Palestine Technical University Research Journal, 2020, 8(2), 40-53

Influence of Different Types of Fertilizers Application on the Lettuce (Lactuca Sativa L.) Growth and Quality

تأثير استخدام أنواع مختلفة من الأسمدة على نمو ونوعية الخس(Lactuca sativa L.)

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Received: 06/09/2020 **Accepted: 22/11/2020** **Published: 01/12/2020**

Abstract: The experiment was conducted during the period from March to the end of April 2019 to observe the effect of different fertilizer regimes on the growth, quality and yield of lettuce under field conditions. The experiment was consisting of four treatments as well as a control without fertilizer T1, compost T2, compost tea T3 and chemical fertilizer T4, in each treatment 50 replicates were planted. The measurements included wet and dry weight for shoot and root, plant length, and chlorophyll percentage. The study revealed that lettuce's best growth values were obtained with the use of eco-friendly organic fertilizer accompanied by more than control one and chemical fertilizer. The average maximum length of plants after 60 days was recorded in T2 (42.3 cm) > T3 (37.3 cm), T4 (35.9 cm) and > T1 (23.8 cm). The results indicated that compost treated plant (T2 and tea compost T3) had highest chlorophyll content, i.e., 42.3 and 40.6%, respectively, as compared to chemical fertilizers T4 (37.3%) and the lowest chlorophyll content was in control T1 (30.9%). The values for wet shoot and root after 60 days were: 1575.2, 81.5 gm T2 > 1367.6, 64.9 gm T3 > 1251.1, 53.4 gm T4 and 612.1, 43.7 gm T1, respectively. The values for dry shoot and root after 60 days were: 131.5, 8.2 gm, T2 > 112.7, 6.4 gm, T3 > 101.9, 5.3 gm T4 and > 51, 4.1 gm T1, respectively.

Keywords: Lettuce, Compost, Tea compost, Fertilizers, Growth, Quality.

المستخلص: أجريت التجربة خلال الفترة من مارس إلى نهاية أبريل 2019 لمراقبة تأثير أنظمة الأسمدة المختلفة على نمو وجودة وإنتاجية الخس تحت الظروف الحقلية. احتوت التجربة على أربع معاملات: بدون سماد (كونترول) T1، والسماد العضوي (كومبوست) T2، والسماد العضوي السائل (شاي الكومبوست) T3، والسماد الكيميائي T4، وفي كل معاملة تمت زراعة 50 مكرراً. تضمنت القياسات الوزن الرطب والجاف للساق والجذر وطول النبات ونسبة الكلوروفيل. أوضحت الدراسة أنه تم الحصول على أفضل قيم لنمو الخس باستخدام السماد العضوي T2 وT3 الصديقة للبيئة أكثر من المعاملة بالسماد الكيماوي. تم تسجيل متوسط الطول الأقصى للنباتات بعد 60 يومًا في T2 (42.3 سم) > T3 (37.3 سم)، T4 (35.9 سم) و> T1 (23.8 سم). أشارت النتائج إلى أن النبات المعامل بالكومبوست (T2 وسماد الشاي T3) كان يحتوي على أعلى محتوى من الكلوروفيل، أي (42.3 و40.6٪) على التوالي، مقارنة بالأسمدة الكيماوية T4 (37.3٪) وكان أقل محتوى من الكلوروفيل في مجموعة الكونترول T1 30.9٪. كانت قيم المجموع الخضري الرطب والجذر

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بعد 60 يومًا: 1575.2، 81.5غم، 1367.6 T2، 64.9 غم T3، 1251.1، 53.4 غم T4 و612.1، 43.7 غم T1 على التوالي. كانت قيم المجموع الخضري الجاف والجذر بعد 60 يومًا: 131.5، 8.2 غم، > 112.7 T2، 6.4 غم T3، > 101.9، 5.3 غم T4 و> 51، 4.1 غم T1 على التوالي.

الكلمات المفتاحية: خس، سماد عضوي، سماد الشاي، أسمدة، نمو، جودة.

INTRODUCTION:

Lettuce (Lactuca sativa L.) is an annual plant that belongs to one of the important vegetables in the salad crop family Compositeae. It is the world's most sought-after salad crops. It is native to Europe, Asia and North Africa, and has been grown for 5000 years. The word lettuce is often used to refer to the succulent, edible L leaves. Sativa, usually consumed raw in salads but can also be cooked (Katz and Weaver, 2003).

