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The Physiological Response of Strawberry (*Fragaria xananassa Duch.*) to Different Types of Organic and Chemical Fertilizer

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Abstract

Two separate experiments were carried out on sandy clay loam soil during fall season at Mu'tah University, Agricultural Research Station, Rabba in the southern part of Jordan. These studies aims to evaluate the effect of organic manure and chemical fertilizers on growth, yield, quality and nutrients uptake of strawberry (*Fragaria xananassa* Duch.). Treatments in experiment were assigned randomly in randomize complete block design with split-split-plot arrangement.

The results revealed that plots treated with combination of organic manure and chemical fertilizers levels tended to increase yield of strawberry, fruits number and leaf area of strawberry were increased in response to organic manure and chemical fertilizers application.

Different manure and chemical fertilizer levels combinations were significantly increased strawberry vegetative growth, but not dry weight, which was found to be increased significantly by chemical fertilizer levels only.

Vitamin C and TSS% content were higher in strawberry received organic manure compared with the chemical fertilizers as well as control treatments. Macro- and micro-nutrients uptake by strawberry (fruit and leaves) were higher in plots treated with the combination of manure and chemical fertilizers levels compared with each of them individually.

Strawberry plant were severely injured or killed after transplanting due to adding high rates of chicken manure (40, 60 and 80 ton/ha). In strawberry soil received different fertilizers combination had no significant effect on macronutrients (N, P and K) content.

Keywords: Organic Manure, NPK Fertilizer, Growth, Yield, Quality, Strawberry

Introduction

Vegetable crops are very important to human daily nutrition, because they are rich in, vitamins, mineral salts, carbohydrate, and proteins. In Jordan, the average area that is planted with vegetables in 2003 was about 34420 hectare; their productivity in the same year was about 1168400 ton (Statistical year book, 2003).

Strawberry (*Fragaria xananassa* Duchesn.) is a perennial, cool-season crop, its popular as a fruit, which is used fresh. Strawberry can be grown in Jordan both in spring and fall, mainly

grown in protected culture, it's growing now in limited area, and however there is a trend to increase cultivation by farmers.

Recently, the alternative practice to chemical fertilizers is organic manurethat was added directly to the soil either before or later on after planting, to overcome the pervious problems. Furthermore, organic fertilizers become a necessity in intensive agriculture and in all around the world where chemicals are used intensively (Tuzel *et al.,* 2003). Although mineral fertilizers are highly soluble; therefore, they are difficult to use them efficiently, the organic fertilizers like manure are not soluble and releases nutrients slowly. It was found that application of 5 ton/acre of chicken manure applied in the fall season before planting may be insufficient to promote highest strawberry productivity than control treatment, or manure applied just before planting. Total yield of strawberry was significantly affected by using organic matter (bark mulch) that was found in the first harvest year, additional NPK fertilizers with different levels (40, 80, 120 kg N/ha) gave no effects (Sonsteby *et al.,* 2004).

In Jordan valley, Suwwan and Hattar (1987) found that poultry manure is considered potentially of great value for increasing tomato yield on calcareous soils. Also, chicken manure 50 ton/ha gave the highest total tomato yield in spring than 50 ton/ha farmyard manure (Tuzel *et al.,* 2000). The highest total tomato yield (7.86 kg/m^2) was obtained from farmyard manure 30 ton/ha and was followed by chicken manure 30 ton/ha (Tuzel *et al.,* 2003). On the other hand, application of chicken manure (0, 5, 10, and 15 ton/ha) did not increased tomato yield significantly. Also, Al-Nasre (2002) indicated that no significant differences in yield of cauliflower due to application of chicken manure, sheep manure, and NPK fertilizers, in general the yield increased with increasing treatment doses. Regarding, Abo-Hadid *et al.,* (2000) showed that application of organic matter increased the early and finally yield of cucumber crop.

Application of chicken manure (5 ton/ha) increased number of strawberry fruit compared to plot without manure treatment. Also, it was found that application chicken manure significantly increased the number of large and medium strawberry fruits. However, Kent and Richard (2002) found that plots received swine effluent produced number of marketable fruit equal to plots that received inorganic or soluble sources fertilizers.

Norman *et al.,* (2003) showed that vermicompost improve plant growth of strawberry, tomato, and pepper plant. On the other hand, 36 ton/ha of poultry manure caused strawberry vegetative burn during the first 3 seasons, which may have reduced yields.

