Impact of Nitrogen and Organic Fertilization on Nutrients Uptake by Lettuce Plants
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ABSTRACT
During the winter season of 2013/2014, a pot trial was done at the nursery of Experimental Station Farm in Faculty of Agriculture, University of Mansoura to investigate the impact of soil types, organic fertilizers, N-levels and their interaction on growth and nutrients concentration and uptake by lettuce (Lactuca sativa L.). The trial was done in factorial trial in complete randomized block design with 3 replications. Where, the first factor integrated with the two types of soil (clay and sandy soils). The second factor incorporated with two organic fertilizers (farmyard manure “20 m³/fed” and compost “15 m³/fed”). The third factor integrated with three levels of nitrogen fertilizer (without nitrogen fertilization, 50 and 100 % of the recommended dose). The obtained results could be summarized as the following: The greatest means of height of plant, plant fresh and dry weights, N, P and K percentages and its uptake by lettuce leaves were recorded when planting seedlings of lettuce in clay soil. Lettuce plants that organic fertilizing by compost (15 m³/fed) produced the maximum values of plant height, plant fresh and dry weights, N, P and K percentages and its uptake by lettuce leaves. Increasing N-level to 60 kg N/fed (100 % of the recommended dose) gave the uppermost values of height of plant, plant fresh and dry weights, N, P and K percentages and its uptake by lettuce leaves. It can be concluded that planting lettuce seedlings in clay soil and organic fertilizing plants with compost (15 m³/fed) and 60 kg N/fed to maximizing its growth and nutrients concentration and also uptake under conditions of this study.
Keywords: Lettuce, soil types, Farmyard manure, FYM, Compost, Organic fertilizers, Nitrogen levels, Growth, Nutrients uptake.

INTRODUCTION
Lettuce (Lactuca sativa L.) is the most common vegetable salad in Egypt and the world. Lettuce is a rich supply of antioxidants in addition vitamins A and C besides phytochemicals that are anti-cancer. Lettuce provides also a number of dietary fiber, carbohydrates, protein and fat in small amounts. Lettuce has become an chief commercial crop for the household market.

The lettuce is fairly tolerant of soil type, and will do well on soils varying from light sand to heavy clay, provided the nutritional and water status is good. Best growth of lettuce obtained from fertile loams, well supplied with organic matter. Soils which crust badly are less suitable, particularly when lettuce is direct-seeded. The most favourable pH appears to be between 5.0 and 6.5. The deep and well-drained soils are suitable for lettuce, which is shallow root system. Thus, lettuce can be grown quite successfully on relatively shallow soils, provided a favourable soil moisture regime can be maintained. Schreiter et al. (2014) stated that soil types affected the rhizosphere microbiome and growth characters of lettuce. Sladonja et al. (2014) showed that the different soil types significantly affected germination percentage of pyrethrum. The highest germination percentage was found on white clay loam, and the lowest on red clay. Seed germination was greatly influenced by soil texture, foremost silt percentage and soil pH. Ohshiro et al. (2016) showed that growth traits and yield of all amaranth lines were superior in gray soil than in dark red soil and red soil.

Farmyard manure (FYM) is the most useful organic manure as organic matter, is provided from various animal wastes. Since FYM is not found in sufficient amounts in farms and it is an expensive material, other organic materials can be used instead of manure to improve soil properties. Caliskan et al. (2014) showed that lettuce growth, yield and vitamin C content were higher in the organic production system compare to conventional production system. Charoempakdee (2014) found that lettuce fresh weight was highest (125 g/plant) with chemical fertilizer closely followed by cattle manure (119 g/plant). Cattle manure can use in place of chemical fertilizer for lettuce production (Melese, 2016).