Lettuce is one of the most widely consumed vegetables in the world as it is a good source of fiber but it has low calories, fat and sodium. Besides, it is a good source of iron, folic acid, and vitamin C, and very good for health from various bioactive compounds (Kim et al., 2016). Lettuce is an annual herbaceous plant that grows upright from (12.5 to 25) cm in leaves, with plant height up to 50 cm in length (Ali et al., 2016).

Lettuce ranks 26th out of 39 vegetables with a high nutritional value and is the fourth feed. It's primarily a cold-loving crop that grows well at 18 to 25°C daytime temperature and 10 to 15°C night temperature (Prota, 2010).

Organic fertilizers not only have the required nutrients but also have positive effects on overall soil produc-tivity and can be used effectively in traditional farming as an essential fertilization method (Bharambe, 2015).

State of the soils and their state of health is important for agricultural production. Degraded soils and low soil productivity are the major constraints to food security and income levels of smallholder farmers in developing countries who are so dependent on the land and deeply attached to it for their survival (Natsheh et al., 2015; WOCAT, 2007; Spore, 2009).

Owing to the high mineralization rates, the Mediterranean climate is mostly characterized by clay soils and a substantial annual loss of organic matter. Large uses of mineral fertilizers have significantly led to envi-ronmental degradation (atmosphere, soil, and water) in recent decades. One of the potential solutions for minimizing the use of chemical fertilizers could be the implementation of organic modifications from agri-cultural waste recycling. Compost application is a good method, as field recycling and agro-industrial res-idues provide many agricultural benefits, e.g. soil preservation/restore organic carbon (C) and plant disease control (Hoitink et al., 2001; Flavel and Murphy, 2006; Raviv et al., 2008) also pointed out that its application constituted a relatively cheap nutrient source.

Because of the environmental effects of mineral fertilization, organic fertilization may be a better choice, with the plant, soil and environment benefits (Leogrande et al., 2013). Since fertilization and irrigation activities tend to be some of the causes of nitrate contamination, the use of the new organic residues

must be inves-tigated (Guerrero et al., 2005); on the other hand, effective management of the application of inorganic fer-tilizers has been shown to minimize the issue of nitrogen leaching in soil and groundwater (Guerrero et al., 2002). Compost application to soil is environmentally sustainable, particularly in soils with lower fertility, characteristic of southern Portugal, increasing soil fertility and improving crop production (Brito et al., 2007). Compost was already applied as organic fertilizer to lettuce (Lactuca sativa L.) and aspects of quantitative and qualitative yield were studied (Alvares et al., 2002).

The chemical fertilizers used in conventional agriculture contain just a few minerals, which quickly dissolve in damp soil and give large doses of minerals to the plants. Organic fertilizers can therefore be used to re-duce the number of toxic compounds (such as nitrates) produced in vegetables such as lettuce by conven-tional fertilizers, thereby improving the quality of the leafy vegetables produced as well as human health (Ma-sarirambi et al., 2010).

Currently, people are willing to get vegetables without inorganic fertilizer because people suffer from some severe diseases due to the inorganic fertilizer effect (Asaduzzaman et al., 2010). With growing consumer concerns about the environment and the chemicals used in food production, and the availability of certified organic products, the outlook for the continued growth of organic production is bright (Dimitri and Greene, 2002). Farm income will also increase as farmers use less money to grow crops with fertilizers and pesti-cides (Masarirambi et al., 2010).

The research was undertaken to observe the evolution and yield of the application of lettuce (Lactuca sativa L.) under various fertilizer regimes (compost, compost tea and chemical fertilizers), to find the optimal ferti-lizer for higher growth and output in an environmentally friendly manner.

MATERIAL AND METHODS

Study Area:

Tulkarm lies northwest of Palestine **Figure (1).** Tulkarm district has a total area of around 246 km2. Its actual population is estimated at 167,000, representing approximately 12 per cent of the total West Bank population (PCBS, 2010). The number of rural residents reaches 55% of the total population. In Tulkarm region, the population density is around 679 people.

