Minufiya J. Agric. Res. Vol. 40 No. 3(2): 793 – 801 (2015)

RESPONSE OF HEAD LETTUCE PLANTS TO ORGANIC FERTILIZATION BY DIFFERENT COMPOST RATES AND COMPOST TEA IN SANDY SOIL

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(Received: Apr. 16, 2015)

ABSTRACT : *An experiment was conducted in the Experimental Farm of Arid Land Agricultural Research and Service Center (ALARC), Faculty of Agriculture, Ain Shams University, Egypt to study the effect of organic fertilization by different compost rates and compost tea on head lettuce plants grown in sandy soil. The head lettuce seedlings (Chianti Hybrid) were planted in sandy soil on 11 and 15 October of 2011 and 2012 respectively. Four rates (50, 75, 100 and 125%) of compost as recommended dose of nitrogen with and without adding compost tea were investigated on growth, yield, quality and minerals content of head lettuce comparing to mineral fertilizer (control). The results mentioned that applying 75, 100 and 125 % of compost with adding compost tea gave significant superiority in growth, mineral content, yield and some of head lettuce quality compared to control. Addition of compost by rates 100 and 125% with adding compost tea gave the highest content of macronutrients (N, P and K) and micronutrients (Fe, Zn, Mn and Cu) in head lettuce plants. All rates of compost with or without compost tea reduced nitrate content in lettuce heads. It is recommended that organic fertilization for producing head lettuce in sandy soil can be performed successfully using rate of 75 or 100% of compost with adding compost tea to get high yield and quality with low nitrate content of head lettuce.*

***Key words**: Head lettuce, organic fertilization, compost, compost tea, sandy soil, nitrate content.*

INTRODUCTION

Lettuce is one of the widely used salad vegetable in Egypt and the world. It has become an important commercial crop for local market and export. The total cultivated area in Egypt was 10000 feddans, produced about 94000 tons on annual basis with an average of 9.4 tons/feddan (Ministry of Agriculture and Land Reclamation, 2013). Recently, the consumers prefer the organic production of vegetables particularly the leafy vegetable that accumulated high levels of nitrate when was fertilized by excess nitrogen mineral fertilizers which is hazard for human health (Hill, 1990).

Most commercial farming rely on the use of mineral fertilizers for growing crops, because they are easy to use, quickly absorbed and utilized by crops (Lampkin, 1990). However, it is believed that these fertilizers contribute significantly to the human, animal food toxicity and environmental degradation. The continued dependence of Egypt and other developing countries on mineral fertilizers has made prices of many agricultural commodities to skyrocket. The mineral fertilizers used in conventional agriculture contain just a few minerals that dissolve quickly in damp soil and give plants large doses of minerals (Vernon, 1999). Organic fertilizers can therefore be used to reduce the amount of toxic compounds (such as nitrate) produced by mineral fertilizers in vegetables like lettuce, hence, improving the quality of leafy vegetables produced as well as human health. Increased consumer awareness of food safety issues and environmental concerns has contributed to the development of organic farming over the last few years (Worthington, 2001and Relf *et al.,* 2002). Thus, it may be possible to lessen the escalating effects of diseases such as cancer and boost immunity of humans. Farm income will also improve when farmers use

less money on fertilizers and pesticides for growing crops (Vernon, 1999). There is increased demand of organic fertilization for producing vegetables in view of its health and nutritional benefits.

The use of compost as organic fertilizer allows improvement in fertility, in addition to being excellent soil conditioner, improving their physical, chemical and biological, such as retention water, aggregation, porosity, the cation exchange capacity, fertility and life soil microbial, however, the value compound fertilizer depends on the material used as raw material (Miyasaka *et al.,*1997; Ahmad *et al.,* 2008; Fiorentino and Fagnano, 2011).