Composting is a biological process in which organic biodegradable wastes are converted into hygienic, hiums rich product (compost) for use as a soil conditioner and an organic fertilizer (Popkin, 1995). Generally, compost improved soil physicochemical properties such as formation and stability of soil aggregates and nutrient availability, resistance against compaction and reduces soil bulk density (Clik et al., 2004). Mrabet et al. (2012) showed that the improving in lettuce yields was proportionally related to the dose of used compost. Farag et al. (2013) indicated that application compost at the highest level (4% by volume) gave the highest vegetative growth and yield of lettuce as comparing with the other treatments (0 and 2.4% by volume). Moreira et al. (2014) recommend the use of organic compost as a source of organic matter, as it showed the best result of plant diameter, plant height, fresh and dry root and shoot weights of lettuce. Piesis and Weerakkody (2015) revealed that Glliricidia leaf extract was the most favourable organic liquid fertilizer for best growth performance of lettuce leaf. While, compost was the lowest. Poultry manure was an intermediate performer for vegetative growth of lettuce leaf.

Nitrogen (N) is an essential element required for successful plant growth. It is the main primary nutrients are the potential for missing plants in these nutrients and because of the large amounts taken from the soil by the plants relative to other essential nutrients. In many agricultural conditions, nitrogen is a nutrient limit for high plant growth and yield (Marschner, 1995). Cercioglu et al. (2012) found that increasing rates of nitrogen fertilizer provided a rise in the yield of lettuce. Farag et al. (2013) indicated that the increasing nitrogen level up to 150 ppm significantly increased plant height, number of leaves per plant, fresh and dry weights and yield of lettuce. Tsiakaras et al. (2014) found that high
The nitrogen rates (300 and 450 mg/L) resulted in higher fresh weight (by 11.2%) and lower dry weight (by 7.5%), respectively. They concluded that nitrogen application could be beneficial for total yield and the total number of leaves of lettuce.

Therefore, this study was conducted to explicate the effect of soil types, organic fertilizers, N-levels and their interaction on growth and nutrients concentration and uptake by lettuce under conditions of Dakahlia Governorate, Egypt.

**MATERIALS AND METHODS**

During the winter season of 2013/2014, a pot trial was done at the nursery of investigational Station Farm in Faculty of Agriculture, University of Mansoura to investigate the impact of soil types, organic fertilizers, N-levels and their interaction on growth and nutrients concentration and uptake by lettuce (*Lactuca sativa* L.).

The trial was done in factorial trial in complete randomized block design with 3 replicates. Hence, the 1st factor incorporated with the two types of soil (clay and sandy soils). Where, the physical and chemical properties of these soil types are shown in Table 1. The second factor incorporated with two organic fertilizers as follows: 1) Farmyard manure (FYM) (20 m³/fed) (1.05 kg FYM/pot). 2) Compost (15 m³/fed) (0.722 kg compost/pot). Farmyard manure (FYM) and compost were mixed at the formerly mentioned rates with each soil type before filling pots. The chemical analysis of FYM and compost is accessible in Table 2.

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**Table 1. Some physical and chemical properties of each soil type used in this study before lettuce sowing during 2014/2015 season.**

