

Impact of Nitrogen and Organic Fertilization on Nutrients Uptake by Lettuce Plants

Taha, A. A.¹ ; M. M. El-Shazly² and Nadia M. M. Ali²

¹Soil Sciences Department, Faculty of Agriculture, Mansoura University.

²Soils, Water and Environment Research Institute, Agricultural Research Center, Giza.



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 with 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. Charoenpakdee (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, hums 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. Peiris 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). Cercioğlu *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

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.

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

Soil characteristics		Clay soil	Sandy soil
Particle size distribution	Coarse sand (%)	2.7	28.0
	Fine sand (%)	18.6	58.0
	Silt (%)	35.5	10.0
	Clay (%)	42.8	4.0
	Soil texture	Clay	Sand
Some physical and chemical properties	Field capacity (%)	34.0	10.0
	Saturation (%)	75.0	15.0
	Calcium carbonate (%)	3.00	3.5
	O.M. (%)	1.10	0.2
	pH (1:2.5)	8.30	7.8
Soluble cations (meq./L)	EC (dSm ⁻¹) soil paste	1.40	1.8
	Ca ²⁺	3.80	5.30
	Mg ²⁺	0.80	2.40
	Na ⁺	4.10	2.10
	K ⁺	1.10	0.10
Soluble anions (meq./L)	CO ₃ ²⁻	-	-
	HCO ₃ ⁻	0.63	4.4
	Cl ⁻	4.22	2.5
Available nutrients (ppm)	SO ₄ ²⁻	5.1	2.6
	P (mg kg ⁻¹ soil)	7.92	2.0
	K (mg kg ⁻¹ soil)	295	12.5
	N (mg kg ⁻¹ soil)	48.6	15.0

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

- 1-N₁ Control treatment (without nitrogen fertilization).
- 2-N₂ 50 % of the recommended dose (30 kg/fed, 0.03 g N/pot).
- 3-N₃ 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^oC 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).
- 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.

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

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 Cercioğlu *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.

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.

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

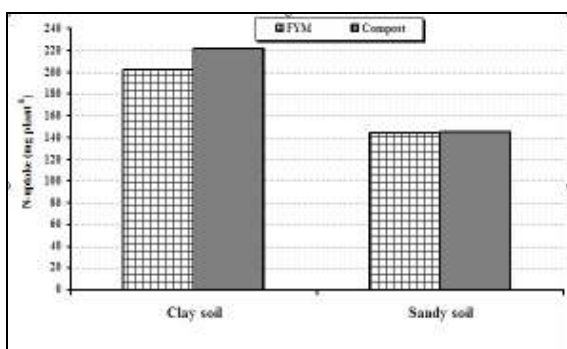


Fig. 1. Nitrogen uptake by lettuce plant at harvest as affected by the interaction between soil types and organic fertilizers in 2013/2014 season.

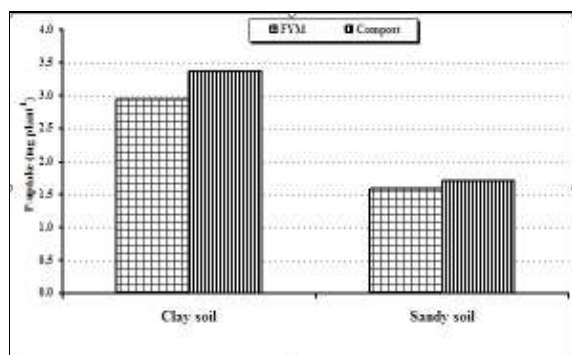


Fig. 2. Phosphorus uptake by lettuce plant at harvest as affected by the interaction between soil types and organic fertilizers in 2013/2014 season.

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.

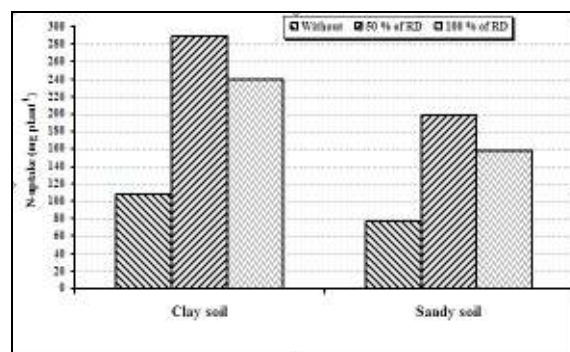


Fig. 3. Nitrogen uptake by lettuce plant at harvest as affected by the interaction between soil types and N-levels in 2013/2014 season.

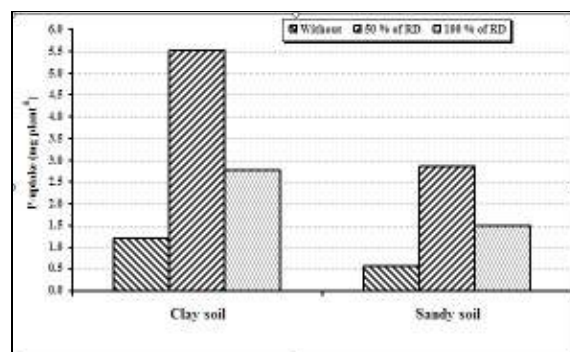


Fig. 4. Phosphorus uptake by lettuce plant at harvest as affected by the interaction between soil types and N-levels in 2013/2014 season.

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 m³/fed) besides 60 kg N/fed as graphically illustrated in Fig. 5. Organic fertilizing lettuce plants with FYM (20 m³/fed) in addition 60 kg N/fed ranked secondly after formerly mentioned interaction treatment.