Compost tea has been utilized in agriculture as a good source of organic matter and soil amendments that providing plants with mineral nutrients and other benefits. In modern terminology compost tea is a compost extract produce of the fermented compost in water (Litterick *et al.,* 2004). Compost tea is proper than compost because it contain an soluble nutrients so it can applied to soil through irrigation systems or to plant foliage. Also, compost tea is very rich in phytohormones and regulators. It stimulates the microorganisms that have a direct or indirect proper effect on the plant rhizosphere, besides improves soil physical and chemical properties as well as suppress some plant disease pathogens (Abbasi *et al.,* 2002, Biocycle, 2004 and Meshref *et al.,* 2010).

MATERIALS AND METHODS

This experiment was carried out in the Experimental farm of the Arid Land Agricultural Research Center (ALARC), Faculty of Agriculture, Ain Shams University, Egypt, during the two successive seasons of 2011 and 2012 to investigate the effect of organic fertilization by different compost rates with or without compost tea on head lettuce plants grown in sandy soil.

Head lettuce (*lactuca sativa L*.) seedlings (Chianti Hybrid) were planted in the sandy soil on 11 and 15 of October in the first and second seasons, respectively.

The experimental trial was conducted in washed sand into plots (1 m^2), each plot was included 8 plants in 3 rows. The space between plants was 25 cm, that irrigated by surface irrigation system. Chemical properties of sandy soil are tabulated in Table (1).

Four rates of compost (50, 75, 100 and 125% from nitrogen recommended dose in sandy soil 70 kg N / feddan) with or without addition of compost tea were investigated for organic fertilization of head lettuce comparing to conventional fertilization (100% NPK) by mineral fertilizer (control). The chemical analyses of compost are illustrated in Table (2).

The mineral fertilizers of NPK were applied in control treatment according to Ministry of Agriculture and Land Reclamation (2009) as follow, 70 kg N/fed. as 209 kg ammonium nitrate (50 g/m^2), 45 kg P_2O_5/fed as 290 kg calcium super phosphate (70 g/m^2) and 48 kg K_2O/fed as 100 kg potassium sulphate (24 g/m^2). Calcium super phosphate was added as one dose during soil preparation, whereas ammonium nitrate and potassium sulphate were added at three equal portions, during soil preparation, after 20 and 40 days from transplanting. The stock solution of compost tea was prepared by soaking 5 L compost in 20 L of water for two days and was filtrated by plastic net, the clear stock solution was used to prepare the diluted compost tea for reaching the electrical conductivity (EC) of the compost tea to 2 dS/m as described El-Shinawy *et al.* (1999) and Abou-El-Hassan (2010). All quantities of compost (0.833, 1.250, 1.670 and 2.085 kg/m^2 as 50, 75, 100 and 125% of N recommended dose) were added as one dose during soil preparation, whereas the compost tea was added every two week by 2 liter per plot.

The Experimental Treatments were as follow:

1. Recommended mineral fertilizer as a control (RMF).
2. 50% compost (50% C)
3. 75% compost (75% C)
4. 100% compost (100% C)
5. 125% compost (125% C)
6. 50% compost+compost tea (50% C+ CT)
7. 75% compost+compost tea (75% C+ CT)
8. 100%compost+ compost tea(100% C+CT)
9. 125% compost+compost tea (125% C+CT)

Table 1: Chemical analyses of the sandy soil.

pH 1:5	EC 1:10 dS/m	Cations meq/l				Anions meq/l			
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Co_3^{-}	HCO_3^{-}	Cl^{-}	$SO_4^{=}$
7.37	0.68	1.30	0.42	1.61	0.56	0.04	1.24	1.51	4.20

Table 2: Chemical analyses of the compost.

pH 1:5	EC 1:10 dS/m	O.M (%)	Macro elements (%)					Micro elements (ppm)			
			N	P	K	Ca	Mg	Fe	Zn	Mn	Cu
7.67	4.83	30.40	1.32	0.67	1.38	0.46	0.33	2630	185	250	163

The experimental treatments were arranged in a completely randomized block design, with three replicates for each treatment.

