

## EFFECT OF DIFFERENT SOURCES OF ORGANIC FERTILIZERS ON VEGETATIVE GROWTH, YIELD AND STORABILITY OF LETTUCE PLANTS

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### Abstract

This investigation was carried out during two winter seasons of 2016/2017 and 2017/2018 at the Agricultural Research Farm, El-Kassasien Hort. Res. Station, Ismailia Governorate, Egypt, to study the effect of different sources of organic fertilizers, i.e. chicken manure, farmyard manure (FYM), compost manure and the mixture of them as compared to mineral fertilizer on vegetative growth, fresh and dry weight per plant, root system, yield and its components of cv. Balady (Local lettuce cultivar) grown under sandy soil conditions. It aimed also to study the effect of the abovementioned treatments on storability of lettuce plants during storage at 0°C and 90-95% RH. Fertilization of lettuce plants with chicken manure at 7.5 m<sup>3</sup>/fed. or with the mixture of chicken at 2.5 m<sup>3</sup> plus FYM at 5 m<sup>3</sup> plus compost manure at 3.7 m<sup>3</sup>/fed. significantly increased vegetative growth, fresh and dry weight of different organs per plant, root system per plant and water content as well as yield and its components, while decreased nitrate content without significant differences between them in most cases. Using organic manure the mixture of chicken manure at 2.5 m<sup>3</sup> plus farmyard manure at 5 m<sup>3</sup> plus compost manure at 3.7 m<sup>3</sup>/fed. or chicken manure improve storability of lettuce plants by reducing weight loss and polyphenol oxidase (PPO) activity, maintained chlorophyll and total phenolic contents during storage and gave plants with good appearance after 12 days of storage for chicken manure and after 16 days for mixture treatment.

**Key words:** Lettuce plants, chicken manure, compost manure, farmyard manure, growth, root system, yield and storability as well as phenolic contents.

### INTRODUCTION

Lettuce (*Lactuca sativa* L.) is an annual plant of the family Asteraceae and one of the most popular among leafy vegetables and salad crops in all world countries grown in cool season. In Egypt, lettuce is an important vegetable crop for both farmers and consumers. For farmers, it is considered as a fast cash crop in the winter season. For consumers, lettuce is eaten fresh and salad, where it is rich in vitamins and minerals. Also, lettuce grown in Egypt for local consumption and exportation.

Newly reclaimed sandy soil had unfavorable physical, chemical and biological conditions, high pH, low water holding capacity and high ability to erosion and scarcity of amended water. Thus, addition of organic manures to sandy soil is very important to increase soil acidity and soil exchange capacity, provide energy for micro-organisms

activity, increase water holding capacity and buffering of the soil infiltration (Hsieh and Hsu, 1993). Organic manure also, contains many species of living organisms which release phyto-hormones as GA, IAA and CYT which stimulate plant growth (Reynders and Vlassak, 1982).

Using mineral fertilizers (NPK) without rationalization may cause environmental pollution as well as contaminate the underground water. Therefore, there was a great attention to use organic fertilizers in the production of vegetables in order to reduce the contamination of plant and soil with different elements, to reduce the usage of mineral fertilizers, to produce clean crop and also to improve the soil properties. Moreover, reducing environmental pollution through decreasing the amount of chemical fertilizers is of great demand nowadays for human, safety and reducing air and water pollution (Ahmed, 2013). Thus, fertilization lettuce plants with Vermicompost (4 t/ha) plus chemical fertilizer recorded higher values for plant height, leaf area, number of leaves plant, average leaf weight, leaf weight plant, leaf yield plot, and leaf yield ha. (Rather *et al.*, 2018). Application of 13 t/ha organic fertilizer significantly increased leaf size (length and breadth) of lettuce; this treatment also increased fresh weight, dry weight and yield (Hossain and Ryu 2017).

Melese (2016) revealed that farm yard manure with the rate of 3.3 kg (15 t/ha) highly increased the yield and yield components (plant height, leaf size, number of leaf per plant, fresh leaf weight, root depth and number of root per plant). Reis *et al.* (2014) suggested the amount of 3.0 kg compost m<sup>2</sup> (30 Ton/ha) as the best application rate, due to the higher growth and lettuce yield, and the lower content of nitrate.

Chicken manure levels significantly affected growth, yield and nutritional quality of lettuce, a trend of superiority of the different level of chicken manure application was observed as lettuce provided with 60 Ton/ha exhibited higher values in number of leaves, plant height, marketable yield and mean leaf dry mass (Masarirambi *et al.*, 2012).

After harvesting, lettuce plants are a highly perishable crop due to its high moisture content, shriveling associated to rapid loss of weight, high respiration rate and short life. The major causes of quality loss of lettuce plants are dehydration, leaf discoloration and decay (similar to lettuce plants). There was a considerable increase in weight loss percentage of stored lettuce plants with prolonging the storage period (Bardisi *et al.*, 2013).

Concerning the effect of organic fertilization on fruit storability, El-Sheikh and Salama (1997) observed that chicken manure improved tomato fruit storability by decrease weight loss and decay percentage and maintained the fruit quality during

storage when compared with mineral fertilizer treatment. Also, Abd El-Rhman and Hosney (2001) found that using organic fertilization (chicken and cattle manures) improved eggplant fruit storability and maintained fruit quality during storage. This improvement was much pronounced at the application of chicken manure.

Thus, this work aimed to investigate the effect of different sources of organic fertilizers on vegetative growth, fresh and dry weight, root system, nitrate content and yield as well as storability of lettuce plants grown under sandy soil conditions.