Addition of chicken manure significantly increased vegetative growth of both brassica species (*B. carinta A. Br.* and *B. oleracea* L.) compared with compost prepared from olive mill and cotton wastes (Walker and Bernal, 2004). Also, application of poultry manure (0, 1, 2, 3 and 4%) in greenhouse experiment was markedly increased spinach growth up to 3% of manure and suppressed with the higher rates of P 50 mg/kg^{-1} as KH_2PO_4 (Maftoun *et al.,* 2004). Application of 40 m^3 of farmyard manure/fed significantly favored both branches and leaves/plant in pea compared with 0 and 20 ton/fed (El-Mansi *et al.*, 1999).

Vegetative fresh weight of strawberry, tomato, and pepper plants grow in plots treated with organic vermicompost was higher compared to those treated with inorganic fertilizers only (Norman *et al.,* 2003). Organic-based fertilizers (4 ton/ha and 2 ton/ha+ 30 kg N/ha) increased fresh weight yield of tomato plant 36.3% compared with applying 60 kg N/ha as chemical fertilizers (Togun and Akanbi, 2003). The highest fresh weight of greenhouse tomato was obtained from applying 30 ton/ha farmyard manure, followed by chicken manure 30 ton/ha (Tuzel *et al.*, 2003).

Nevertheless, fresh weight of tomato (plants and fruit) indicated a clear increase with application farmyard manure 5 % compared with 0 and 10%, then decreased in pot experiments with sandy calcareous soil. In loamy textured soil, Slurry gave 1-20 kg /ha higher fresh weight of leek than did chicken manure (Bath and Ramet, 2000).

Dry weight of both plants and fruits of tomato increased with application farmyard manure up to 5% then decreased in pot experiments. On the other hand, application farmyard manure, chicken manure and different irrigation treatments had no significant effect on total dry matter content of cucumber fruits (Tuzel *et al.*, 2003).

Lettuce dry matter content was significantly lower in the control treatment compared to biosolids treatment proportion 0 to 100% (Zubillaga and Lavado, 2002). Arisha and Bardisi (1999) reported that application of NPK fertilizer up to 60+45+75 kg/fed or farmyard manure up to 45 m^3/fed increased potato dry weight of roots, vegetative, tubers and total/plant. Dry weights of

different pea plant organs were significantly favored by the application of 40 m^3 of farmyard manure/fed (El-Mansi *et al.,* 1999).

A higher level of ascorbic acid was found in organically and sustainable grown strawberry as compared to those produced by conventional agricultural practices (Danny *et al.,* 2003). Tuzel *et al.,* (2003) reported that organic fertilizers application significantly influence on vitamin C content of tomato fruit juice on the second analysis at harvesting date (22 January 2001) compared with first analysis in autumn. Furthermore, chicken manure 50 ton/ha gave the highest figure as 15.45 mg/100ml.

Total soluble solids of tomato fruit were significantly increased with farmyard manure application (Tuzel *et al.,* 2000). Tuzel *et al.,* (2003) indicted that no consistent effects of fertilizers treatment on tomato total soluble solids at the first date of fruit sampling, also for the last sampling date there were insignificant differences.

The objectives of this study was to investigate the following:

1- Effects of different levels of chemical and organic fertilizers on yield and its component.
2- Effects of different levels of chemical and organic fertilizers on plant growth and fruit quality.
3- Effects of different levels of chemical and organic fertilizers on nutrient status of plant and soil.

Material and Methods

In the experiment, strawberry transplants of *ferscka* cultivar were planted in plastic house of 50x9 m. Experimental treatments werearranged in split-plot in a randomized complete block design with 3 replications. Main plots (25.5 m^2) were assigned to levels of cattle manure (0, 40, 60 or 80 ton/ha) and sub-plots (9 m^2) were assigned to the levels of chemical fertilizers (0, 20, 60 or 100 kg/ha). The distance between treatments in the same replicate as well as between replicates was 0.6m. There were 16 treatment consisting cattle manure, chemical fertilizers and their combinations. Each experimental unit was planted on both sides of a 3m- raised bed with plant set at 0.4 m within the row. The distance between bed centers was 0.60 m^2.

Cultural practices:

In the experiments, soil prepared for planting by plowing, disking and leveling. Organic manure was added two weeks before planting and saturated with irrigation water, they allowed reaching

field capacity. Manuals raised beds of 0.20 m height, 0.60 m wide were prepared. After that drip irrigation lines and black plastic mulch were spread on the raised beds for both experiments.