After 60 days from transplanting, the plants were harvested and total yield was recorded for each plot. Three plants were randomly chosen from each experimental plot to determine the head fresh weight, head length, head surround, chlorophyll reading in the second outer leaf by using Minolta Chlorophyll Meter Spad 501, head firmness by using Pressure Tester and percentage of total soluble solids (TSS) by using Digital Refractometer.

The contents of macronutrients (N, P, K and Ca), micronutrients (Fe, Zn, Mn and Cu) and nitrate of lettuce head, were determined in dry matter of wrapping leaves according to Cottenie *et al.* (1982). Total nitrogen was determined by Kjeldahl method according to the procedure described by FAO (1980). Phosphorus content was determined using spectrophotometer according to Watanabe and Olsen (1965). The nutrients of K, Ca, Fe, Zn, Mn and Cu were determined spectrometrically using Phillips Unicum Atomic Absorption Spectrometer as described by Chapman and Pratt (1961). Assessment of NO_3 in the lettuce heads was performed using Brucine method reported by Holty and Potworowski (1972).

Data were statistically analyzed by the analysis of variance using one way ANOVA according to Snedecor and Cochran (1980) with SAS software, version 2004. Comparison of treatment means was done using Tukey test at significance level 0.05.

RESULTS AND DISCUSSION

The effect of different treatments on total yield of head lettuce is presented in Table (3). Data showed that 100% and 125% compost with adding compost tea treatments gave the highest total yield compared to other treatments. Applied 75% compost with adding compost tea treatment came in the second order that superior on recommended mineral fertilizer treatment (control). The lowest total yield was obtained by 50% compost without adding compost tea treatment in the two seasons.

This trend was true with head weight and head surround of lettuce heads with there weren't significant differences between 75% compost with adding compost tea treatment and control treatment. On the other hand, the highest head length was resulted from 75, 100 and 125% of compost + compost tea with non significant differences compared to control treatment in two seasons. These results were in agreement with those obtained by Abou-El-Hassan and Desoky (2013) they reported that using compost with compost tea increased the production of head lettuce in sandy soil.

Table 3: Effect of compost with or without compost tea on total yield, head weight, head length and head surround of head lettuce during 2011 and 2012 seasons.

Treatments	Total yield kg / m^2		Average head weight (kg)		Average head length (cm)		Average head surround (cm)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
RMF (control)	9.53 c	10.11 c	1.19 b	1.21 b	13.92 a	13.99 a	50.84 b	51.96 b
50% C	4.84 h	5.19 h	0.60 g	0.61 g	10.72 d	10.85 d	38.52 f	39.19 f
75% C	5.96 g	6.30 g	0.74 f	0.75 f	11.67 c	11.81 c	42.03 e	42.73 e
100% C	7.22 f	7.55 f	0.89 e	0.89 e	12.78 b	13.01 b	45.17 d	45.72 d
125% C	7.88 e	8.21 e	0.98 d	0.97 d	12.83 b	12.92 b	47.46 c	50.10 c
50% C + CT	8.48 d	8.82 d	1.06 c	1.05 c	12.78 b	12.90 b	48.51 c	50.10 c
75% C + CT	9.73 b	10.15 b	1.22 ab	1.22 b	13.78 a	14.07 a	51.92 b	52.36 b
100% C + CT	10.04 a	10.37 a	1.25 a	1.25 a	14.09 a	14.20 a	53.83 a	54.00 a
125% C + CT	10.02 a	10.36 a	1.24 a	1.24 a	14.03 a	14.19 a	53.95 a	54.04 a

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.