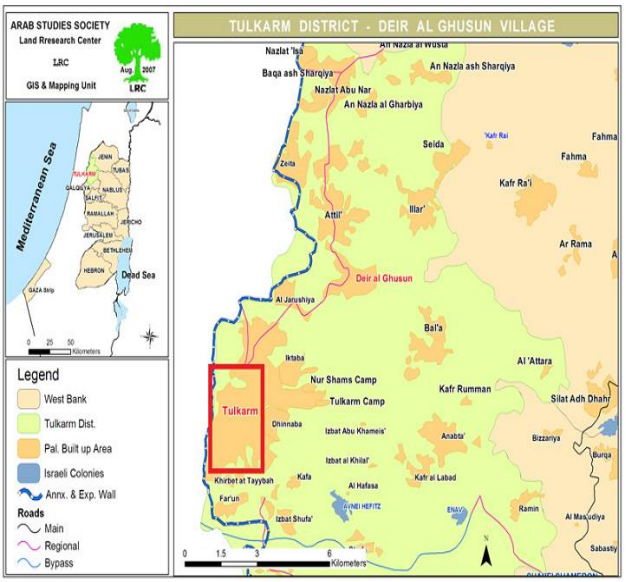

Figure (1): Study area in Tulkarm city including place point from the experiment.

This study was conducted in 2019 to observe the effect of different application of fertilizer regimes on the growth and yield of lettuce during the period from March to the end of April 2019 under the field conditions. The experiment was consisting of four treatments as follows: without fertilizer (control) (T1), Compost (T2), Tea Compost (T3) and Chemical fertilizer (T4). Two lines * 25 plants give 50 replicates were planted in each treatment, as shown in (Figure 2). The measurements included wet and dry weight for the shoot, wet and dry weight for root, plant length and percentage of chlorophyll. The plants were grown with temperature regimes of 18/26°C night/day. Other Crop Management aspects followed conventional practices. Lettuce samples were taken 4 times and harvested 60 days later.

Land Preparation:

To obtain a good tilth condition, the experiment land was ploughed a few times. The field was levelled and all the weeds, stubbles and crop residue cleared and eventually prepared for lettuce transplants to be planted. The field was divided into four blocks, as illustrated in **Figure (2),** and irrigated by tap water using a drip irrigation system, soil which used clay soil and high retention water. Plastic mulch also used as a layer of material applied to the surface of the soil. Reasons for applying mulch include soil moisture conservation, improvement of soil fertility and health, reduction of weed growth and enhancement of area visual appeal. A soil science tensiometer is used as a measuring tool to assess the capacity of matric water (moisture stress of the soil) in the root region. The plants were cultivated with a temperature regime of 18/26°C night/day. Some crop management elements accompanied traditional methods.

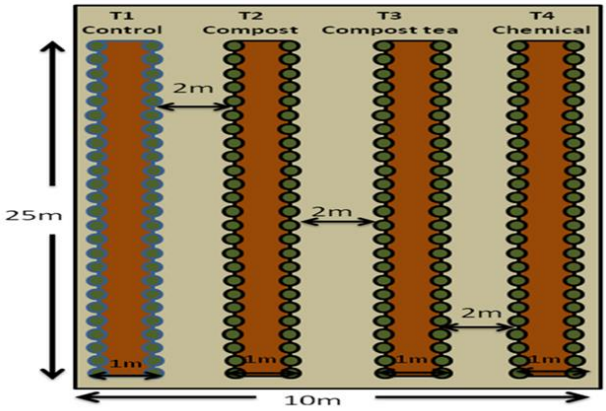

Figure (2): The layout of the experimental field. Note: T = Treatment and ● = Replications

Fertilizers:

ompost is an organic matter (animal product, plant product, or manure bio-solids) that has been broken down into a nutrient-rich, humus-like substance to be used as fertilizer and soil alteration (Bezanson, 2014). Compost tea is generally produced by steep compost in water, just like a teabag in hot water, producing a high-nutrient liquid that is rich in organic matter (Ingram and Millner, 2007). The smallholder farm can see commercially available products with names such as compost extract, compost leachate, organic tea or manure tea, but all of these refer to the watery end-product of circulating water through compost, thus maintaining conditions conducive to the microbial activity required to break down the organic base material (Valerisa et al., 2017).

There are many reported benefits for applying compost teas to soil and/or plants, including increased soil water retention, enhanced soil fertility and reduced dependency on chemical pesticides and fertilizers (Dearborn, 2011).