## MATERIALS AND METHODS

### Field experiment:

The field experiments was carried out during the winter seasons of 2016/2017 and 2017/2018 at the Agricultural Research Farm, El-Kassasien Hort. Res. Station, Ismailia Governorate, Egypt, to study the effect of different sources of organic fertilizers, i.e. chicken manure, farmyard manure (FYM), compost manure and the mixture of them, as compared to mineral fertilizer on vegetative growth, fresh and dry weight, root system, yield, and storability of cv. Balady lettuce (Local cultivar) plants grown under sandy soil conditions during cold storage.

This experiment included five treatments as follows:

Mineral fertilizer at 40 kg N/fed., chicken manure at a rate of 7.5 m<sup>3</sup>/fed., farmyard manure at a rate of 15 m<sup>3</sup>/fed., and compost manure at a rate of 11 m<sup>3</sup>/fed., as well as a mixture of chicken (2.5 m<sup>3</sup>) plus farmyard (5 m<sup>3</sup>) and compost manure (3.7 m<sup>3</sup>) per feddan, with knowing that these rates contained the same nitrogen level (40 kg N nearly) according to the chemical analysis of the used organic manure). These treatments were distributed in a randomized complete block design with three replications.

**Table 1. The physical and chemical properties of the experimental soil field**

Properties	2016/2017	2017/2018
Physical Properties (%)		
Sand	96.5	95.6
Silt	1.7	1.6
Clay	1.8	2.8
Texture	sandy	sandy
Chemical properties		
Organic matter (%)	0.06	0.08
pH	8.1	8.1
Available N (ppm)	5.4	6.9
Available P (ppm)	5.5	6.2
Available K (ppm)	52	64
Calcium carbonate (%)	0.18	0.26
Sample of the soil was obtained from 25 cm soil surface.		

The experimental unit area was 12.6 m<sup>2</sup>, every plot consisted of six rows 3.5 m in length and 60 cm in width with about 210 plants in every plot. Lettuce seeds were sown in nursery bed on 4<sup>th</sup> and 6<sup>th</sup> of October in both seasons and then transplants of nearly 40 days were transplanted on 14<sup>th</sup> and 16<sup>th</sup> of November in the permanent field on both sides of dripper lines at 20 cm between plants. Two rows (4.2 m<sup>2</sup>) were used to measure vegetative growth traits and the other four rows (8.4 m<sup>2</sup>) were used for estimating yield and its components and storability of plants. The chemical analysis of used organic manures was scheduled in schedule 1. Also, nitrogen amount in each of one m<sup>3</sup> of different organic manure was shown in schedule 2.

**Schedule 1. Chemical analysis of used organic manure during 2016/2017 and 2017/2018 seasons**

Type of analysis	Kind of manure					
	Chicken		FYM		Compost	
Season	1 <sup>ST</sup>	2 <sup>ND</sup>	1 <sup>ST</sup>	2 <sup>ND</sup>	1 <sup>ST</sup>	2 <sup>ND</sup>
<b>O.M.%</b>	59.78	58.37	30.32	33.38	47.45	47.88
<b>N%</b>	2.21	2.29	0.55	0.61	0.98	1.02
<b>P%</b>	0.51	0.53	0.31	0.36	0.45	0.51
<b>K%</b>	1.28	1.33	0.93	0.96	1.08	1.13

**Schedule 2. Nitrogen amount in different organic manure (Kg/m<sup>3</sup>)**

Kind of manure	2016/2017	2017/2018
<b>1m<sup>3</sup>Chicken (243Kg)</b>	5.37	5.49
<b>1m<sup>3</sup>FYM (486Kg)</b>	2.67	2.96
<b>1m<sup>3</sup>Compost (380kg)</b>	3.72	3.87

All amounts of organic fertilizers were added during soil preparation before sowing, whereas mineral nitrogen fertilizer were divided into three portions, the first was added at 15 days after transplanting and the others two portions were added at 30 and 45 days after transplanting. All plots received equal amounts of FYM at a rate of 20m<sup>3</sup>/fad. during soil preparation, the other recommended agricultural practices for commercial lettuce production were practiced.

### Data Recorded

#### Vegetative Growth

A random sample of three plants from every experimental unit was taken after 60 days from transplanting to investigate the following growth parameters: Plant height, number of leaves /plant, leaf area/plant, fresh weight of stem, fresh weight of leaves and total fresh weight/plant (leaves plus stem).

**Dry Weight:** Different plant parts were oven dried at 70° C till constant weight, and the following data were recorded: Dry weight of stem, leaves and total dry weight/plant (stem plus leaves).

**Water content %:** It was measured according to the following equation: [(fresh weight – dry weight)/fresh weight] x100

**Root system traits:** The root of lettuce plants were carefully separated by washing the sand from them and roots were placed in a flat glass dish containing a little amount of water. Roots were straighter with forceps, so that they cannot overlap and were held in position, and the following data were recorded per root: root length, fresh and dry weight of root, and root volume.

**Nitrate content:** It was determined on the basis of dry weight according to the method described by Cafado *et al.* (1975).

**Yield and its Components:** At harvesting time (about 70 days after transplanting) all plants from each plot were harvested to measure average head fresh weight, yield/plot and total yield/fad.

**Storage Experiment:**

This experiment was conducted to study the effect of different sources of organic fertilizers as compared to mineral fertilizer on keeping quality of lettuce plants during storage period.

**Plant material and treatments:**

In this experiment, Lettuce (*Lactuca sativa* L.) Cv. Balady plants of the field experiment were harvested at suitable maturity stage of marketing on January 23<sup>rd</sup> and 25<sup>th</sup> (70 days from transplanting) in the first and second season, respectively.

