improve photosynthesis which intensify the assimilating activity of the whole plants (Marschner, 1995). The effect of spraying Fe, Zn and Mn on the physiological processes of vegetable crops were studied by many investigators e.g. Kherde and Yawalker (1966); Vagonov and Sorokina (1970) and Anderson and Cartens (1974) on peas; Hassan (1982) on pea and bean plants; Melton et al. (1970); Polson and
Adams (1970); Abo-EL-Hassan (1974); Singh (1974); Gonzalez (1980) and
EL-Assiouty (1983) on beans; Zaki et al (1981) and Youssef et al. (2001) on
tomato; EL-Beheidi et al. (1978); EL-Fadaly (1992) and Alphonse and Saad
(2000) on cucumber and Zaki et al. (1979) on squash. Because of the
alkalinity of the soils in several regions in Egypt, most of the added nutritional
elements, particularly P, Mn, Zn and Fe will be unavailable for plants. The
addition of sulphur reduces soil pH due to increasing the availability of the
nutritional elements, increasing the value of electrical conductivity and
increasing the content of organic carbon. Many investigators studied the role
of sulphur on the previous characters of the soil, such as Khashirad and
Bazargani (1972); Ryon et al. (1974); EL- Leboudi and Omar (1975);
Procopio et al. (1976), EL- Leboudi et al. (1982); Yousry et al. (1984) and
Hetzer (1985). Besides, the role of sulphur on the growth and yield of
vegetable plants was also studied by Abdel - Al et al. (1973) on tomato;
Kasim (1984) on pepper; Shaheen et al. (1989) on sweet pepper; Omar et al.
(1990) and Hilal et al. (1992) on peas; Lopez et al. (1994); Rahman and
Hoque (1994) and Sawan and Rizk (1998) on eggplants.

This study aimed to investigate the response of pea plants to the
addition of different levels of sulphur element to the soil and foliar application
of Fe, Zn and Mn.

MATERIALS AND METHODS

This work was carried out at Kaha Research Farm, Kaflu
Governorate, during the two successive winter seasons of 1998/1999 and
1999/2000 to study the effect of sulphur and some trace elements on plant
growth, green pods yield, dry seeds yield, content of Fe, Zn and Mn in leaves,
in addition to the protein percentage in dry seeds of pea cv. Master B. The
experimental soil was a clay loam texture with pH of 8.1. The soil analysis
was done according to Jackson (1967). The physical and chemical analysis of
the soil is presented in Table (1). Seeds were sown on one side of beds on
20th of October in both seasons of study. After emergence, seedlings were
thinned to one plant per hill, the distance between hills was 10 cm. split plot
design with four replicates was used. The main plots consisted of two levels
of sulphur 0 and 50 kg feddan which was applied after preparation of soil
before planting. The sub-plots were assigned for foliar applications with
100ppm of Fe-EDTA, 50ppm of Zn EDTA, 60ppm of Mn-EDTA, Fe + Zn +
Mn with the previous concentrations and distilled water for control. The
spraying of trace elements and distilled water took place four times at 10
days intervals started from 5th of December. All agricultural treatments in the
area regarding peas cultivation were carried out according to the
recommendations of Ministry of Agriculture. Each sub-plot consisted of 8
rows, 4 meters long and 60 cm wide. Four rows were used to determine the
plant growth and chemical constituents of leaves as well as green pods yield,
while the other four rows were used to record the dry yield and its
components. Ten plants from each plot were selected randomly and the
following data were recorded after 15 days from the last foliar application (after 75 days from plants thinned).

1- Vegetative growth :-
   a- Plant height (cm).
   b- Number of branches.
   c- Number of leaves.

2- Green pods yield:-
   At harvesting stage fresh pods yield per plot at each picking was determined. In the meantime, samples of 10 edible green pods from each sub-plot were collected and the following data were recorded:-
   a- Average pod weight (g.)
   b- Number of pods per plant.
   c- Number of seed per fresh pod.
   d- Number of aborted ovules per fresh pod.
   c- Fresh pods yield (ton/ fed).  
   f- Weight of 100 green seed (g.).