Adding compost to the soil every season of planting is a good practice, as compost is rich in nutrients, and it encourages soil microbes to help grow plants. In a nutshell, compost is organic matter, which is decomposed. Composting is a natural process of recycling organic materials such as leaves and vegetable scraps into a rich soil modification that gardeners nickname Black Gold with fondness.

The best way to differentiate between compost and fertilizer is to feed the soil to feed the plants. The organic matter in compost sponges up the nutrients of the fertilizer until the plants need them. Compost also contains many nutrients, such as boron, which is needed by plants in small quantities. The farmer can use fertilizer without compost, but will miss a chance to improve the fertility of the soil and its capacity to retain the moisture. Soil that is frequently changed (i.e. improved) with compost becomes marvelously dark and crumbly and therefore needs much less fertilizer than soil that has not yet benefited from daily composting aids.

In treatments, the fertilizer system was different. Organic fertilizers (compost) used as solid materials 600 kg/dunum applied to the soil as a pre-farming section, tea compost extract liquid organic fertilizer applied with irrigation water 560L / dunum six times during the agricultural era. On the other side, the various chemical fertilizers used as examples during the agricultural era as illustrated in **Table (1)**.

Table (1): Illustrated fertilizers used in the experiment per dunum (1000m^2).

Fertilizer	Components	Amount	Unit
Compost	Organic bulk	600	Kg
Tea Compost	liquid	360	Litter
	Composed fertilizer		
Chemical	NPK 13-13-13 and	20	kg
fertilizers	NPK 11-8-20	20	
	Fe-EDDHA	2	

Harvesting and Collecting Data:

The harvesting was performed four times at various stages of growth to test growth and yield. Harvesting was done at 15, 30, 45 and 60 days after the transplants were grown. Different yield contributing data were collected from the mean of four harvested plants, which were randomly selected from each harvesting stage of each procedure.

DATA ANALYSIS:

Collected data were statistically analyzed by Microsoft Office Excel and multivariate statistical analysis. Multivariate statistical data analysis and calculations were carried out using 'Unscrambler' v. 10.3 (Camo, ASA, Oslo, Norway), a statistical software package for multivariate data analysis. Principal component analysis (PCA) was used for the experiment data. PCA is one of the multivariate techniques, and it is used to identify patterns in a data set derived from recording several characteristics at a time to eliminate redundancy in univariate analysis The PCA is explained by principal components (PCs), which are composite variables, since they are linear functions of the original variables, estimated to contain the main structured information in the data. PCs are also called latent variables, and a PC is the same as a score vector. The scores plot in PCA reveals the relation between samples measured (Khayat et al., 2012; Marei et al., 2014)

RESULTS AND DISCUSSION:

Figure (3) shows the scores plot of PCA. Two principal components explained 99% of the total variation. There is a clear distinguishing between groups of treatments (i.e., T1, T2, T3 and T4) during the cultivation time (i.e., 15, 30, 45 and 60 days.

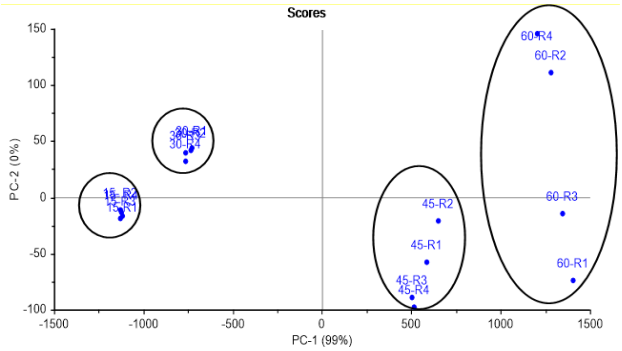

Figure (3): Score's plot of the principal component analysis (PCA) for different treatments. Groups are separated clearly according to different treatments and cultivation time.

Effect of different fertilizers application on Lettuce length (cm):

The results showed substantial differences in lettuce length parameter among treatments **Figure (4)**. Where using different types of fertilizers, i.e., T2, T3 and T4, resulted in an increased length for lettuce more than control T1 during the 4 stages time of the experiment. On the other hand, the average maximum length of plants after 60 days was recorded in T2 (42.3 cm) > T3 (37.3 cm) T4 (35.9 cm) which are greater than > T1 (23.8 cm). Also, the effect of organic fertilizers T2 and T3 gave better lettuce length more than chemical fertilizer T4.