RMF = Recommended mineral fertilizer C = Compost CT = Compost Tea

Data in Table (4) showed that the highest values of chlorophyll reading and TSS% of lettuce heads were obtained by 75, 100 and 125% of compost + compost tea treatments with non significant differences compared to recommended mineral fertilizer treatment. While the lowest values were obtained by 50% compost without adding compost tea treatment, in both seasons. Concerning lettuce head firmness there were no significant differences among all treatments except 50% and 75% compost treatments, that decreased of head firmness. This effect could be resulted from the decrease of calcium element concentration in the plant tissues that treated by 50% and 75% compost where this element in plant tissue is located in the middle lamella, which give the strength to the cell walls leads to an increase in the firmness of the fruit as was reported by Marschner (1995). This explained the low firmness of lettuce heads obtained with 50% and 75% compost treatments.

Generally, applying compost by rates of 75, 100 and 125% with compost tea significantly increased the plant growth and yield for lettuce plants. This could be a result of use the compost as organic fertilizer that has many advantages about inorganic fertilizer particular in sandy soil such as: conditioning effect, raising the cation exchange capacity, contributes to soil aggregation(erosion), favors tillage operations (plasticity and cohesion), increases water retention, greater stability temperature, improves nutrient availability, which are essentially required to plant growth (Abdel Mouty *et al*., 2001 on squash; EL-Etr *et al*., 2004; Hafez and Mahmoud 2004 on pea; Xu *et al.,* 2005 on leafy vegetables; Masarirambi *et al.,* 2010 on red lettuce). Also, addition of compost tea to compost treatments increased plant growth, yield and head quality of lettuce. This effect might be due to the beneficial effects of compost tea that contains many macro and micro nutrients in available form, natural hormones, cytokines, vitamins and antioxidants which be available for plant usage and so reflect on plant growth and its composition as mentioned Abbasi *et al.*

(2002), Biocycle (2004) and Meshref *et al.* (2010) that led to improve yield and quality of lettuce plants.

The effect of treatments on the nutritional status in lettuce heads are shown in Tables (5 and 6). Concerning macronutrients content in lettuce heads, the highest concentrations of N, P and K were preceded by 100% and 125% compost + compost tea treatments followed by 75% compost + compost tea and control. On the other hand, the lowest concentrations of N, P and K in lettuce heads were found with 50 and 75% of compost without compost tea treatments. While 75, 100, 125% of compost + compost tea and recommended mineral fertilizer gave the highest concentration of Ca in lettuce heads. On the contrary, 50% compost without compost tea treatment gave the lowest concentration of Ca.

Table 4: Effect of compost with or without compost tea on chlorophyll reading, head firmness and TSS% of head lettuce during 2011 and 2012 seasons.

Treatments	Chlorophyll reading (Spad)		Head firmness (kg/cm^2)		TSS (%)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
RMF (control)	33.66 a	34.48 a	2.55 a	2.69 ab	3.42 a	3.54 a
50% C	27.30 c	28.30 e	2.22 c	2.29 d	2.43 e	2.42 e
75% C	28.00 c	28.93 d	2.42 b	2.43 c	2.72 d	2.73 d
100% C	32.33 b	33.27 c	2.50 ab	2.63 b	2.87 cd	2.99 c
125% C	33.11 ab	33.93 b	2.58 a	2.72 a	3.12 bc	3.26 b
50% C + CT	32.90 ab	33.69 bc	2.60 a	2.73 a	3.14 bc	3.27 b
75% C + CT	33.70 a	34.84 a	2.62 a	2.75 a	3.41 a	3.53 a
100% C + CT	33.92 a	34.90 a	2.58 a	2.77 a	3.42 a	3.59 a
125% C + CT	33.86 a	34.94 a	2.59 a	2.77 a	3.54 a	3.56 a

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.

RMF = Recommended mineral fertilizer C = Compost CT = Compost Tea

Table 5: Effect of compost with or without compost tea on macronutrints percent of head lettuce during 2011 and 2012 seasons.