3- Dry yield :-
   Four rows were used to determine the following characteristics.
   a- Weight of 1000 - dry seed : (seed index).
   b- Dry seeds yield (ton/ fed).

4- Chemical composition of leaves :-
   a- Leaf contents of Fe, Zn and Mn i.e. number 4 and 5 from the top on the main stem at the end of growing seasons. Three plants from each treatment were randomly chosen to determine the previous parameters. Fe, Zn and Mn were estimated in pea leaves digests using Philips PU 9100 atomic absorption.

Table (1): Physical and chemical analysis of the soil of the experimental site.

A- Physical analysis :-
   Soil texture   Clay loam
   Clay %        60.85
   Silt %        18.95
   Fine sand %   12.65
   Coarse sand % 7.55

B- Chemical analysis :-
   available K (mg/100g soil) 0.59
   available P (mg/100g soil) 4.48
   available N (mg/100g soil) 139.32
   Ca ** meq/100g 0.76
   Mg ** meq/100g 0.26
   Na * meq/100g 1.61
   CaCO3 meq/100g 2.34
   HCO3 meq/100g 0.49
   CL- meq/100g 0.42
   SO4- meq/100g 1.37
   PH  8.1
   EC (mhos/Cm/25°C) 2.11

6085
5. Chemical composition of seeds:
   a. Total protein was determined in dry seeds as g/100g dry weight by using
      Micro-kjeldalh method according to Piper (1947).
      All collected data were exposed to the proper statistical analysis and
      least significant difference (LSD 0.05) was used for comparison between
      treatments according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

1. Vegetative growth:
   a. Plant height:
      The results presented in Table 2 show that the plant height was
      influenced by the sulphur application during the two seasons of study. Plant
      height was significantly greater due to sulphur application compared with
      control in both years of study. These findings were in agreement with those
      obtained by Omar et al. (1990) on pea; Rohman and Hoque (1994) and
      Sawan and Rizk (1996) on eggplant. In the meantime foliar spray with
      micronutrients significantly affect plant height in both seasons of study. All
      foliar spray treatments resulted in significant increase in plant height over
      control. However, the most effective treatment was the mixture of Fe + Zn +
      Mn. These results agreed with those obtained by EL-Assiuty (1983) on bean
      and Omar et al. (1990) on pea plants. In addition, the interaction between
      sulphur and micronutrients was significant. Plants subjected to sulphur
      application and spraying with mixture of Fe + Zn + Mn gave significantly the
      highest values of plant height in the two years of study.

   b. Number of branches/plant:
      Regarding the effect of sulphur addition on number of branches of pea
      plants, data presented in Table (2) showed that this treatment increased
      number of branches per plant in the two seasons of study however the
difference was significant in the second season only. Micronutrient treatments
      had significant effect on no. branches during both seasons of study and the
      highest values of no. branches/plant were recorded for plants sprayed by Fe +
      Zn + Mn (2.100 per plant and 2.180 per plant) in the two seasons,
      respectively. The interaction between the addition of sulphur and spraying
      with micronutrients was only significant in the second season of study, i.e.,
      highest value was obtained from addition of sulphur and spraying with
      mixture of Fe + Zn + Mn.

   C. Number of leaves/plant:
      Data in Table (2) show that addition of sulphur significantly increased
      number of pea plant leaves in both years of study. These results are in line
      with those obtained by Sawan and Rizk (1998). Concerning the effect of
      spraying different micronutrients treatments on no. leaves/plant Table (2)
      showed that spraying plants with Fe + Zn + Mn significantly produced highest
      number of leaves per plant as compared with control. These results agreed
      with those obtained by Malash and Ahmed (1990); EI-Fadaly (1992) and Al-
Phanas and Saad (2000). The interaction between sulphur and micronutrient treatments on no leaves/plant was significant in the second season only, however the highest values were obtained by adding sulphur and spraying plants with mixture of Fe + Zn + Mn during the two years of study, followed by S + Zn treatment.