Uncompacted and non-uniform plants were eliminated and chose healthy with dark green outer leaves, symmetrical in shape and good ones of plants were transferred directly to the laboratory of Postharvest Handling of Vegetable Crops Department, Horticulture Research Institute, Agriculture Research Center, Giza, Egypt. Plants were trimmed (leaf tips and root cut) and every plant served as one replicate was packed individually in macro perforated polypropalyne bags with pin holes (one head/polypropalyne bag) were used.

Sixteen replications were prepared for each treatment and packed in carton boxes (each box contained three bags and stored at 0° C ±1° C and 95% relative humidity. Four samples of lettuce plants were randomly taken at 4, 8, 12 and 16 days from storage period to determine the following data:

**Weight loss:** It was measured as the percentage of loss from the initial weight.

**General appearance:** It was determined according to the following score system: 9 = excellent, 7 = good, 5 = fair, 3 = poor, and 1 = unusable. This scale depends on vegetative defects such as leaf wilting, and leaf discoloration.

**Total chlorophyll:** It was measured in fresh leaves by using Minolta chlorophyll meter SPAD-501 as SPAD units.

**Polyphenol oxidase (PPO) activity:** polyphenol oxidase was determined by the colorimetric modified method of Dogan *et al.* (2002).

**Total phenolic:** The phenolic content was determined by the colorimetric modified method of Velioglu *et al.* (1998) using Folin-Ciocalteu reagent.

**Statistical Analysis:** The obtained data of the first and second experiments were statistically analyzed by Snedecor and Cochran (1982) and difference among treatments were statistically compared using Duncan's multiple range test at a level of 0.05 using the CoStat v6.4 program.

## RESULTS AND DISCUSSION

### Field experiment

#### Root stem

Data presented in Table (2) show that there were significant differences among the tested organic manures and mineral fertilization in root system of lettuce plants expressed as root length, fresh and dry weight of root per plant as well as root volume. Such data revealed that using chicken manure at a rate of 7.5 m<sup>3</sup>/fed. significantly increased all different root system parameters during both seasons of growth followed by mineral fertilization in case of root length only, while using the mixture of the three manures (chicken manure at 2.5 m<sup>3</sup> plus farmyard manure at 5 m<sup>3</sup> plus compost manure at 3.7 m<sup>3</sup>/fed.) ranked the second in all root system measurements and without significant differences between them and chicken manure in case of root dry weight merely.

On the contrary, the lowest values in all measured root system traits were recorded in case of using farmyard manure (FYM) at a rate of 15 m<sup>3</sup>/ fed. The stimulate effect of chicken manure and the mixture of three manures on root system of lettuce plant by improved physical environment and added supply of nutrients and proliferous root system developed early resulting and better absorption of water and nutrients (Rather *et al.*, 2018). Organic manures also produced the highest average root length because it ensures favorable condition for the growth of lettuce. In this respect, similar findings were reported by Melese (2016) and Masarirambi *et al.*, (2012) on lettuce.

### Vegetative Growth:

Data presented in Table 3 showed that there were significant differences among the tested organic manures and mineral fertilizer on morphological characters of lettuce plants; i.e., plant height, number of leaves per plant and leaf area. Such data reveal that using chicken manure at a rate of 7.5 m<sup>3</sup>/fed. significantly increased all different vegetative growth parameters during both seasons of growth followed by fertilization of the mixture of chicken manure (2.5 m<sup>3</sup>/fed.) plus farmyard manure (5 m<sup>3</sup>/fed.) plus compost manure (3.7 m<sup>3</sup>/fed.) without significant differences between them in most cases.

On the contrary, the lowest values in all measured growth traits were recorded in case of using farmyard manure (FYM) at a rate of 15 m<sup>3</sup>/fed. during both seasons of study. The enhancing effect of chicken manure and mixtures manures on plant growth may be due to that such organic manures play a role as soil amendment which improve water capacity of sandy soils and increase macro and micro elements availability in the rhizosphere around root system which in turn increased plant growth (Ahmed, 2013) also this could be attributed to large quantities of available phosphorus and potassium per kilogram in the chicken manure (Schedule 1). Obtained results are in conformity with those of Masarirambi *et al.* (2012) on lettuce.

**Table 2. Effect of different sources of organic fertilizers on root system of lettuce plants at 60 days after transplanting during 2016/2017 and 2017/2018 seasons.**

Treatments	Root length (cm)		Root fresh weight (g)		Root dry weight (g)		Root volume (cm <sup>3</sup> )	
	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season
Mineral fertilizer	21.43a	19.68a	38.2cd	31.3d	8.58bc	7.54c	47.8c	40.4d
Chicken manure	20.62a	20.07a	44.8a	41.2a	10.17a	9.97a	56.0a	49.1a
FYM manure	15.28d	14.16d	37.5d	31.4d	8.46c	7.58c	46.9d	40.5d
Compost manure	17.12c	14.83c	38.9c	37.7c	8.79bc	9.07b	48.6c	43.6c
Mixture (2+3+4)	18.31b	16.39b	41.6b	39.8b	9.38ab	9.63ab	52.4b	46.2b

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test.

\* Mixture (chicken manure at 2.5 m<sup>3</sup>plus FYM at 5 m<sup>3</sup>plus compost manure at 3.7m<sup>3</sup>/fed.)