<table>
<thead>
<tr>
<th>Soil characteristics</th>
<th>Clay soil</th>
<th>Sandy soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse sand (%)</td>
<td>2.7</td>
<td>28.0</td>
</tr>
<tr>
<td>Fine sand (%)</td>
<td>18.6</td>
<td>58.0</td>
</tr>
<tr>
<td>Silt (%)</td>
<td>35.5</td>
<td>10.0</td>
</tr>
<tr>
<td>Clay (%)</td>
<td>42.8</td>
<td>4.0</td>
</tr>
<tr>
<td>Soil texture</td>
<td>Clay</td>
<td>Sand</td>
</tr>
<tr>
<td>Field capacity (%)</td>
<td>34.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Saturation (%)</td>
<td>75.0</td>
<td>15.0</td>
</tr>
<tr>
<td>Calcium carbonate (%)</td>
<td>3.00</td>
<td>3.5</td>
</tr>
<tr>
<td>O.M. (%)</td>
<td>1.10</td>
<td>0.2</td>
</tr>
<tr>
<td>pH (1:2.5)</td>
<td>8.30</td>
<td>7.8</td>
</tr>
<tr>
<td>EC (dSm⁻¹) soil paste</td>
<td>1.40</td>
<td>1.8</td>
</tr>
<tr>
<td>Mg²⁺</td>
<td>3.80</td>
<td>5.30</td>
</tr>
<tr>
<td>Na⁺</td>
<td>0.80</td>
<td>2.40</td>
</tr>
<tr>
<td>(meq/L)</td>
<td>4.10</td>
<td>2.10</td>
</tr>
<tr>
<td>K⁺</td>
<td>1.10</td>
<td>0.10</td>
</tr>
<tr>
<td>Soluble cations (meq/L)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CO₃²⁻</td>
<td>0.63</td>
<td>4.4</td>
</tr>
<tr>
<td>HCO₃⁻</td>
<td>4.22</td>
<td>2.5</td>
</tr>
<tr>
<td>(meq/L)</td>
<td>5.1</td>
<td>2.6</td>
</tr>
<tr>
<td>Available nutrients (mg kg⁻¹ soil)</td>
<td>7.92</td>
<td>2.0</td>
</tr>
<tr>
<td>N (ppm)</td>
<td>48.6</td>
<td>15.0</td>
</tr>
</tbody>
</table>

The third factor integrated with three levels of nitrogen fertilizer as follows:

1-N, Control treatment (without nitrogen fertilization).
2-N, 50 % of the recommended dose (30 kg/fed, 0.03 g N/pot).
3-N, 100 % of the recommended dose (60 kg/fed, 0.60 g N/pot).

The nitrogen fertilizer (ammonium sulphate "20.5% N") was added to each soil types of pots at the aforementioned levels in 2 equal doses; after 15-days from transplanting and 15-days after the first dose.

The plastic pots dimension was 25-cm in diameter and 35-cm in height with total number of 36 pots. Each pot was overflowing with 10 kg air-dried soil of each soil types (clay and sandy soils).

Uniform lettuce seedlings Balady cultivar with 3 to 4 green true leaves (nearly 20 days old) were obtained from Horticulture Research Station in Mansoura, Agricultural Researches Center, ARC, and transplanted into the pots on 10th November 2013.

**Sampling Times:**

1- Growth characters:

After 70 days from transplanting *i.e.* on 21st January, 2014 (harvest stage), three plants were randomly taken to measure:

- Plant height (cm).
- Plant fresh weight (g).
- Plant dry weight (g).

2- Chemical analyses:

After 70 days from transplanting (harvest stage), plant samples were air-dried, then oven dried at 70°C till constant weight, then thoroughly ground and stored to estimate N, P and K percentages in lettuce plant leaves, and then its uptakes were calculated (mg/plant).

The oven-dried material of lettuce plant was wet digested (Peterburgski, 1968) and N, P and K contents in the lettuce plant were analyzed (Page *et al.*., 1982):

- Total nitrogen (%) was determined (Pregle, 1945), using micro-Kjeldahl.
- Total phosphorus (%) was determined (Jackson, 1967).
- Total potassium (%) was determined (Black, 1965).

All obtained data were analyzed according to the factorial experiment which done in design of complete randomized blocks (Gomez and Gomez, 1984). LSD method was used to compare the differences among means (Snedecor and Cochran, 1980).

**RESULTS AND DISCUSSION**

1- Effect of soil types:

The impact of soil types (clay and sandy soils) on growth characters (plant height, fresh and dry weights of plant) and nitrogen, phosphorus and potassium percentages and its uptake by lettuce leaves after 70 days from transplanting was significant in the growing season (Tables 2 and 3). Significant differences were recorded in all studied characters between both soil types in the growing season. Since, the highest values of plant height, fresh and dry weights of plant, nitrogen, phosphorus and potassium percentages and its uptake by lettuce leaves after 70 days from transplanting were recorded when planting seedlings of lettuce in clay soil. On the other direction, the lowest values of these characters were produced from planting seedlings of lettuce in the sandy soil. The increases in lettuce growth...
and nutrients concentration and uptake due to planting lettuce in clay soil may be ascribed to clay soils holds maximum moisture per unit volume and provides moisture for plant growth (Jacson, 1987). These findings came in the comparable with those stated by Schreiter et al. (2014), Sladonja et al. (2014) and Ohshiro et al. (2016).