Chemical fertilizers (Green leaf 20-20-20- TE) were added manually monthly as formulas of 20-20-20 as liquid soluble. The first dose of chemical fertilizers was applied 3 weeks after planting then continued until harvesting.

Strawberry transplants (average height 5 - 10 cm). Irrigation commenced at a time of planting and continued at rate of two times a week throughout growing season using a drip irrigation system with drippers placed along the laterals at 0.4m. These transplants were obtained from BDUI HAFEZ AGRICULTURAL COMPANY. (AMMAN- JORDAN).

Red mature strawberry fruits were harvested from each treatment at 4 to 7-day intervals through the harvesting season. Total yield and number of fruits were calculated from 7 picking times.

Fresh and dry weight:

At termination of the harvest season, plants were cut down to the soil surface. Vegetative fresh weight of three plants was taken. Representative vegetative samples of 200gm were taken and dried to a constant weight at 75C°; dry matter contents were then calculated.

Leaf area:

At the end of harvest season, the leaf area of three plants for each treatment was measured using (leaf area meter Li3100, Li-cor Inc. Lincoln, Nebraska, USA).

Product quality

Vitamin C (ascorbic acid): -

Eight fruits per plot were randomly picked for the determination of vitamin C content (mg/100g); it was determined by using 2, 6-Dichloroindophenol titrimetric methods (AOAC official methods of analysis 1995).

Total soluble solids (TSS %):

Eight fruits per each treatment were randomly picked for total soluble solids determination. Total soluble solids were determined by using electrical (ABBE Referactometer) from the juice obtained from strawberry fruits.

Collection, preparation and analysis of fruit and leaf samples:

Mature strawberry fruit samples were taken two times for chemical analysis. For chemical analysis of strawberry and lettuce leaves, youngest fully expanded matured leaves were selected (Tandon, 1995).

Leaf and fruit were washed by distilled water to remove dust deposited on the surface. Samples were oven dried at 75C° for 72 hours to the constant weight, and grounded to reduce the material to a fineness suitable analysis using a mechanical grinder. The samples were stored in airtight plastic containers for chemical analysis.

Total nitrogen was determined by digestion 0.5 gm of dry samples with H_2SO_4 68% in kjeldahl digestion until sample colorless and titrated with 0.1 of H_2SO_4.

Phosphorus was determined according to Wantanbe and Olsen method, (1965). K^+ in plant tissue was analyzed. Micronutrient (Fe, Mn, Zn) estimated by atomic absorption technique (Tandon, 1995).

Statistical analyses:

MSTAT-C statistical package was used to analyze the data that obtain from the two experiments. Analysis of variance was determined by using Duncan's Multiple Ranges Test (DMRT) to determent the mean separations of separated means. The level of significance was calculated with an error probability of 0.05 (Lentner and Bishop, 1993).

Table (1)Characteristic of some soil properties of investigated experiments before planting time.

Soil characteristics	Strawberry soil
Texture	Sandy clay loam
pH	7.78
EC (ms/cm)	1.28
$CaCO_3$ (%)	36
Total-N (%)	0.28
Available P (ppm)	320
Exchangeable K (ppm)	288
Available Zn (ppm)	2.54
Available Mn (ppm)	12.12
Available Fe (ppm)	8.14

Organic matter (%)	1.63
Total P (mg/g)	Not determined
Total K (mg/g)	Not determined

Table (2) Characteristic of organic manure and irrigation water before application time.

Characteristics	**Irrigation water**	**Organic manure**	
		Chicken	**Cattle**
Texture	n.d	n.d	n.d
pH	6.84	5.8	6.7
EC (ms/cm)	1.11	2.01	1.45
$CaCO_3$ (%)	n.d	n.d	n.d
Total-N (%) mg/g	n.d	33	15
Available P ppm	n.d	n.d	n.d
Exchangeable K ppm	n.d	n.d	n.d
Available Zn ppm	n.d	n.d	n.d
Available Mn ppm	n.d	n.d	n.d
Available Fe ppm	n.d	n.d	n.d
Organic matter (%)	n.d	n.d	n.d
Total P (mg/g)	n.d	9	5
Total K (mg/g)	n.d	16	6

Yield and yield components: -

Yield

Analysis of variance Appendix II Table (1) showed significant main effect of cattle manure and chemical fertilizers levels on strawberry yield. Cattle manure levels had pronounced significant effects on strawberry yield (Table 1). Generally, each increase in levels of cattle manure resulted in an increase in strawberry yield (Table 1). Application of different chemical fertilizer levels significantly increased strawberry yield.