**Table 3. Effect of different sources of organic fertilizers on vegetative growth of lettuce plants at 60 days after transplanting during 2016/2017 and 2017/2018 seasons.**

Growth Treatments	Plant height (cm)		No. of leaves/plant		Leaf area (cm <sup>2</sup> /plant)	
	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season
Mineral fertilizer	35.7bc	41.7bc	21.3bc	24.3b	2256.1c	2581.4bc
Chicken manure	39.7a	44.7a	24.3a	27.3a	2603.6a	2926.3a
FYM manure	34.3c	40.3c	20.0c	23.3b	2002.4d	2496.5c
Compost manure	36.3bc	42.7b	21.3bc	24.0b	2260.3c	2544.0bc
Mixture *	37.7ab	43.3ab	22.7ab	24.3b	2450.7b	2626.6b

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test.

\* Mixture (chicken manure at 2.5 m<sup>3</sup>plus FYM at 5 m<sup>3</sup>plus compost manure at 3.7m<sup>3</sup>/fed.)

#### **Fresh weight and water percentage:**

It is obvious from the data presented in Table 4 that fertilization lettuce plants with chicken manure at a rate of 7.5 m<sup>3</sup>/fed. was the most favorable treatment for enhancing fresh weight significantly. In addition, using the mixture of the three manures ranked the second in all fresh weight measurements. On the contrary, the lowest values in all measured fresh weight traits were recorded in case of using FYM at a rate of 15 m<sup>3</sup>/fed., the stimulative effect of chicken manure and mixture of the three manures on fresh weight of lettuce is a reflection of increasing root system and growth (Tables 2 and 3). These findings agree with those reported by Masarirambi *et al*, (2012) and Hossain and Ryu (2017) on lettuce.

Regarding water percentage, it is clear from the same data in Table 4 that fertilization lettuce plants with mineral fertilizer at 40 kg N/fed., was the superior treatment for increasing water percentage which gave 92.6 and 92.9 % in the first and 2nd seasons, respectively. On the other side the lowest values in this respect were recorded in case of using the mixture of the three manures which gave 90.9 and 91.6 % in the first and second seasons, respectively.



**Table 4. Effect of different sources of organic fertilizers on fresh weight and water percentage of lettuce plants at 60 days after transplanting during 2016/2017 and 2017/2018 seasons.**

Growth Treatments	Fresh weight / plant (g)						Water percentage	
	leaves		Stem		total		1 <sup>st</sup> season	2 <sup>nd</sup> season
	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season		
<b>Mineral fertilizer</b>	295.27b	242.16c	50.26b	38.26c	345.53b	280.42c	92.59a	92.86a
<b>Chicken manure</b>	341.35a	348.27a	58.49a	51.23a	399.84a	399.50a	91.26b	91.97b
<b>FYM manure</b>	286.02b	240.66c	48.86b	37.29c	334.88b	277.95c	90.87b	91.76b
<b>Compost manure</b>	297.43b	290.43b	51.08b	44.99b	348.51b	335.42b	91,12b	91.67b
<b>Mixture *</b>	306.37b	298.55b	52.13b	46.69b	358.50b	345.24b	90.92b	91.60b

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range tests.

\* Mixture (chicken manure at 2.5 m<sup>3</sup> plus FYM at 5 m<sup>3</sup> plus compost manure at 3.7m<sup>3</sup>/fed.)

#### **Dry weight and nitrate content:**

Data in Table (5) showed that the highest values of leaves, stems and total dry weight per plant were recorded as a result of fertilization lettuce plants with chicken manure followed by the mixture treatment then compost manure without significant differences among the three treatments in most cases, while the lowest values in this regard were recorded by the control treatment (mineral fertilizer).

The enhancing effect of the above mentioned treatments on dry weight may be due to the increasing palisade tissues of leaf and this intern enhance the photosynthesis process and translocation of photosynthesis assimilates rate and consequently increased vegetative growth and this reflected on increasing dry weight of plant (Arisha *et al.*, 2015).

As for nitrate content, it is clear from the same data in Table 5 that fertilization lettuce plants with mineral fertilizer at 40 kg N/fed. was the superior treatment for increasing nitrate content which gave 71.70 and 74.36 mg/kg in the first and second seasons, respectively. On the contrary, the lowest values in this respect were recorded in case of using chicken manure that gave 33.01 and 29.01 mg/kg followed by mixture treatment which gave 39.01 and 37.01 mg/kg in the first and second seasons, respectively.

**Table 5. Effect of different sources of organic fertilizers on dry weight and nitrate content of lettuce plants at 60 days after transplanting during 2016/2017 and 2017/2018 seasons**

Growth Treatments	Leaves		stem		total		No <sub>3</sub> (mg/kg)	
	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season
Mineral fertilizer	14.11c	11.19c	11.48b	8.82c	25.59c	20.01d	71.70a	74.36a
Chicken manure	19.21a	18.89a	15.75a	13.20a	34.96a	32.09a	33.01c	29.01d
FYM manure	16.43b	13.64bc	14.15ab	9.27bc	30.58b	22.91c	49.02b	46.35c
Compost manure	17.13ab	16.07ab	13.82ab	11.86ab	30.95b	27.93b	49.02b	51.02b
Mixture *	17.81ab	16.81ab	14.75a	12.18ab	32.56b	28.99b	39.01d	37.01e

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test.

\* Mixture (chicken manure at 2.5 m<sup>3</sup>plus FYM at 5 m<sup>3</sup>plus compost manure at 3.7m<sup>3</sup>/fed.)