<table>
<thead>
<tr>
<th>Treatments</th>
<th>Plant height cm.</th>
<th>No. of branches/plant</th>
<th>No. leaves/plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micronutrients</td>
<td>Fe 48.5 49.2 1.800 1.900 20.50 23.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zn 51.4 52.3 1.900 1.950 22.40 24.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mn 50.5 50.6 1.800 1.800 21.40 23.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fe + Zn + Mn 54.5 56.6 2.020 2.100 25.90 27.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control 47.8 48.4 1.800 1.800 19.30 22.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fe 50.3 51.6 2.100 2.020 22.00 24.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zn 55.6 56.2 2.180 2.200 25.10 28.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mn 53.4 55.6 2.060 2.000 23.10 23.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fe + Zn + Mn 56.7 58.8 2.200 2.180 28.40 28.90</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control 49.5 50.3 2.020 1.950 22.80 23.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean A</td>
<td>50.54 51.40 1.864 1.910 21.800 24.320</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 S</td>
<td>53.10 54.70 2.112 2.070 24.300 25.740</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50 S</td>
<td>49.40 50.40 1.950 1.960 21.250 24.150</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean B</td>
<td>53.55 54.25 2.040 2.075 23.750 26.550</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>51.95 53.10 1.930 1.900 22.250 23.450</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>55.60 57.70 2.110 2.140 27.150 28.200</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control 48.50 49.35 1.910 1.875 21.050 22.800</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L. S. D. 5%</td>
<td>A 0.13 0.10 N.S 0.038 1.090 0.390</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B 0.18 0.17 0.27 0.032 1.270 0.610</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A x B 0.26 0.28 N.S 0.072 N.S 0.870</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It could be concluded that addition of sulphur to the soil had a promotion effect on growth of pea plants. These findings are in agreement with that obtained by Shaheen et al. (1999a), who reported that sulphur increased the ability of the plant in building metabolities. Additionally, Omar et al. (1990) on pea reported that sulphur has been known as a helpful factor for activating vegetative growth. The addition of sulphur to the soil decreased pH value, increased electrical conductivity and increased the available of phosphorus and Fe, Zn and Mn through oxidation of soil microorganisms which are able to produce sulphuric acid in amounts enough to lower the pH (Youni et al. 1964). Many investigators reported that, adding sulphur to the soil caused an increase in growth parameters of vegetable plants (Shaheen
et al., 1989a and b) on broad bean and sweet pepper; Omar et al., 1990 on pea and Rahman & Hoque, 1994 and Sawan & Zaki, 1998 on eggplants).

Concerning the foliar spray with Fe, Zn and Mn Which led to increasing vigorous vegetative growth. Many studies indicated that foliar application of Fe, Zn and Mn enhanced growth of vegetable plants (Anderson & Cartens, 1974 on peas, Hassan, 1982 and EL-Assiouty, 1983 on beans; Malash & Ahmed 1990; El-Fadaly, 1992 and Alphonse & Saad, 2000 on Cucumber plants.

It is clear that each micronutrient has a role in improving plant growth. Zn directly involved in the synthesis of the indole acetic acid (IAA). Mn is directly involved catalytic rates in plants being the enzyme activator of some respiratory enzymes and in reactions of nitrogen metabolism and photosynthesis (Marschner, 1995).

Average fresh pod weight (gm): The effect of sulphur application and spraying of micronutrients on average pod weight is presented in Table 3. Data showed that in the two seasons added sulphur increased significantly the average fresh pod weight than control.

As regard to the effect of micromutrients, plants sprayed with any used micronutrients or mixture of them gave significantly greater average fresh pod weight as compared with control in the two seasons. In the meantime, a mixture of the aforementioned nutrients surpassed significantly any individual micronutrient applied to the plants in terms of average fresh pod weight in both years of study. The results agreed with those obtained by El-Fadaly (1992) on cucumber and Youssef et al. (2001) on tomato.

Concerning the interaction between sulphur addition and spraying microelements, data indicated that there was a significant effect due to the application of these chemicals on average fresh pod weight in the two seasons of the experiment. Plant received sulphur and sprayed with Fe + Zn + Mn recorded the highest average fresh pod weight followed by S x Zn in the two seasons of study.