Table 2. Plant height, fresh and dry weights of lettuce plant at harvest as affected by soil types, organic fertilizers and N-levels in 2013/2014 season.

<table>
<thead>
<tr>
<th>Character</th>
<th>Plant height (cm)</th>
<th>Plant fresh weight (g)</th>
<th>Plant dry weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A- Soil types:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clay soil</td>
<td>29.28</td>
<td>316.1</td>
<td>15.12</td>
</tr>
<tr>
<td>Sandy soil</td>
<td>26.27</td>
<td>296.5</td>
<td>14.68</td>
</tr>
<tr>
<td>F. test</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>B- Organic fertilizers:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farmyard manure (FYM)</td>
<td>26.83</td>
<td>301.4</td>
<td>14.65</td>
</tr>
<tr>
<td>Compost</td>
<td>28.72</td>
<td>311.1</td>
<td>15.16</td>
</tr>
<tr>
<td>F. test</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>C- Nitrogen fertilizer levels:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without nitrogen fertilization</td>
<td>21.08</td>
<td>257.6</td>
<td>12.45</td>
</tr>
<tr>
<td>50 % of the recommended dose</td>
<td>28.67</td>
<td>322.2</td>
<td>15.79</td>
</tr>
<tr>
<td>100 % of the recommended dose</td>
<td>33.58</td>
<td>339.1</td>
<td>16.47</td>
</tr>
<tr>
<td>F. test</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>LSD at 5 %</td>
<td>0.96</td>
<td>3.06</td>
<td>0.54</td>
</tr>
<tr>
<td>D- Interactions:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A × B</td>
<td>NS</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>A × C</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>B × C</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>A × B × C</td>
<td>*</td>
<td>*</td>
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</tbody>
</table>

2- Effect of organic fertilizers:

Concerning to the effect of organic fertilization treatments which were farmyard manure (FYM) (20 m³/fed) & compost (15 m³/fed), the obtained results without a doubt show that organic fertilization treatments show considerable effect on growth traits (height of plant, plant fresh and dry weights) and nitrogen, phosphorus and potassium percentages and its uptake by lettuce leaves after 70 days from transplanting in the growing season (Tables 2 and 3). It is commendable to point out that organic fertilizing lettuce plants with compost (15 m³/fed) produced the maximum values of height of plant, plant fresh and dry weights, nitrogen, phosphorus and potassium percentages and its uptake by lettuce leaves after 70 days from transplanting in the growing season. The increases in lettuce growth and nutrients concentration and uptake due to application organic fertilizers (FYM or compost) may be attributed to these organic fertilizers is extremely foremost for plant growth and yield, since it provide steady supply of both macro- and micronutrients, and improves soil physical, chemical and biological properties (Belay et al., 2001). These results are in harmony with those found by Mrabet et al. (2012), Farag et al. (2013), Caliskan et al. (2014), Moreira et al. (2014) and Melese (2016).

3- Effect of nitrogen fertilizer levels:

N-levels i.e. control treatment (without nitrogen fertilization), 50 % of the recommended dose (30 kg N/fed) and 100 % of the recommended dose (30 kg N/fed) significantly affected growth traits and N, P and K percentages and its uptake by lettuce leaves after 70 days from transplanting (Tables 2 and 3). In that manner, each increase in nitrogen levels from 0 to 50 and 100 % of the recommended dose resulted in significant increases in growth characters and chemical nutrients and its uptake, and also the differences between them were significant. Using 60 kg N/fed gave the highest values of plant height, fresh and dry weights of plant, nitrogen, phosphorus and potassium percentages and its uptake by lettuce leaves after 70 days from transplanting in the growing season. Fertilizing lettuce plants with 30 kg N/fed ranked secondly after fertilizing with 60 kg N/fed in the growing season. These increases in lettuce growth and nutrients concentration and uptake by using 60 kg N/fed can be recognized to the role of nitrogen in photosynthetic activity, dry matter gathering and chemical composition of lettuce leaves. These findings are in conformity with those determined by Cercioglu et al. (2012), Farag et al. (2013) and Tsiakaras et al. (2014).