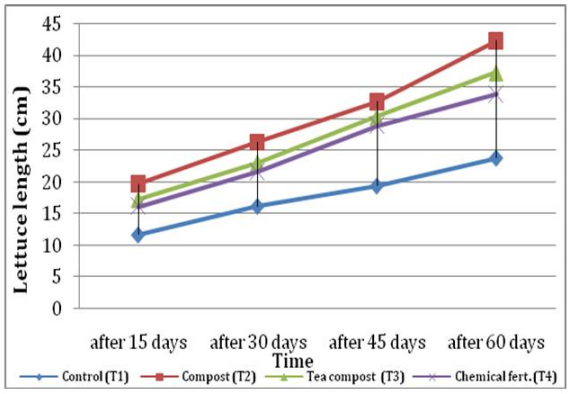

Figure (4): Impact on Lettuce length (cm) of various fertilizers

Sanni et al. (2016) stated that plant height is a variety of genetic character but its ability can be obtained through adequate soil fertility. The positive response and increased in lettuce plant height with applied fertilizer treatments may be due to the low initial nutrient status in the used soils, which revealed the vital role of soil nutrient status in crop production.

Our findings were similar to Michael et al. (2012) who reported that the plant treated with poultry manure gained maximum plant height compared with inorganic fertilizer. This is consistent with the many researchers' observations and studies (Izunobi, 2002). It is also similar to the findings of Fagimi and Odebode (2007) which recorded an increased plant height of pepper resulting from high chicken manure application. Taha et al. (2017) stated that it is commendable to note that organic compost-fed lettuce fertilizer plants (15 m3/fed) provided the maximum plant height values after 70 days of growing season transplantation.

Impact of various application of fertilizers on the chlorophyll content:

SPAD (Chlorophyll Meter) system calculated the results of the chlorophyll data. The chlorophyll readings of the leaves during the experimental phase in all treatments for the four phases. Chlorophyll is the green pigment that allows plants to photosynthesize. The chlorophyll content was significantly influenced by organic fertilizers and interaction of compost and lettuce cultivars **(Figure 5).** The results indicated that compost T2 and Tea compost T3 treated plant had highest chlorophyll content with 42.3 and 40.6%, respectively, as compared to chemical fertilizers T4 37.3% and the lowest chlorophyll content was in control T1 30.9%.

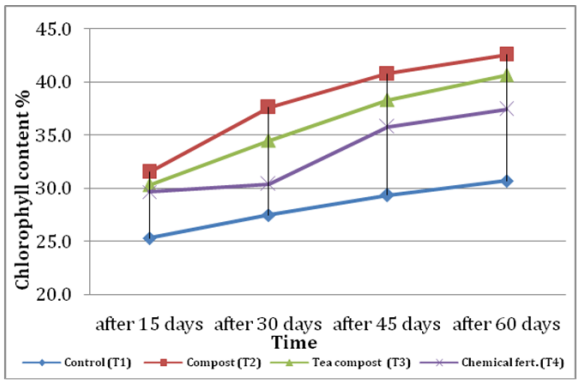

Figure (5): Impact of various application of fertilizers on the chlorophyll content (%)

Hasan et al. (2014) reported the impact of organic material form and sheep manure application system on a 3% increase in chlorophyll compared to the one treated with peat. The chlorophyll content in the leaves has shown important interactions between organic materials, application methods, and concentration. Because of this association, marigold has the highest chlorophyll amount in the leaves with sheep manure administered by 40 per cent spraying (76.9 mg/100 gm wet weight).

Factors affecting chlorophyll synthesis include the availability of light, carbohydrate, temperature, genetic, and nitrogen. Chlorophyll is the main pigment in plants, the main purpose of which is to absorb solar energy in photosynthesis, cause CO2 to generate carbohydrates and provide energy. Different organic fertilizers do not significantly affect the total chlorophyll in lettuce plants because the dose of fertilizer provided by crop N requires similar but separate sources, so that N is similar to that required for the growth of lettuce plants. Based on organic sources including essential nutrients for plant growth, chlorophyll and chloroplast formation is positively affected (Hasan et al., 2014; Widyati et al., 2017). Organic acids and carbon dioxide play a role in improving the availability of certain nutrients such as Mg, which plays an important role in chlorophyll molecule formation. (Reis et al., 2014) demonstrates leaf SPAD (Chlorophyll meter), determined along with the experiment. The findings showed an increase with the compost added increasing.