Number of pods / plants: Data in Table (3) indicated that addition of sulphur significantly increased number of pods / plant during the two seasons of study. Omar et al. (1990) and Hlal et al. (1992) worked on peas and Sawan and Rizk (1998) on eggplant, reported that addition of sulphur to the soil increased number of pods or fruits per plant over control.

Regarding spraying pea plants with microelements data indicated that all microelements increased number of pods / plant as compared with control in both seasons and the highest values were obtained from plants sprayed with mixture of Fe + Zn + Mn followed by plants sprayed with Zn in the two seasons, respectively. In other words, it seems that Zn application was efficient treatment among the other individual micronutrients used in this experiment. These results are in accordance with those obtained by El-Fadaly (1992) on cucumber and Youssef et al. (2001) on tomato who found
that applying a mixture of Fe, Zn and Mn as chelate (EDTA) increased number of fruits / plant.

The interaction of sulphur x microelements exhibited significant effect on the no. of pods / plant during the two seasons of study. Generally, the most effective treatment in increasing number of pods was addition of sulphur combined with spraying a mixture of Fe + Zn + Mn. On the other hand, the lowest number of pods per plant was recorded for the control i.e., plants received no sulphur and sprayed with water only.

Number of seeds per pod:

Assessment of mean values of the effect of the treatments included in this experiment on number of seeds per pod are shown in Table (3). Data illustrated that addition of sulphur had no significant effect on this parameter in both seasons of study. These results are in line with those obtained by Omar et al. (1990) and Hilal et al. (1992).

Concerning the effect of foliar application of micronutrients, results showed that apart from Mn all treatments gave significant increase in number of seeds per pod in both years of study. Moreover, mixture of Fe + Zn + Mn induced significantly the highest values in this concern compared with any other treatment used in two seasons. This point was studied by EL-Assiouny (1983) who reported that spraying bean plants with Zn and Mn increased number of seeds per pod but insignificant.

Regarding the interaction of sulphur and micronutrients data in Table (3) showed that addition of sulphur + Zn or sulphur + Fe + Zn + Mn gave significant increase in number of seeds per pod. However, the latter treatments surpassed significantly the former one in this concern in the two years.

Number of aborted ovules per pod:

The illustrated data in Table (3) indicated that, the treatment of sulphur applied decreased significantly the aborted ovules per pod than control in both seasons.

Concerning the effect of micronutrients on the aborted ovules per pod, data in Table (3) showed that the desirable treatment was reflected by spraying mixture of Fe + Zn + Mn in both seasons, which had the lowest values of aborted ovules per pod. Meanwhile, the undesirable treatment was that spraying water only in the first as well as the second seasons.

The interaction between sulphur and micronutrients application was significant. Plants received sulphur and sprayed with mixture of Fe + Zn + Mn produced the lowest values of aborted ovules per pod, followed by S x Zn treatment in both seasons of the experiment. It is obvious that sulphur addition and foliar application of micronutrient had reflected positive decrease in aborted ovules of pods.

This may be due to their positive effect on vegetative growth and chemical constituents which resulted from improving chemical and physical properties of the soil by sulphur application beside receiving sufficient microelements.
Table 3: Effect of application of sulphur and micronutrients on peas

<table>
<thead>
<tr>
<th>Treatments</th>
<th>No. pods / plant</th>
<th>Average fresh pod weight (gm)</th>
<th>No. seed / pod</th>
<th>No. aborted ovules / pod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphur</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>8.752</td>
<td>8.880</td>
<td>18.52</td>
<td>17.18</td>
</tr>
<tr>
<td>Fe</td>
<td>9.050</td>
<td>9.018</td>
<td>22.71</td>
<td>23.11</td>
</tr>
<tr>
<td>Zn</td>
<td>9.110</td>
<td>9.120</td>
<td>24.33</td>
<td>24.92</td>
</tr>
<tr>
<td>50 Mn</td>
<td>9.000</td>
<td>9.050</td>
<td>23.28</td>
<td>23.64</td>
</tr>
<tr>
<td>Fe + Zn + Mn</td>
<td>9.320</td>
<td>8.296</td>
<td>26.88</td>
<td>27.57</td>
</tr>
<tr>
<td>Control</td>
<td>8.950</td>
<td>8.917</td>
<td>19.23</td>
<td>19.79</td>
</tr>
</tbody>
</table>