4- Effect of interactions:

Significant interactions among soil types × organic fertilizers × N-levels were found on lettuce growth and nutrients concentration and uptake (Tables 2 and 3). The authors reported only the significant interaction concerning nutrients uptake only.
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Table 3. Total nitrogen, phosphorus and potassium percentages and its uptake by lettuce plant at harvest as affected by soil types, organic fertilizers and N-levels in 2013/2014 season.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Character</th>
<th>N (%) in plant</th>
<th>N-uptake (mg plant⁻¹)</th>
<th>P (%) in plant</th>
<th>P-uptake (mg plant⁻¹)</th>
<th>K (%) in plant</th>
<th>K-uptake (mg plant⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A- Soil types:</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Clay soil</td>
<td>1.359</td>
<td>211.7</td>
<td>0.020</td>
<td>3.161</td>
<td>0.663</td>
<td>101.3</td>
<td></td>
</tr>
<tr>
<td>Sandy soil</td>
<td>0.956</td>
<td>144.6</td>
<td>0.011</td>
<td>1.643</td>
<td>0.603</td>
<td>89.7</td>
<td></td>
</tr>
<tr>
<td>F. test</td>
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<td>*</td>
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<td></td>
</tr>
<tr>
<td>B- Organic fertilizers:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farmyard manure (FYM)</td>
<td>1.111</td>
<td>173.2</td>
<td>0.014</td>
<td>2.262</td>
<td>0.622</td>
<td>93.3</td>
<td></td>
</tr>
<tr>
<td>Compost</td>
<td>1.205</td>
<td>183.1</td>
<td>0.017</td>
<td>2.542</td>
<td>0.645</td>
<td>97.8</td>
<td></td>
</tr>
<tr>
<td>F. test</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>C- Nitrogen fertilizer levels:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without nitrogen fertilization</td>
<td>0.741</td>
<td>92.3</td>
<td>0.007</td>
<td>0.889</td>
<td>0.548</td>
<td>68.2</td>
<td></td>
</tr>
<tr>
<td>50 % of the recommended dose</td>
<td>1.253</td>
<td>198.7</td>
<td>0.014</td>
<td>2.134</td>
<td>0.612</td>
<td>96.7</td>
<td></td>
</tr>
<tr>
<td>100 % of the recommended dose</td>
<td>1.479</td>
<td>243.5</td>
<td>0.026</td>
<td>4.183</td>
<td>0.739</td>
<td>121.7</td>
<td></td>
</tr>
<tr>
<td>F. test</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>LSD at 5 %</td>
<td>0.048</td>
<td>8.06</td>
<td>0.001</td>
<td>0.128</td>
<td>0.004</td>
<td>4.1</td>
<td></td>
</tr>
</tbody>
</table>

D- Interactions:

A × B                      | *         | *              | *                      | *              | *                      | NS             |
A × C                      | *         | *              | *                      | *              | *                      | NS             |
B × C                      | *         | *              | NS                     | NS             | *                      | NS             |
A × B × C                  | NS        | NS             | *                      | *              | *                      | NS             |