Treatments	N		P		K		Ca	
	%							
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
RMF (control)	3.20 b	3.82 b	0.47 b	0.65 b	4.56 b	4.96 b	2.38 a	2.58 a
50% C	2.14 f	2.83 g	0.32 d	0.50 f	2.77 g	3.27 g	1.29 d	1.63 e
75% C	2.41 e	3.09 f	0.34 d	0.52 e	3.26 f	3.55 f	1.65 c	2.00 d
100% C	2.67 d	3.35 e	0.38 c	0.56 d	3.68 e	4.09 e	1.79 bc	2.14 c
125% C	2.85 c	3.55 c	0.39 c	0.57 c	3.92 d	4.41 d	1.99 b	2.32 b
50% C + CT	2.74 d	3.43 d	0.38 c	0.56 d	4.18 c	4.75 c	1.83 bc	2.18 c
75% C + CT	3.21 b	3.83 b	0.47 b	0.65 b	4.53 b	4.96 b	2.35 a	2.62 a
100% C + CT	3.32 a	3.96 a	0.49 ab	0.68 a	4.80 a	5.33 a	2.39 a	2.64 a
125% C + CT	3.33 a	3.99 a	0.51 ab	0.68 a	4.86 a	5.37 a	2.42 a	2.65 a

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.

RMF = Recommended mineral fertilizer C = Compost CT = Compost Tea

Table 6: Effect of compost with or without compost tea on micronutrints content of head lettuce during 2011 and 2012 seasons.

Treatments	Fe		Zn		Mn		Cu	
	ppm							
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
RMF (control)	60.17 c	64.19 c	19.67 bc	23.75bc	15.50 cd	16.69c	4.36 d	4.50 e
50% C	35.13 d	45.69 c	16.43 c	17.00d	13.77 d	14.32d	4.27 d	4.65 e
75% C	53.50 c	59.96 c	17.33 c	17.86d	15.00 d	15.63cd	4.61 cd	5.14 d
100% C	77.17 ab	75.24 b	22.67 ab	24.71ab	19.33 b	18.44b	5.33 bc	6.86 ab
125% C	80.83 ab	83.74 ab	26.17 a	25.39a	21.67 ab	19.79a	6.13 ab	6.93 ab
50% C + CT	60.00 c	62.71 c	18.00 c	18.09d	12.33 d	14.32d	6.17 ab	6.11 c
75% C + CT	74.83 b	76.96 b	22.83 ab	20.67c	18.83 bc	15.99c	6.60 a	6.65 b
100% C + CT	86.67 a	83.27 ab	25.00 a	25.22a	21.67 ab	20.50a	6.80 a	7.17 a
125% C + CT	85.33 ab	85.71 a	26.33 a	25.76a	23.67 a	21.07a	6.93 a	7.31 a

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.

RMF = Recommended mineral fertilizer C = Compost CT = Compost Tea

Concerning micronutrients content in lettuce heads, 100% and 125% of compost with or without compost tea treatments gave the highest contents of Fe, Zn, Mn and Cu. Conversely, 50, 75% of compost without compost tea and recommended mineral fertilizer treatments gave the lowest content of Fe, Zn, Mn and Cu. The same trend was true in two seasons. Similar results were reported by Masarirambi *et al.* (2010), they reported that there was relatively higher macro and micronutrient contents in lettuce plants produced by organic fertilizers than those grown with conventional fertilizers.

This can be attributed to the balanced quantity of nutrients in the compost and compost tea. Beside, mineral fertilizers are less suitable for use in a sandy soil because it's are easy dissolving and loses quickly in sandy soil by leaching, on the contrary compost advantage as a slow release and has a high cation exchange capacity exceeded the capacity of sandy soil to maintain nutrients are absorbed by plants, which leads to increment minerals content of lettuce plants (Miyasaka *et al.,*1997; Vernon, 1999; Ahmad *et al.,* 2008; Fiorentino and Fagnano, 2011; Abou-El-Hassan and Desoky, 2013).