The highest strawberry yield (15.4 ton/ha) was obtained by application of cattle manure (80 ton/ha) and 60 kg/ha of chemical fertilizers; while, the lowest strawberry yield (9.9 ton/ha) was obtained by control treatment. The respective yield tended to increase by about 108 and 155% over control treatment.

Generally, plots treated with both cattle manure and chemical fertilizers resulted in higher strawberry yield (Table 1). These results confirm the findings of Abo-Haded *et al.*, (2000).

However, Sonsteby *et al.,* (2004) reported that application of chemical fertilizers with different levels (40, 80 and 120 kg N/ha) had no additional significant effects when applied with organic fertilizers on strawberry yield.

The increase in yield of strawberry might be due to the increase in organic matter rate, which may be caused by liberation of carbon dioxide during compost decomposition as cited by Turemis (2002). Other possible explanation is due to improvement of soil structure following organic manure application. These results are in agreement with the results obtained by Togun and Akanbi, (2003).

The low productivity of strawberry in the present study could be attributed to the lower temperature that prevailed during growing season, especially during January and February, which delayed plant growth and restricted the pollination activity which resulting in low fruit set, low yield and relatively inferior fruit quality.

Generally, average yield of grown lettuce and strawberry followed the same trend in response to the organic manure and chemical fertilizers levels treatments.

Fruits number

Total strawberry fruit number significantly affected by different treatment combinations (Table 12). Fruit number trended to increase by increasing cattle manure levels. On the other hand, the higher level of chemical fertilizers (60 or 80 kg/ha) significantly increased fruit number compared with the control treatment. The highest fruit number (193/plot) was obtained by application of (80 ton/ha) of cattle manure and (20 kg/ha) of chemical fertilizers. These results are in consistency with the results obtained by Norman *et al.,* (2003).

Product quality

Vitamin C and TSS%

The analysis of variance for vitamin C and TSS% of strawberry fruit Table (2) showed no significant differences among all treatment combinations. Vitamin C and TSS% tended to increase by increasing level of cattle manure, however, this increase was insignificant.

The highest vitamin C content (61.14 mg/100gm) was obtained by the application of 80 ton/ha of cattle manure whereas the lowest value (33.13 mg/100gm) was obtained by control treatment. For TSS % measurements the highest value (11.96 %) was produced by application 80

ton/ha of cattle manure and the lowest (10.67 %) was produced by the control treatment (Table 13). Results of TSS% are in agreements with those obtained by Tuzel *et al.*, (2003).

Results of vitamin C content are in harmony with those obtained by Fjelkner-Modig *et al.*, (2000). Sturm *et al.*, (2003) reported that TSS is a function of several factors of which total sugars and organic acids constitute the major part. Organic grown strawberry had more sugar than conventional grown ones (Leskinen *et al.*, 2002).

Table (1): Interactive effect of cattle manure and chemical fertilizer levels on strawberry yield (ton/ha) and total fruit number/plot.

Cattle manure level (ton/ ha)	Chemical fertilizer level (kg/ha)				Mean
	0	20	60	100	
Yield					
0	9.9 g [(1)]	10.7 fg	11.6 ef	12.1 def	**11.1 c**
40	12.0 ef	12.8 cde	12.9 bcde	12.7 cde	**12.6 bc**
60	12.8 cde	12.8 cde	13.8 abc	13.7 bcd	**13.3 ab**
80	14.5 ab	14.6 ab	15.4 a	14.5 ab	**14.7 a**
Mean	**12.3 b**	**12.7 ab**	**13.5 a**	**13.2 a**	
Total fruit number/ plot					
0	123 gh	121 gh	147 def	143 def	**133 c**
40	121 gh	120 gh	149 cde	114 h	**126 d**
60	134 efg	128 fgh	158 bcd	145 def	**141 b**
80	150 cde	193 a	173 b	167 bc	**171 a**
Mean	**132 c**	**141 bc**	**157 a**	**142 b**	

[(1)] Valueswithin each interaction or means having different letters are significantly different at 0.05 level of probability according to DMRT.