Impact of application of various fertilizers on the wet and dry shoot and root weight (gm):

Concerning the effect of various fertilizers on treatments such as Compost T2, Tea compost T3 and chemical fertilizers T4, the results obtained showed that organic fertilization treatments (T2 and T3) have a major impact on fresh and dry weights of lettuce plants after 60 days of growing season transplantation **(Figures 6 and 7)** more than chemical fertilizer T4. On the other hand, it is important to use the fertilizers in the agriculture irrespective of the form of fertilizer because it increases productivity more than control T1. It is commendable to note that organic fertilizers such as compost provided the maximum values of plant fresh and dry weights, concentration and uptake of nutrients due to the application of organic fertilizers (com-post T2 and compost tea T3) for shooting and root plants can be attributed to organic fertilizers ex-mostly for growth and yield of lettuce plants, the values for the wet shoot and root after 60 days were as follow 1575.2, 81.5 gm T2 > 1367.6, 64.9 gm T3 > 1251.1, 53.4gm T4 and 612.1, 43.7gm T1, respectively **(Figures 6 and 7)**. Also, the use of organic fertilizers (compost T2 and compost tea T3) is more friendly with the environment and give more good effects with time for soil. It provides a steady

supply of both macro and micronutrients and improves soil physical, chemical and biological properties, while chemical fertilizer T4 can increase productivity, but there are some negative environmental impacts, especially on agricultural soils.

The use of organic fertilizer in agriculture has a long history; it has given rise to interest in recent years by recognizing the very harmful environmental impacts of chemical fertilizers and by taking serious account of sustainable and organic farming. These results are in line with the findings of Caliskan et al. (2014) and Melese (2016).

Mrabet et al. (2012) found that the lettuce yield improvement was proportionally related to the dose of the compost used. Farag et al. (2013) indicated that the highest amount of application compost (4% by volume) provided the highest vegetative growth and lettuce yield relative to other treatments (0 and 24% by volume). Moreira et al. (2014) suggest the use of organic compost as a source of organic matter, as it showed the best outcome of lettuce plant diameter, plant height, fresh and dry root and shoot weights.

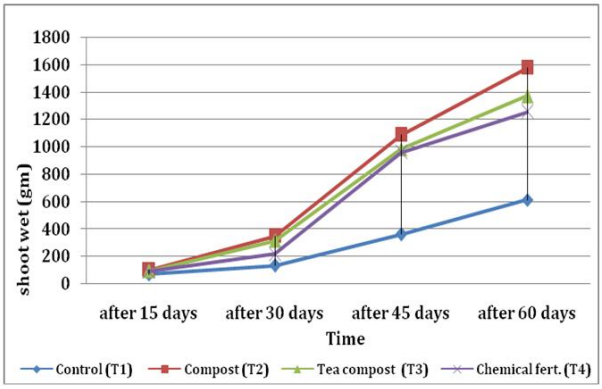

Figure (6): Impact of different application of fertilizers on wet weight shoot (gm)

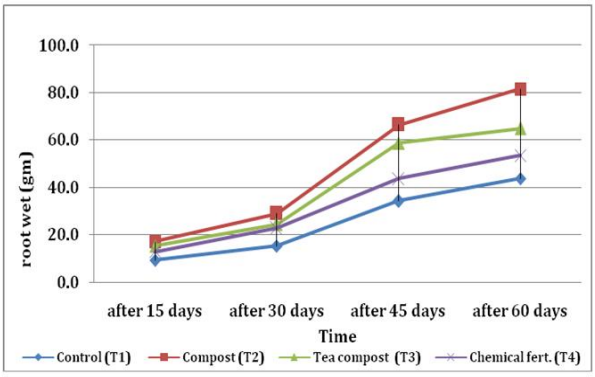

Figure (7): Impact of different application of fertilizers on wet weight root (gm)

Organic fertilizer allowed microbe biomass to improve soil fertility (Purbajanti et al., 2016). Increasing the amount of organic matter would improve the soil's capacity to hold water and increase the quality of soil nutrients, including nitrogen, phosphate and trace nutrients mobilized and concentrated in the top layer of soil that can be used by plants and hence the incorporation of organic material into plant cultivation Abiotic stress is expected to increase the availability of plant resources needed to increase crop productivity in soil dry experiences (Subaedah et al., 2016). Nitrogen release from most of these sources is sluggish and highly dependent on processes of soil mineralization. The supply of nitrogen affects a series of physiological processes, morphological features and yield components (Tiemens-