Mean A
Mean B
Fe | 8.975 | 8.976 | 20.835 | 21.120 | 8.342 | 8.440 | 1.572 | 1.597 |
Control | 8.851 | 8.899 | 17.475 | 18.485 | 8.281 | 8.394 | 1.770 | 1.797 |
L. S. D. 5% A | 0.018 | 0.021 | 0.037 | 0.026 | N.S. | N.S. | 0.028 | 0.033 |
B | 0.024 | 0.028 | 0.041 | 0.036 | 0.077 | 0.072 | 0.042 | 0.048 |
A x B | 0.041 | 0.047 | 0.068 | 0.053 | 0.098 | 0.082 | 0.058 | 0.068 |

Fresh pods yield (ton/ha): 
Data in Table 4 show that fresh pod yield of pea plants as tons/ha were significantly increased by sulphur addition to the soil as compared with control. Many workers studied the effect of sulphur on the yield of vegetable plants and reported that sulphur caused an increase in fruits yield of sweet pepper (Shaheen et al., 1989 b); peas (Omar et al., 1990 and Hifaf et al., 1992) and eggplant (Lopez et al., 1992; Rahman & Hoque, 1994 and Sawan & Rizk, 1998). 
Data also indicated that micronutrients significantly influenced pods fresh yield (Table 4). Plants sprayed with an used micronutrient produced insignificantly higher yield than control. Besides spraying mixture of micronutrients Fe + Zn + Mn onto pea plants resulted significantly greater yield than control or any other individual micronutrient used in both years of study. These results agreed with those obtained by El-Fadaly (1992) on cucumber and Youssef et al. (2001) on tomato who found that applying a mixture of Fe, Zn and Mn as Chelate (EDTA) increased number and weight of fruits and produced the highest early and total yields/ha. Similar results were obtained by Andreason and Cartens (1974) on peas; Hassan (1982) on peas.
100 - fresh seed weight (g):  

Data presented in Table 4 show that the effect of sulphur addition on average 100- fresh seed weight (g). Data revealed that there was no significant effect due to sulphur addition on this character in both seasons.  

Concerning application of micronutrients, data in the same table indicated that any used micronutrient increased significantly 100- fresh seed weight over control in the two years of the experimental study. Moreover, mixture of Fe + Zn + Mn had significant increase in these concern over any applied individual micronutrient in both years.  

Regarding the interaction between sulphur and micro-nutrients, data presented in Table 4 indicated that there was significant effect on 100-fresh seed weight. Plants received S and sprayed with a mixture of Fe, Zn and Mn gave significantly the highest values in both seasons of study. As known, sulphur which is considered one of the soil amendments. Such favourable effect was obtained with Garcia and Carlone (1977) who found that S promoted the solubilization of apatite - P already present, or add to the soil. Moreover, Hausenflieger (1972) reported many interaction affecting the micronutrients availability by sulphur application, such as Fe, Zn, Mn and Cu. In addition to the favourable effect by foliar application with Fe + Zn + Mn which plays important roles in the physiological processes and important for enzyme system and having a vital role in the metabolism and for carbohydrate manufacture.

Seed index (1000 - dry seed weight):  

Data presented in Table 4 showed that sulphur addition increased significant seed index in both seasons of study as compared with control.  

Concerning the effect of micronutrients on seed index, data in Table (4) showed that the differences between micronutrients treatments and control were significant in the two seasons of study. The highest values were recorded for plants sprayed with a mixture of Fe + Zn + Mn followed by plants sprayed by Zn. These results are in line with those obtained by Hassan (1982) on peas and beans and EL-Assiouty (1983) on beans.  