Vegetative growth

Fresh and dry weight

Vegetative fresh weight significantly increased with cattle manure, chemical fertilizers levels and their interaction (Table 3). The highest fresh weight (257.7 gm/plant) was produced by the application of 80 ton/ha of cattle manure and 100 kg/ha of chemical fertilizers, while the lowest weight (132.7 gm/plant) was produced by control treatment. In general, vegetative fresh weight increased with increasing rates of cattle manure and chemical fertilizers levels.

Chemical fertilizers levels had significantly increased vegetative dry weight (Table 3). Applications of 60 or 100 kg/ha of chemical fertilizers significantly increase vegetative dry weight, however, the differences between them were insignificant. It might be due to the fact that fertilizers provide plant with different nutrients, and might be due to the improvement of soil water holding capacity by organic manure application.

Leaf area

Leaf area was significantly affected by the main effect of cattle manure and chemical fertilizers levels (Table 3). In general, each increase in cattle manure levels significantly increases leaf area (Table 3). These results are in harmony with those obtained by Norman *et al.*, (2003), and Abdelrazzag (2002). It might be due to the fact that manure provides suitable nutrients to the plant.

The data reveals that levels of cattle manure and chemical fertilizers and their interactions had no significant effects on soil pH. However, soil pH slightly increased by increasing cattle manure levels. The highest soil pH (8.4) was obtained by application of 60 ton/ha of cattle manure and with all levels of chemical fertilizers, while the lowest pH (7.5) was obtained by no addition of cattle manure. Cattle manure levels significantly increase EC. The higher levels of cattle manure (60 or 80 ton/ha) significantly increase soil-EC comparing with the lower levels (0 and 40 ton/ha) Regardless of cattle manure levels other treatment had insignificant effect on soil-EC. These results are in good line with those reported by Walker and Bernal, (2004). (Non- published data).

Plant nutrients uptake

Macronutrients

Nitrogen and potassium uptake by strawberry leaves and fruits were significantly affected only by the application of cattle manure levels (Table 4 and 5). Application of cattle manure

significantly increase N and K uptake by leaves and fruit, however the differences between levels were insignificant. The highest N-uptake (3.14 % and 2.60 %) in fruit and leaves respectively, occurred with the application of intermediate level of cattle manure (60 ton/ha) and with the application of the highest cattle manure (80 ton/ha) coupled with 100 kg/ha of chemical fertilizers, respectively.

Table (2): Interactive effects of cattle manure and chemical fertilizer levels on strawberry fruit vitamin C and total soluble solid content (TSS %).

Cattle manure level (ton/ ha)	Chemical fertilizer level (kg/ha)				Mean
	0	20	60	100	
Vitamin C (mg/100ml)					
0	33.13 b [(1)]	34.13 b	35.27 b	36.87 b	**34.85 a**
40	57.43 a	39.90 b	58.60 a	58.77 a	**53.67 a**
60	58.53 a	58.60 a	58.67 a	58.80 a	**58.65 a**
80	59.50 a	61.14 a	59.80 a	60.33 a	**60.19 a**
Mean	**52.15 a**	**48.44 a**	**53.08 a**	**53.69 a**	
TSS %					
0	10.67 a	10.90 a	10.93 a	11.42 a	**10.98 a**
40	11.21 a	11.05 a	10.97 a	11.07 a	**11.08 a**
60	11.25 a	11.31 a	11.17 a	11.11 a	**11.21 a**
80	11.71 a	11.25 a	11.96 a	11.92 a	**11.71 a**
Mean	**11.21 a**	**11.13 a**	**11.26 a**	**11.38 a**	

[(1)] Valueswithin each interaction or means having different letters are signifi- cantly different at 0.05 level of probability according to DMRT.

Chemical fertilizers levels were significantly increased P-uptake by strawberry fruits compared with control treatment, however not between levels (Table 5). On the other hand,

chemical fertilizers had a insignificant effect on P-uptake by strawberry leaves (Table 6). Such observation was previously reported by Maftoun *et al.*, (2004).

Nitrogen content in lettuce tissue was found higher than that in strawberry. This might be due to the fact that lettuce as a leafy crop is a high N-demanding. On the other hand, P and K concentration was found higher in strawberry tissue than in lettuce; which might be because strawberry needed these macronutrients to induce fruit formation.

Table (3): Interactive effects of cattle manure and chemical fertilizer levels on vegetative fresh and dry weight and leaf area of strawberry.