#### **Yield and yield components:**

Data presented in Table 6 show that fertilization lettuce plants with chicken manure at 7.5 m<sup>3</sup>/fed. was the superior treatment for increasing yield and its components which gave 495.8 and 478.4 g for average head fresh weight, 104.1 and 100.4 kg for yield per plot and 34.7 and 33.4 ton for total yield per feddan, while the increase in yield over control was 127.0 and 139.7 % in the first and second seasons, respectively.

Using the mixture of the three manures (chicken at 2.5 m<sup>3</sup>plus FYM at 5 plus compost manure at 3.7 m<sup>3</sup> /fed.) ranked the second in all yield and its components measurements. On the other hand, the lowest values in all measured yield and its components traits were recorded in case of using FYM at a rate of 15 m<sup>3</sup> /fed. and mineral fertilizer at 40 kg N/fed., without significant differences between them. Increasing lettuce yield and its components as results of chicken manure fertilization may be due to the enhancing effect of chicken manure on formation a perfect root system (Table 2) and a good vegetative growth (Table 3) which reflection of increasing yields and its components. Similar findings were reported by Hossain and Ryu (2017) and Masarirambi et al., (2012) on lettuce.

**Table 6. Effect of different sources of organic fertilizers on yield and its components of lettuce plants during 2016/2017 and 2017/2018 seasons.**

Growth Treatments	Yield and its components							
	Average head F.W. / plant (g)		Yield / plot (kg)		Total yield / fed.(ton)		Yield increase over control (%)	
	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season
Mineral fertilizer	390.45cd	342.42d	81.994cd	71.908d	27.331cd	23.969d	100	100
Chicken manure	495.81a	478.47a	104.120a	100.478a	34.706a	33.492a	127	139.7
FYM manure	365.02d	314.08d	76.654d	65.956d	25.551d	21.985d	93.5	91.7
Compost manure	421.69bc	385.42c	88.554bc	80.938c	29.518bc	26.979c	108	112.6
Mixture *	448.14d	428.24b	94.109b	89.930b	31.369b	29.976b	114.8	125.1

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test.

\* Mixture (chicken manure at 2.5 m<sup>3</sup> plus FYM at 5 m<sup>3</sup> plus compost manure at 3.7 m<sup>3</sup>/fed.)

### Storage experiment

#### Weight loss percentage:

It is clear from the data presented in Table 7 that there was a considerable and continuous increase in weight loss percentage of stored lettuce plants when the storage period was prolonged, and the maximum loss was occurred at the end of storage period (16 days) being 1.45 and 0.44% in the first and 2<sup>nd</sup> seasons respectively. This continuous loss in weight during storage period resulted from the loss of water by increasing transpiration and dry matter by respiration on lettuce plants. Similar results were obtained by Bardisi *et al.* (2013) and Shehata *et al.* (2012) on lettuce.

Concerning treatments; It is obvious from the data presented in Table 7 that application lettuce plants with the mixture of the three manures (chicken at 2.5 m<sup>3</sup> plus FYM at 5 plus compost manure at 3.7 m<sup>3</sup>/fed.) significantly decreased weight loss percentage of lettuce plants as compared to other treatments, the weight loss percentage reached 0.54 and 0.35 % in the first and 2<sup>nd</sup> seasons, respectively, while fertilization lettuce plants with chicken manure ranked the second in weight loss percentage which recorded 0.73 and 0.38 % in the first and second seasons, respectively. These results may be due to organic manure could increase dry matter, potassium and phosphorus in the lettuce plants (Masarirambi *et al.*, 2010) which depressed the respiration rate. Besides potassium increased osmotic potential in the

cells of fruits (Gardener, 1985) which diminished water loss in eggplant fruit during storage, and consequently retarded fresh weight loss. Similar results were obtained by El-Sheikh and Salama (1997) on tomato, which showed that chicken manure reduced weight loss and decay percentages of tomato fruits during storage.

On the contrary, fertilization lettuce plants with mineral fertilizers significantly increased weight loss percentage of lettuce plants during storage period. The increasing in weight loss percentage of lettuce plants due to application of mineral fertilizers may be owed to the high content of moisture in plants.

Regarding the effect of interaction between different sources of fertilizers and storage period, the results in Table 7 show that the highest values of weight loss percentage were recorded from lettuce plants which fertilized with mineral fertilizers at the end of storage period (16 days) which gave 1.82 and 0.50% in the first and 2<sup>nd</sup> seasons, respectively, on contrast, the lowest values of weight loss percentage at the end of storage period were occurred in a case of application lettuce plants with the mixture of the three manures that gave 0.97 and 0.38 % at the same period in the first and second seasons, respectively. These results were true in the two seasons and are in agreement with those of Abd El-Rahman and Hosny (2001) on eggplant fruits and Masarirambi *et al.*, (2010) on red lettuce.

**Table 7. Effect of different sources of organic fertilizers on weight loss percentage of lettuce plants during storage period in 2017 and 2018 seasons.**

Growth Treatments	Storage period in days				
	4	8	12	16	Means
	<b>Season 2016/2017</b>				
Mineral fertilizer	0.87f	1.12e	1.54b	1.82a	0.88a
Chicken manure	0.42j-l	0.74g	0.95f	1.32c	0.86d
FYM manure	0.75g	0.90f	1.30cd	1.61b	0.91b
Compost manure	0.62hi	0.87f	1.20de	1.51b	1.05c
Mixture *	0.32lm	0.52ij	0.71gh	0.97f	0.63e
Means	0.56d	0.83c	1.14b	1.45a	-
	<b>Season 2017/2018</b>				
Mineral fertilizer	0.42b-g	0.45a-d	0.47ab	0.50a	0.46a
Chicken manure	0.37h-k	0.37g-k	0.40e-i	0.42c-g	0.39c
FYM manure	0.40d-i	0.42b-g	0.45b-e	0.47a-c	0.42b
Compost manure	0.38g-k	0.39f-j	0.42c-h	0.44b-f	0.44c
Mixture *	0.33kl	0.35j-l	0.37i-k	0.38g-k	0.36d
Means	0.38bc	0.40b	0.42a	0.44a	-

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test.