The interaction between sulphur addition and micronutrients treatments was significant. Plants received S and sprayed with a mixture of Fe, Zn and Mn gave the highest values followed by plants received S x Zn, while control treatment resulted in the lowest values during the two seasons of experiment.
Table (4) Effect of sulphur and micronutrients application on fresh pod yield (ton/fed.); 100-fresh seed weight (g) seed index; Dry seed yield (ton/fed.) in 1998/1999 and 1999/2000 seasons.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Fresh pod weight (ton/fed.)</th>
<th>100-fresh seed weight (gm)</th>
<th>Seed index</th>
<th>Dry seed yield (ton/fed.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micronutrients</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fe</td>
<td>2.524</td>
<td>2.790</td>
<td>48.125</td>
<td>48.611</td>
</tr>
<tr>
<td>Zn</td>
<td>2.811</td>
<td>2.910</td>
<td>49.020</td>
<td>49.346</td>
</tr>
<tr>
<td>Mn</td>
<td>2.757</td>
<td>2.840</td>
<td>48.300</td>
<td>48.877</td>
</tr>
<tr>
<td>Fe + Zn + Mn</td>
<td>2.984</td>
<td>3.169</td>
<td>49.445</td>
<td>49.633</td>
</tr>
<tr>
<td>Control</td>
<td>2.311</td>
<td>2.514</td>
<td>47.667</td>
<td>47.835</td>
</tr>
<tr>
<td>Fe</td>
<td>2.938</td>
<td>2.980</td>
<td>48.216</td>
<td>48.936</td>
</tr>
<tr>
<td>Zn</td>
<td>3.033</td>
<td>3.115</td>
<td>49.188</td>
<td>49.815</td>
</tr>
<tr>
<td>Mn</td>
<td>2.965</td>
<td>3.050</td>
<td>48.550</td>
<td>48.880</td>
</tr>
<tr>
<td>Fe + Zn + Mn</td>
<td>3.258</td>
<td>3.325</td>
<td>50.778</td>
<td>51.111</td>
</tr>
<tr>
<td>Control</td>
<td>2.852</td>
<td>2.884</td>
<td>48.011</td>
<td>48.536</td>
</tr>
<tr>
<td>Mean A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>2.677</td>
<td>2.845</td>
<td>48.511</td>
<td>48.860</td>
</tr>
<tr>
<td>5</td>
<td>3.009</td>
<td>3.071</td>
<td>48.949</td>
<td>49.456</td>
</tr>
<tr>
<td>Mean B</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fe</td>
<td>2.731</td>
<td>2.885</td>
<td>48.71</td>
<td>48.774</td>
</tr>
<tr>
<td>Zn</td>
<td>2.922</td>
<td>3.013</td>
<td>49.104</td>
<td>49.581</td>
</tr>
<tr>
<td>Mn</td>
<td>2.861</td>
<td>2.945</td>
<td>48.425</td>
<td>48.879</td>
</tr>
<tr>
<td>Fe + Zn + Mn</td>
<td>3.121</td>
<td>3.247</td>
<td>50.112</td>
<td>50.372</td>
</tr>
<tr>
<td>Control</td>
<td>2.582</td>
<td>2.699</td>
<td>47.839</td>
<td>48.186</td>
</tr>
<tr>
<td>L. S. D. 5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>0.133</td>
<td>0.181</td>
<td>N.S.</td>
<td>N.S.</td>
</tr>
<tr>
<td>B</td>
<td>0.147</td>
<td>0.171</td>
<td>0.148</td>
<td>0.153</td>
</tr>
<tr>
<td>A x B</td>
<td>0.163</td>
<td>0.167</td>
<td>0.166</td>
<td>0.175</td>
</tr>
</tbody>
</table>

Dry seed yield (ton/fed.):

Data in Table (4) showed that the studied sulphur treatments significantly increased seed yield as compared with control in the first and second years of the present work. This result agreed with those obtained by Omar et al. (1990) and Hilaal et al. (1992) on peas.

Regarding the effect of micronutrients on the seed yield of pea plants, it is evident from data in Table 4 that plants sprayed with any of the used micronutrients gave significantly higher dry seed yield than control. In the mean time spraying pea plants with a mixture of Fe, Zn and Mn produced significantly greater dry seed yield over either control or any of the individual micronutrient treatment. This was true in the first and second year of the experiment. These results are in agreement with those obtained by Hassan (1982) on peas and El-Assiouly (1983) on beans. These results could be due to the increase of seed index and/or number of pods.
Concerning the interaction between S addition and microelements, data presented in Table 4 indicated that there was a significant effect on seed yield of pea plants. Plants received S and sprayed with a mixture of Fe, Zn and Mn gave the significantly seed yield as compared with control or any other micronutrient used. Further more any micronutrient included in this experiment had significantly greater dry seed yield than control.