Nitrogen and phosphorus uptake by lettuce leaves after 70 days from transplanting was significantly affected by the interaction between soil types and organic fertilizer as presented in Table 3. The highest nitrogen and phosphorus uptake by lettuce leaves was resulted from planting lettuce seedlings in clay soil along with organic fertilizing by compost (15 m³/fed) as graphically illustrated in Figs. 1 and 2, respectively. Planting lettuce in clay soil and organic fertilizing with farmyard manure (20 m³/fed) was the second best interaction treatment after previously mentioned interaction treatment.
The interaction between soil types and N-levels significantly affected nitrogen and phosphorus uptake by lettuce leaves after 70 days from transplanting as presented in Table 3. The highest nitrogen and phosphorus uptake by lettuce leaves after 70 days from transplanting was resulted from planting lettuce seedlings in clay soil and fertilizing with 60 kg N/fed as graphically illustrated in Figs. 3 and 4, respectively. Nitrogen uptake by lettuce leaves after 70 days from transplanting was significantly affected by the interaction between organic fertilizers and N-levels (Table 3). It can be noticed that, the highest nitrogen uptake by lettuce leaves was resulted from organic fertilizing lettuce plants with compost (15 m^3/fed) besides 60 kg N/fed as graphically illustrated in Fig. 5. Organic fertilizing lettuce plants with FYM (20 m^3/fed) in addition 60 kg N/fed ranked secondly after formerly mentioned interaction treatment.

**CONCLUSION**

It can be concluded that planting lettuce seedlings in clay soil and organic fertilizing plants with compost (15 m^3/fed) and 60 kg N/fed in order to maximizing its growth and nutrients concentration.

**REFERENCES**


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تأثر التسليم النيتروجيني والعضوي على امتياز العناصر بواسطة نبات الخس

أحمد عبد القادر طه ، مجدى محمد الشاذلي و نادية مصطفى محمد على

قسم علوم الأرضية ، كلية الزراعة ، جامعة المنصورة.

مِعْهَد بحوث الأرضية والبيئة ، مركز البحوث الزراعية ، الجزة.

أجريت تجربة أقصى بالمراعية البحثية، مركز التجارب والبحوث الزراعية، كلية الزراعة، جامعة المنصورة خلال موسم شتاء 2014/2013 لدراسة تأثير أنواع التربة والأسماك العضوية ومستويات السماد النيتروجيني، وكذلك تفاعلاهما على نمو ومحصول

وامتصاص العناصر الغذائية بمحصول الخس. نفذت التجربة في تصميم تجربة عاملية في القطاعات كاملاة الطباشير في ثلاث مكرات، حيث تضمن العامل الأول نوعي التربة تحت دراسة (الترية الطينية والترية الرملية)، أما العامل الثاني فقد اشتمل على نوعين من الأسماك

العذبة (300 كجم/فتان) و (1500 كجم/فتان) و (2200 كجم/فتان) كمبوست / أصيص). أما العامل الثالث فقد أعفى على ثلاثة مستويات من السماد النيتروجيني على النحو التالي: مادة المقارنة (بدون

تسميد نتروجيني) و (50 و 100 % من الصرف الموسمي) كجم. وكانت أهم النتائج كما يلي: تراجعت أقصى الإجمالي من نمو وتركيز

والإمتصاص النيتروجيني، الفوسفور والعناصر في أوراق نبات الخس عند زيادة نسبة السماد في النباتات الخاسة بفطنتين مستويات السماد العذبة (15 كجم/فتان) الفوسفور / و (150 كجم/فتان) في النباتات الخاسة عند زيادة مستويات السماد النيتروجيني ل (100 % من الصرف الموسمي) كجم نتروجين / (150 % من الصرف الموسمي) كجم نتروجين.

للحصول على أقصى النمو والتركيز وامتصاص العناصر في نباتات الخس، يتم التعامل مع التربة الطينية مع السماد العذبة بمعدل 15 كجم/فتان بالإضافة إلى التعامل مع التربة الطينية مع السماد العذبة بمعدل 15 كجم/فتان وذلك لتحقيق أقصى نمو و

تركيز وامتصاص العناصر الغذائية تحت الظروف البيئية لمنطقة المنصورة، محافظة الدقهلية، مصر.