\* Mixture (chicken manure at 2.5 m<sup>3</sup>plus FYM at 5 m<sup>3</sup>plus compost manure at 3.7m<sup>3</sup>/fed.)

### General appearance (GA)

General appearance (GA) included vegetative defects which occur in lettuce plants during storage period such as wilting and leaf discoloration. Concerning storage period, it is clear from the data presented in Table (8) that there was significant

decrease in general appearance of lettuce plants when the storage period was prolonged for all treatments, while the minimum values were occurred at the end of storage period (16 days). Generally, general appearance of lettuce plants began to deteriorate in all tested treatments after 12 days from storage. Obtained results were similar to those reported by Shehata *et al.* (2012) on lettuce.

As for treatments, the same data in Table (8) show that fertilization lettuce plants with the mixture of three manures (chicken plus FYM plus compost manure) led significantly to the highest general appearance of lettuce plants when compared to the other treatments followed by chicken manure without significant differences between them in both seasons of study.

On the contrary, the rate of decrement in general appearance was significantly the highest in plants that fertilized with mineral fertilizer. The decreasing in general appearance of lettuce plants due to application of mineral fertilizers may be owed to the high content of moisture in plants.

Regarding the effect of interaction, results in Table 8 show that the lowest values of general appearance were recorded from lettuce plants that fertilized with mineral fertilizer at the end of storage period (16 days) which recorded 1.00 and 3.67 in the first and 2nd seasons, respectively, on the other side, the best values of GA at the end of storage period were occurred in case of fertilization lettuce plants with the mixture of three manures which gave good appearance at the after 16 days of storage in both seasons of study.

**Table 8. Effect of different sources of organic fertilizers on general appearance of lettuce plants during storage period in 2017 and 2018 seasons.**

Growth Treatments	Storage period in days					
	Start	4	8	12	16	Means
	<b>Season 2016/2017</b>					
Mineral fertilizer	9.00a	9.00a	5.67de	3.00g	1.00h	5.53d
Chicken manure	9.00a	9.00a	8.33ab	7.67a-c	5.67de	7.93ab
FYM manure	9.00a	9.00a	7.00b-d	5.00ef	3.67fg	6.73c
Compost manure	9.00a	9.00a	7.67a-c	6.33c-e	5.00ef	7.40bc
Mixture *	9.00a	9.00a	9.00a	8.33ab	7.00b-d	8.47a
Means	9.00a	9.00a	7.53b	6.07c	4.47d	-
	<b>Season 2017/2018</b>					
Mineral fertilizer	9.00a	9.00a	7.00c	5.67d	3.67e	6.87d
Chicken manure	9.00a	9.00a	9.00a	8.33ab	7.00c	8.47ab
FYM manure	9.00a	9.00a	7.67bc	7.00c	5.00d	7.53c
Compost manure	9.00a	9.00a	8.33ab	7.67bc	5.67d	7.93bc
Mixture (2+3+4)	9.00a	9.00a	9.00a	9.00a	7.67bc	8.73a
Mixture *	9.00a	9.00a	8.20b	7.53c	5.80d	-
Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test.						
* Mixture (chicken manure at 2.5 m <sup>3</sup> plus FYM at 5 m <sup>3</sup> plus compost manure at 3.7m <sup>3</sup> /fed.)						

**Chlorophyll content:**

Data presented in Table (9) show a progressive and a significant decrease happened in chlorophyll content as the storage period was prolonged, where the maximum chlorophyll content was occurred at harvesting time, the minimum values were occurred at the end of storage period (16 days). Generally, lettuce plants became yellowish green with the extension of the storage period.

The reduction in chlorophyll content with the elapse of storage period may be due to the destruction of the chlorophyll and transformation of chloroplasts to chromoplasts by chlorophyllase activity (Hulme, 1970). These results are in agreement with those obtained by Shehata *et al.* (2012) on lettuce who found that chlorophyll reading in different plant organs decreased gradually with the prolongation of storage period.

Regarding treatments, it is clear from the same results in Table (9) that fertilization of lettuce plants with the mixture of the three manures (chicken manure plus FYM plus compost manure) significantly increased chlorophyll content of lettuce plants as compared to other treatments, the chlorophyll means all over the storage period were 41.02 and 43.02 SPAD in the first and second seasons, respectively, while using chicken manure ranked the second in chlorophyll means were 36.02 and 37.5 SPAD in first and 2<sup>nd</sup> seasons, respectively.