Mineral contents of pea leaves:

The results indicated that sulphur addition significantly increased microelements (Fe, Zn and Mn) contents in pea leaves at the end of experiment in both seasons (Table 5). The results may be attributed to the positive effect of the sulphur on the availability of micronutrients for plants uptake.

Regarding the effect of micronutrients foliar application on Fe, Zn and Mn content in pea leaves results in Table (5) showed that spraying Fe or Fe + Zn + Mn as a mixture markedly increased Fe content in pea leaves, in addition to Zn and Mn contents in both seasons. Application of Zn as foliar spray onto plants had a different effect as it gave a significant increase only in Zn content over control in both years of study. Concerning Mn addition, data also indicated that spraying Mn resulted in significant increase in Zn and Mn contents in pea leaves in the two seasons.

The interaction between sulphur addition and foliar application of micronutrients was significant in both seasons except Fe and Mn contents in pea leaves in the first season. The most effective treatment on Zn content was adding sulphur and spraying with the mixture of Fe + Zn + Mn in the two seasons of study.

For the aforementioned results under the condition of this study, it could be concluded that Kaha clay loam soil tended to alkaline condition. Therefore, sulphur addition and foliar application of micronutrients of Fe, Zn and Mn in chelated form was markedly increased their concentrations in the leaves of peas plants. El-Fouly (1983) reported that foliar application of microelements is highly recommended under Egyptian conditions. In view of the fact the soil pH exceeds 7.5 and sometimes even 8.0 some areas show high Ca CO3 contents which among other factors, make soil application of micronutrients more costly and unpractical. Also, these increases in pea yield and in the contents of micronutrients in pea leaves due to the foliar application of micronutrients agree with the finding of Soliman (1996) and Alphonse and Saad (2000) on cucumber plants. Moreover, it seems from data that application of an element usually gave the highest content of this particular element in the leaves than the other elements. These results agree with those obtained by Malash & Ahmed (1990) and El-Fadaly (1992) who concluded that applying Fe, Zn and Mn tended to increase the contents of these elements in cucumber leaves.
Table (5) Effect of sulphur and micronutrients application on Fe, Zn and Mn contents in leaves and protein content (%) in dry seeds of pea plants 1998/1999 and 1999/2000 seasons.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>1998-1999</th>
<th>1999-2000</th>
<th>Protein content %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>228</td>
<td>138</td>
<td>218</td>
</tr>
<tr>
<td>Zn</td>
<td>220</td>
<td>135</td>
<td>206</td>
</tr>
<tr>
<td>5</td>
<td>218</td>
<td>135</td>
<td>206</td>
</tr>
<tr>
<td>Fe + Zn + Mn</td>
<td>234</td>
<td>135</td>
<td>226</td>
</tr>
<tr>
<td>Control</td>
<td>210</td>
<td>132</td>
<td>202</td>
</tr>
<tr>
<td>Fe</td>
<td>234</td>
<td>135</td>
<td>226</td>
</tr>
<tr>
<td>Zn</td>
<td>228</td>
<td>135</td>
<td>206</td>
</tr>
<tr>
<td>50</td>
<td>222</td>
<td>145</td>
<td>214</td>
</tr>
<tr>
<td>Mn</td>
<td>222</td>
<td>145</td>
<td>214</td>
</tr>
<tr>
<td>Fe + Zn + Mn</td>
<td>246</td>
<td>150</td>
<td>230</td>
</tr>
<tr>
<td>Control</td>
<td>218</td>
<td>150</td>
<td>208</td>
</tr>
<tr>
<td>Mean A</td>
<td>222</td>
<td>145</td>
<td>214</td>
</tr>
<tr>
<td>0</td>
<td>222</td>
<td>145</td>
<td>214</td>
</tr>
<tr>
<td>5</td>
<td>230</td>
<td>145</td>
<td>214</td>
</tr>
<tr>
<td>Mean B</td>
<td>222</td>
<td>145</td>
<td>214</td>
</tr>
<tr>
<td>0</td>
<td>222</td>
<td>145</td>
<td>214</td>
</tr>
<tr>
<td>5</td>
<td>230</td>
<td>145</td>
<td>214</td>
</tr>
</tbody>
</table>