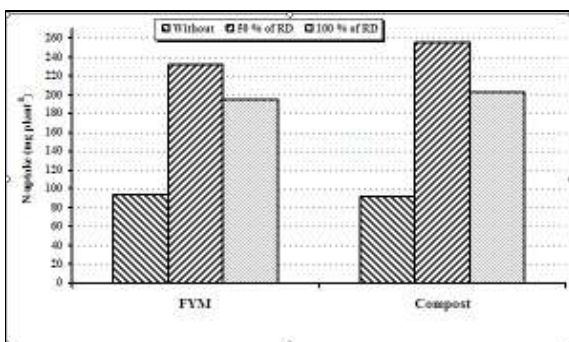


Fig. 5. Nitrogen uptake by lettuce plant at harvest as affected by the interaction between organic fertilizers and N-levels in 2013/2014 season.

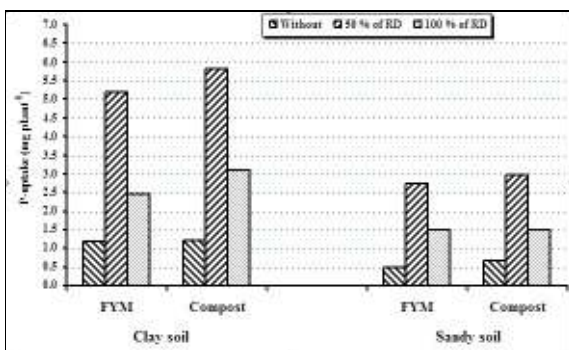


Fig. 6. Phosphorus uptake by lettuce plant at harvest as affected by the interaction among soil types, organic fertilizers and N-levels in 2013/2014 season.

The effect of interaction among soil types × organic fertilizers × N-levels on phosphorus uptake by lettuce leaves after 70 days from transplanting was significant (Table 3). The highest phosphorus uptake by lettuce leaves was resulted from planting lettuce seedlings in clay soil and organic fertilizing plants with compost (m³/fed) as well 60 kg N/fed as graphically illustrated in Fig. 6. Planting lettuce seedlings in clay soil and organic fertilizing plants with FYM (20 m³/fed) as also mineral fertilizing with 60 kg N/fed ranked secondly, followed by planting lettuce seedlings in clay soil and organic fertilizing plants with compost (15 m³/fed) as well mineral fertilizing with 30 kg N/fed.

CONCLUSION

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 in order to maximizing its growth and nutrients concentration.

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تأثير التسميد النيتروجيني والعضوي على امتصاص العناصر بواسطة نبات الخس أحمد عبد القادر طه^١ ، مجدى محمد الشاذلى^٢ و نادية مصطفى محمد على^٢ ^١قسم علوم الأراضى ، كلية الزراعة ، جامعة المنصورة. ^٢معهد بحوث الأراضى والمياه والبيئة ، مركز البحوث الزراعية ، الجيزة.

أجريت تجربة أصص بالمزرعة البحثية، مركز التجارب والبحوث الزراعية، كلية الزراعة، جامعة المنصورة خلال موسم شتاء ٢٠١٣/٢٠١٤ لدراسة تأثير أنواع التربة والأسمدة العضوية ومستويات السماد النيتروجيني وكذلك تفاعلاتها على نمو ومحتوى وأمتصاص العناصر الغذائية بمحصول الخس. نفذت التجربة في تصميم تجربة عاملية في القطاعات كاملة العشوائية في ثلاث مكررات ، حيث تضمن العامل الأول نوعي التربة تحت الدراسة (التربة الطينية والتربة الرملية). أما العامل الثاني فقد اشتمل على نوعين من الأسمدة العضوية وهما؛ السماد البلدى بمعدل ٢٠ م^٣/ فدان (١.٠٥ كجم سماد بلدى / أصيص) والكمبوست بمعدل ١٥ م^٣/ فدان (٠.٧٢٢ كجم كمبوست / أصيص). أما العامل الثالث فقد احتوى على ثلاثة مستويات من السماد النيتروجيني على النحو التالي: معاملة المقارنة (بدون تسميد نيتروجيني) و ٥٠ و ١٠٠ % من المعدل الموصى به. وكانت أهم النتائج كما يلي: نتجت أعلى القيم من صفات النمو وتركيز وإمتصاص النيتروجين ، الفوسفور والبوتاسيوم في أوراق نبات الخس عند زراعة شتلات الخس في التربة الطينية أدى التسميد العضوي لنباتات الخس بالكمبوست بمعدل ١٥ م^٣/ فدان للحصول على أعلى القيم من صفات النمو وتركيز وإمتصاص النيتروجين ، الفوسفور والبوتاسيوم في أوراق نبات الخس. أدى زيادة مستويات السماد النيتروجيني لـ ١٠٠ % من المعدل الموصى به (٦٠ كجم نيتروجين / فدان) للحصول على أعلى القيم من صفات النمو وتركيز وإمتصاص النيتروجين ، الفوسفور والبوتاسيوم في أوراق نبات الخس. من النتائج المتحصل عليها في هذه الدراسة يمكن التوصية بزراعة شتلات الخس في التربة الطينية مع التسميد العضوي بالكمبوست بمعدل ١٥ م^٣/ فدان بالإضافة إلى التسميد المعدنى بـ ١٠٠ % من المعدل الموصى به (٦٠ كجم نيتروجين/ فدان) وذلك لتحقيق أقصى قدر من النمو وتركيز وإمتصاص العناصر الغذائية تحت الظروف البيئية لمنطقة المنصورة ، محافظة الدقهلية، مصر.