**Table 9. Effect of different sources of organic fertilizers on chlorophyll content (SPAD) of lettuce plants during storage period in 2017 and 2018 seasons.**

Growth Treatments	Storage period in days					
	Start	4	8	12	16	Means
	Season 2017					
Mineral fertilizer	36.11a-g	31.30d-i	28.22g-j	25.31ij	21.40j	28.47c
Chicken manure	41.11a-c	38.24a-e	36.53a-f	33.11c-i	31.11d-i	36.02b
FYM manure	38.25a-e	35.50b-g	33.13c-i	30.14e-i	26.21h-j	32.65b
Compost manure	39.23a-d	37.11a-e	34.21c-h	31.24d-i	28.31f-j	34.02b
Mixture *	44.35a	43.25ab	41.30a-c	39.00a-d	37.20a-e	41.02a
Means	39.81a	37.08ab	34.68bc	31.76cd	28.35d	-
	Season 2018					
Mineral fertilizer	36.41c-i	31.60g-k	28.52i-l	25.61kl	21.70l	28.77d
Chicken manure	42.61a-d	39.74a-g	38.03b-h	34.61d-j	32.61f-k	37.52b
FYM manure	38.75a-h	36.00c-i	33.63e-k	30.64h-k	26.71j-l	33.15c
Compost manure	40.23a-f	38.11a-h	35.21c-i	32.24f-k	29.31i-l	35.02bc
Mixture *	46.35a	45.25ab	43.30a-c	41.00a-e	39.20a-g	43.02a
Means	40.87a	38.14ab	35.74bc	32.82cd	29.91d	-

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test.

\* Mixture (chicken manure at 2.5 m<sup>3</sup> plus FYM at 5 m<sup>3</sup> plus compost manure at 3.7m<sup>3</sup>/fed.)

These results may be due to the different specifying of nitrogen and magnesium content in mixture manure and chicken manure more than its contents in the other treatments. This result was in line with the work of Silva *et al.* (2017) on lettuce plants who reported that using organic fertilizers significantly increased chlorophyll content in leaves.

Concerning the effect of interaction, generally it is clear that the highest values of chlorophyll content at the end of storage period (16 days) were noted in case of fertilization lettuce plants with the mixture manure (37.2 and 39.2 SPAD) followed by fertilization with chicken manure (31.11 and 32.61 SPAD) in the first and second seasons, respectively.

**Polyphenol oxidase activity (PPO):**

Data presented in Table (10) show that there was a progressive and significantly increase in PPO activity as the storage period was extended, where the minimum values of polyphenol oxidase activity occurred at harvesting time (0.373 and 0.369 %) while the maximum values were occurred at the end of storage period (0.458 and 0.454 %) in the first and second seasons, respectively. These results are in agreement with those obtained by Shehata *et al.* (2012) on lettuce.

Concerning treatments, it is clear from the same data in Table 10 that fertilization lettuce plants with mineralfertilizer significantly increased polyphenol oxidase activity of lettuce plants as compared to other treatments; the man of PPO activity was 0.457 and 0.455 % in the first and 2<sup>nd</sup> seasons respectively, while using farmyard manure ranked the second.

**Table 10. Effect of different sources of organic fertilizers on polyphenol oxidase percent of lettuce plants during storage period in 2017 and 2018 seasons.**

Growth Treatments	Storage period in days					
	Start	4	8	12	16	Means
	<b>Season 2016/2017</b>					
<b>Mineral fertilizer</b>	0.398e-i	0.431b-f	0.462a-c	0.482ab	0.510a	0.457a
<b>Chicken manure</b>	0.362h-j	0.386f-j	0.392e-j	0.420c-g	0.440b-e	0.400c
<b>FYM manure</b>	0.387f-j	0.411c-h	0.432b-f	0.458b-d	0.477ab	0.433b
<b>Compost manure</b>	0.376g-j	0.395e-i	0.413c-h	0.437b-f	0.457b-d	0.416bc
<b>Mixture *</b>	0.342j	0.357i-j	0.374g-j	0.395e-i	0.408d-i	0.375d
<b>Means</b>	0.373c	0.396bc	0.415b	0.438a	0.458a	-
	<b>Season 2017/2018</b>					
<b>Mineral fertilizer</b>	0.376f-j	0.429b-g	0.460a-c	0.480ab	0.508a	0.455a
<b>Chicken manure</b>	0.357i-k	0.381g-k	0.387f-k	0.415c-h	0.435b-f	0.395c
<b>FYM manure</b>	0.384f-k	0.408d-i	0.429b-g	0.455b-d	0.474ab	0.430b
<b>Compost manure</b>	0.372h-k	0.391f-j	0.409c-h	0.433b-f	0.453b-e	0.412bc
<b>Mixture *</b>	0.336k	0.351jk	0.368h-k	0.389f-j	0.402e-j	0.369d
<b>Means</b>	0.369c	0.392bc	0.411b	0.434a	0.454a	-

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test.

\* Mixture (chicken manure at 2.5 m<sup>3</sup>plus FYM at 5 m<sup>3</sup>plus compost manure at 3.7m<sup>3</sup>/fed.)

On contrast, the lowest mean values of polyphenol oxidase activity occurred in case of fertilization with the mixture of the three manures which recorded 0.375 and 0.369 % in both seasons, respectively.

Regarding the effect of interaction, the same results in Table 10 show that, the lowest values of PPO activity were recorded from lettuce plants which fertilized with the mixture of the three manures (chicken manure plus FYM plus compost

manure) at the beginning of storage period whilst, the highest values were at the end of storage period (16 days) in case of fertilization with mineral fertilizer.

#### Total phenolic contents:

Data presented in Table (11) show that total phenolic contents increased at the beginning of the storage period then dramatically decreased at the end of storage period (16 days).

The decrease of this content is probably due to the oxidation by PPO (Shehata *et al.* 2012), it is also reported that, quercetin was oxidized directly by PPO. Moreover, Robards *et al.* (1999) found that the role of phenolic compounds in processing of oxidation as antioxidants and as substrates in browning reaction. Obtained results were similar to those reported by Shehata *et al.* (2012) on lettuce.