Hulscher et al., 2014). Manure significantly increased fruit yield, fruit weight, fruit diameter flesh thickness, and sugar content, but did not increase seed weight, and reduced Psidium guava's total fruit acid content (Purbajanti et al., 2016). Many data suggest that the use of organic fertilizers such as manure can improve soil and nutrient biological properties, crop production and crop quality. Manure is a valuable source of plant nutrients since it can improve soil quality and productivity (Hariadi et al., 2015).

Lettuce plants have undergone substantial differences in shooting and root dry matter. The values for the dry shoot and root after 60 days were as follow 131.5, 8.2 gm T2 > 112.7, 6.4 gm T3 > 101.9, 5.3gm T4 and 51, 4.1gm T1, respectively **(Figures 8 and 9)**. The maximum content of dry matter was found in T2 and T3 when organic fertilizers were used, and the minimum content of dry matter was found in T1. Research by Magkos et al. (2003) also found similar results in determining the dry matter content of many vegetables and found that organically grown crops had a higher dry matter content than conventionally grown crops. However, these findings are only evident for plants growing above the ground (leaf vegetables), such as spinach, lettuce, chard, savoy cabbage and white cabbage (Magkos et al., 2003).

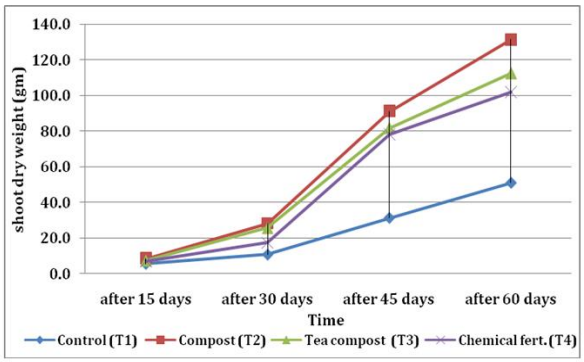

Figure (8): Impact of various application of fertilizers on dry weight shoot (gm)

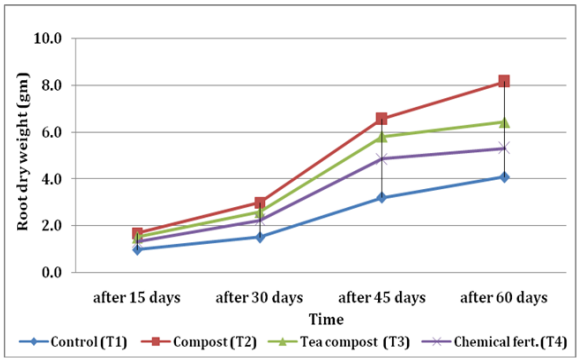

Figure (9): Impact of different application of fertilizers on dry root weight (gm)

Moreira et al. (2014) suggest the use of organic compost as a source of organic matter, as it showed the best outcome of lettuce plant diameter, plant height, fresh and dry root and shoot weights. Caliskan et al. (2014) showed that the lettuce growth, yield and content of vitamin C were higher in the organic system compared to conventional production.

The quality of lettuce in post-harvest stages will be affected by the pre-harvested stages according to many studies, where they found that there is an effect of different nitrogen applications on quality parameters of lettuce (Liu et al. 2014; Mampholo et al. 2019) .

CONCLUSION:

Using organic fertilizers in agriculture provides an alternative solution to chemical fertilizers in low fertility agricultural areas. Indeed, our work has shown that organic fertilizer fertilization affects lettuce growth (Lactuca sativa L.) and this can affect the quality. Results from the experiment suggested that the best lettuce growth values were obtained by the use of eco-friendly organic fertilizer (Compost T2 and Tea Compost T3) compared with chemical fertilizers and the lowest yield was obtained after 60 days of transplantation via control treatment. The study also concluded that T2 treatment by using 600 kg/dunum compost was the best dose of organic fertilizer to increase lettuce output as it provided the highest yield per dunum which was also economically viable.

ACKNOWLEDGMENT:

The researchers would like to thank Palestine Technical University- Kadoorie (PTUK) for continuous support the applied research.

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