Protein content in dry seed (%):

Data in Table (5) show the effect of sulphur addition, foliar application of Fe, Zn and Mn and the interaction between sulphur and micronutrients on dry seed protein content. Results revealed that protein content of dry seeds produced by pea plants grown in soil received sulphur was significantly greater than control. Additionally, application of Zn alone or mixture of micronutrients Fe + Zn + Mn resulted in significantly higher protein content in the dry seeds as compared with control or the other micronutrients used in this experiment. It seems that the most efficient element in this concern is Zn. Similar results were obtained from the interaction between sulphur and Zn alone or a mixture of Fe + Zn + Mn. These results agreed with those obtained by Hassan (1982) on pea and bean plants and Zeine et al. (1984) on bean plants.
REFERENCES

Abd-AL, E.Z.; M.A. EL-Shal; A.M. Khalf-Allah and M.R.A. Gabal (1973). Yield and quality of tomatoes as affected by methods and levels of sulfur application. The fourth vegetable Research conference 2-4 September, Alexandria, Egypt.


EL-Fouly M.M. (1983). Micronutrients acid and Semiarid areas: Levels in soil and plants and plant for fertilizers, with particular reference to Egypt proc. 17th Colloquium international potash inst., Rabat and Marrakesh / Morocco, II.


6095
Youssef, A. M. and A. S. S. Amer


6096


استجابة نمو ومحصول نباتات البسملة للإضافة الأرضية للكبريت الزراعي والرش
بعض العناصر الصغرى

عبد السلام محمد يوسف - عمرو سلامة عامر
أقسام بحوث الحضر - معهد بحوث البساتين - مركز بحوث الزراعية - القاهرة - مصر

تمت الدراسة في تجريبيتين حقلتين خلال موسمي الزراعي 1998/1999 و 2000/1999 على نباتات البسملة صنف ماستر ب القدوم لدراسة تأثير إضافة الكبريت الزراعي معجل صغير و 2 كجم/طن إلى النباتات قبل الزراعة والرش بالعناصر الصغرى المخلوطة (حديد 100 جزء في المليون وكروم 50 جزء في المليون ومغنيزيوم 50 جزء في المليون) وكذلك بمخلوط من نكاس العناصر بنفس التركيزات السابقة.۴ رشاتات فاصلة ۱۰ أيام بين كل رشة وأخرى وذلك على نمو محصول البسملة وكانت أهم النتائج المتغذية عليها هي:

- أدت إضافة الكبريت إلى زيادة طول النباتات وعدد الأوراق وعدد الأوراق وزيادة محصول الأوراق من الحديد والكروم والكربون. زاد وزن القرن الطازج وقل عدد الدور الغر مكتنطة النمو بالقرن وكذلك عند القرن/نبات والمحصول الكلي للفرون وكذلك مثبت الفصل في البذرة (۱۰00 بذرة/جناة) ومحصول البذرة الجافة والكربون بالبطور الفاصل.]
- نتائج زاد زنكم-مغنيزيوم، أوزن القرن، أوزن الزنكم وزيادة محصول الطازج للقرن وكذلك الصافات التي درست عليه بالإضافة إلى وزن ۱۰00 بذرة/جناة ومحصول البذرة الجافة وكذلك محصول البذرة من الفراولة. أدت التفاعلات بين إضافة الكبريت للقرن والرش بمخلوط العناصر السابقة إلى زيادة محصول النبات الطازج والمحصول الطازج للقرن. الصافات هذا المحصول. كنسبة زاد وزن ۱۰00 بذرة جافة ومحصول البذرة الجافة والكربون ينخفض البذرة.

من النتائج المتغذية منها أن ظوسي إضافة الكبريت الزراعي للأرضيات الطينية مع الرس بالعناصر الصغرى على نباتات البسملة لزيادة المحصول وصافات الجودة به.