**Table 11. Effect of different sources of organic fertilizers on total phenolic contents (mg/100g f.w) of lettuce plants during storage period in 2017 and 2018 seasons.**

Growth Treatments	Storage period in days					
	Start	4	8	12	16	Means
<b>Season 2016/2017</b>						
Mineral fertilizer	12.50hi	11.70k	11.00mn	10.06p	9.01q	10.35e
Chicken manure	13.90b	13.02ef	12.70g	12.00j	10.90n	12.50b
FYM manure	13.30d	12.60gh	11.90j	11.10m	10.10p	11.80d
Compost manure	13.60c	12.90f	12.55g-i	11.70k	10.60o	12.27c
Mixture *	14.22a	13.68c	13.20de	12.40i	11.40l	12.98a
Means	13.50a	12.78b	12.27c	11.45d	10.40e	-
<b>Season 2017/2018</b>						
Mineral fertilizer	13.50h	12.70j	12.00l	11.06n	10.01o	11.85e
Chicken manure	14.93b	14.05e	13.73fg	13.03i	11.93l	13.53b
FYM manure	14.31d	13.61gh	12.91i	12.11l	11.11n	12.81d
Compost manure	14.61c	13.91ef	13.56gh	12.71j	11.61m	13.28c
Mixture *	15.27a	14.73c	14.25d	13.45h	12.45k	14.03a
Means	14.52a	13.80b	13.29c	12.47d	11.42e	-

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test.

\* Mixture (chicken manure at 2.5 m<sup>3</sup>plus FYM at 5 m<sup>3</sup>plus compost manure at 3.7m<sup>3</sup>/fed.)

As for treatments, it is obvious from the same data in Table 11 that application lettuce plants with the mixture of the three manures (chicken at 2.5 m<sup>3</sup>plus FYM at 5 plus compost manure at 3.7 m<sup>3</sup>/fed.) significantly increased total phenolic content of lettuce plants as compared to other treatments while chicken manure ranked the second in this respect.

The interaction between different sources of fertilization and storage period was significant; however the lowest values of total phenolic contents were at the end of storage period (16 days) in plants fertilized with mineral fertilizers. While the highest ones of this compound was found in lettuce plants treated with the mixture of the three manures (chicken at 2.5 m<sup>3</sup>plus FYM at 5 plus compost manure at 3.7 m<sup>3</sup>/fed.), these results hold true in both seasons of study.



## CONCLUSION

From the previous results of this investigation, it could be concluded that fertilization lettuce plants with chicken manure (7.5 m<sup>3</sup>/fed.) or with the mixture of chicken at 2.5 m<sup>3</sup> plus FYM at 5 plus compost manure at 3.7 m<sup>3</sup>/fed., were the superior treatments for produce the best values of vegetative growth parameters, fresh and dry weight per plant organs, root system, nitrate content and yield of lettuce plants. These treatments also reduced weight loss percentage and PPO activity, maintained chlorophyll and total phenolic contents and gave lettuce plants with good appearance after 12 days at 0°C and 90-95% RH. for chicken manure and after 16 days for the mixture treatment.

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## تأثير مصادر مختلفة من الأسمدة العضوية على النمو والمحصول والقدرة التخزينية لنباتات الخس

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أجريت هذه الدراسة خلال الموسم الشتوى لعامى 2017/2016 ، 2018/2017 بمزرعة التجارب البحثية، محطة بحوث البساتين بالقصاصين – محافظة الاسماعيلية لدراسة تأثير مصادر مختلفة من الأسمدة العضوية مثل سماد الدواجن ، السماد البلدى ، سماد الكمبوست وخليط منهم مقارنة بالسماد المعدنى على الصفات المورفولوجية ، الوزن الطازج والجاف لأجزاء النبات المختلفة ، قياسات المجموع الجذرى للنبات ، المحصول ومكوناته على نباتات الخس البلدى النامية تحت ظروف الأرض الرملية. كما تهدف الدراسة أيضاً إلى دراسة تأثير المعاملات سابقة الذكر على القدرة التخزينية لرؤوس الخس أثناء التخزين على درجة صفر 0 مئوية ورطوبة نسبية من 90-95% خلال فترات تخزين مختلفة (صفر ، 4، 8، 12 ، 16 يوماً).

سجلت معاملة تسميد نباتات الخس بسماد الدواجن بمعدل 3م7.5 /فدان ، ومخلوط من الأسمدة (سماد الدواجن بمعدل 3م2.5+ سماد بلدى بمعدل 3م3+ سماد الكمبوست بمعدل 3م3.7 /فدان) بأى منهما زيادة معنوية لكلا من القياسات المورفولوجية ، الوزن الطازج والجاف لأجزاء النبات المختلفة ، قياسات المجموع الجذرى للنبات ، النسبة المئوية لمحتوى النبات من الماء بالإضافة إلى المحصول ومكوناته. بينما أدت إلى إنخفاض محتوى الأوراق من النترات وبدون فرق معنوى بين المعاملتين فى معظم الحالات.

كما اوضحت النتائج أن استخدام سماد الخليط ( سماد الدواجن بمعدل 3م2.5+ سماد بلدى بمعدل 3م3+ سماد الكمبوست بمعدل 3م3.7 /فدان) أو سماد الدواجن قد أدى إلى تحسين القدرة التخزينية لنباتات الخس حيث أدى إلى تقليل نسبة فقد الوزن ونشاط انزيم البولى فينول أوكسيديز كما حافظت على كمية الكلوروفيل والفينولات الكلية أثناء التخزين وأعطت نباتات ذات مظهر جيد بعد 12 يوم من التخزين للمعاملة سماد الدواجن وبعد 16 يوم للمعاملة بالخليط.