Response of nitrate content in lettuce heads for different treatments was shown in Table (7). Generally, all compost with or without compost tea treatments reduced NO_3 content of lettuce heads significantly comparing to recommended mineral fertilizer treatment in both seasons. This suggests that several plant species accumulate NO_3 as a result of an excess of N uptake. In this respect, Worthington (2001) and Mahmoud *et al.* (2009) reported that applied organic fertilizer decrease nitrate accumulation in vegetables. Similar finding was obtained by El-Shinawy *et al.* (1999) and Abou-El-Hassan and Desoky (2013) on lettuce, Abou-El-Hassan (2010) on cantaloupe, and Abou-El-Hassan *et al*. (2014) on cucumber.

Table 7: Effect of compost with or without compost tea on nitrate percent of head lettuce during 2011 and 2012 seasons.

Treatments	%NO_3	
	1st season	2nd season
RMF (control)	0.390 a	0.408 a
50% C	0.133 d	0.163 e
75% C	0.157 dc	0.189 de
100% C	0.214 b	0.244 bc
125% C	0.233 b	0.263 bc
50% C + CT	0.177 c	0.227 cd
75% C + CT	0.234 b	0.267 bc
100% C + CT	0.232 b	0.262 bc
125% C + CT	0.238 b	0.281 b

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.

RMF = Recommended mineral fertilizer C = Compost CT = Compost Tea

Conclusion

It could be concluded that, organic fertilization of head lettuce in sandy soil can be performed successfully using rate of 75 or 100% of compost as recommended dose of nitrogen with adding compost tea to produce good yield, quality and healthy head lettuce.

Acknowledgement

This work has been supported by Central Lab of Organic Agriculture, Central Laboratory for Agricultural Climate, Agricultural Research Center and Arid Land Agricultural Research and Service Center, Faculty of Agriculture, Ain Shams University.

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استجابة نباتات خس الرؤوس للتسميد العضوى بمستويات كمبوست مختلفة ومنقوع الكمبوست فى التربة الرملية

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الملخص العربى

أجريت التجربة فى المزرعة البحثية التابعة لمركز خدمات و بحوث الزراعة فى المناطق القاحلة بكلية الزراعة – جامعة عين شمس – جمهورية مصر العربية . لدراسة تأثير التسميد العضوى بالكمبوست ومنقوع الكمبوست على نباتات خس الرؤوس فى التربة الرملية.

تم زراعة شتلات خس الرؤوس هجين شيانتى فى ارض رملية خلال موسمى 2011 و2012.

تم دراسة استخدام الكمبوست بمعدلات 50 و 75 و 100 و 125% (من المعدل الموصى به من عنصر النيتروجين) مع او بدون اضافة منقوع الكمبوست فى انتاج خس الرؤوس ومقارنتها باستخدام المعدل الموصى به من الاسمدة الكيماوية من حيث نمو النباتات ومحتواها من العناصر الغذائية والمحصول وجودة رؤوس الخس.

وقد أظهرت النتائج المتحصل عليها أن معاملات الكمبوست بمعدل 75 و 100 و 125% مع اضافة منقوع الكمبوست تفوقاً معنوياً فى النمو الخضرى والمحصول وبعض صفات الجودة فى رؤوس الخس مقارنة بمعاملة السماد المعدنى (المقارنة). اضافة الكمبوست بمعدل 100 و 125% مع اضافة منقوع الكمبوست انتجت نباتات خس ذات محتوى عالى من العناصر الكبرى (ن ، فو ، بو) والعناصر الصغرى (ح ، ز ، م ، نح). كما لوحظ ان كل معدلات الكمبوست باضافة او بدون اضافة منقوع الكمبوست قللت من محتوى رؤوس الخس من النترات.

اوصت هذه الدراسة بامكانية التسميد العضوى لخس الرؤوس فى التربة الرملية باستخدام 75 و 100% من معدل الكمبوست الموصى به مع اضافة منقوع الكمبوست للحصول على خس عالى المحصول وذو جودة عالية ومحتواه من النترات منخفض.