Cattle manure level (ton/ ha)	**Chemical fertilizer level (kg/ha)**				**Mean**
	0	**20**	**60**	**100**	
Vegetative fresh weight (gm/plant)					
0	132.7 e [(1)]	133.3 e	133.0 e	137.0 e	**134.0 c**
40	203.0 d	203.7 d	209.7 cd	216.3 bcd	**208.2 b**
60	210.3 cd	214.3 cd	217.3 bcd	226.3 bc	**217.1 ab**
80	205.7 d	210.0 cd	233.3 b	257.7 a	**226.7 a**
Mean	**187.9 c**	**190.3 bc**	**198.3 b**	**209.3 a**	
Vegetative dry weight (g/100g)					
0	22.66 f	22.65 f	22.54 f	23.05 f	**22.73 a**
40	24.06 e	24.17 e	24.71 de	24.74 de	**24.42 a**
60	25.44 cd	25.63 c	25.65 c	25.84 bc	**25.64 a**
80	26.10 abc	26.24 abc	26.61 ab	26.81 a	**26.44 a**
Mean	**24.56 b**	**24.67 b**	**24.88 ab**	**25.11a**	
Leaf area (cm^2)					

0	12.23 c	12.99 c	13.52 c	13.34 c	**13.02 c**
40	12.45 c	14.32 bc	14.76abc	15.19 abc	**14.18 b**
60	14.75abc	14.96 abc	14.90abc	14.79 abc	**14.85 b**
80	14.45 bc	13.67 c	18.20 a	17.60 ab	**15.98 a**
Mean	**13.47 a**	**13.98 ab**	**15.34 a**	**15.23 a**	

(1) Valueswithin each interaction or means having different letters are signifi-cantly different at 0.05 level of probability according to DMRT

Micronutrients

Micronutrients uptake by strawberry leaves and fruit proceed by different ways. Fe-uptake by strawberry fruit significantly affected by the application of cattle manure and chemical fertilizers levels, however their interaction had no effects (Table 6,7). In general, the highest levels of cattle manure significantly increase Fe-uptake by strawberry fruits compared with other levels.

While the uptake of Mn by strawberry fruits significantly affected by cattle manure levels, Mn-uptake by leaves significantly affected by chemical fertilizers (Table 6, 7). The highest Mn-uptake by leaves (545 ppm) was obtained with the application of 40 ton/ha of cattle manure and 100 kg/ha of chemical fertilizers whereas the lowest Mn-uptake (316 ppm) was obtained by control treatment.

Zn-uptake by strawberry leaves reveals insignificant increased between different chemical fertilizers levels or interaction of cattle manure and chemical fertilizers levels (Table 7). Generally, micronutrients in fruit and leaves increased with increasing the application rates of cattle manure and chemical fertilizers. These results of Fe confirm the findings of William and Greig, (1972). For Mn and Zn similar results were reported by Viatore *et al.*, (2002).

Table (4): Interactive effects of cattle manure and chemical fertilizer levels on macronutrient content of strawberry fruit.

Cattle manure level (ton/ ha)	Chemical fertilizer level (kg/ha)				Mean
	0	**20**	**60**	**100**	
N%					
0	1.71 c [(1)]	1.75 c	1.91 c	1.83 c	**1.80 b**
40	2.91 ab	2.95 ab	3.00 ab	2.97 ab	**2.96 a**
60	3.14 a	2.64 b	2.89 ab	3.00 ab	**2.92 a**
80	2.87 ab	2.92 ab	2.62 b	2.94 ab	**2.84 a**
Mean	**2.66 a**	**2.56 a**	**2.60 a**	**2.69 a**	
P (ppm)					
0	740 f	819 cd	802 e	823 c	**796 b**
40	805 de	810 cde	811 cde	812 cde	**810 ab**
60	814 cde	849 b	856 ab	857 ab	**844ab**
80	858 ab	863 ab	866 a	867a	**863 a**
Mean	**804 b**	**835 a**	**834 a**	**840 a**	
K (ppm)					
0	536 b	538 b	533 b	534 b	**535 b**
40	589 a	596 a	591 a	580 a	**589 a**
60	594 a	598 a	585 a	580 a	**589 a**
80	582 a	590 a	597 a	575 a	**586 a**
Mean	**575 a**	**580 a**	**577 a**	**567 a**	

[(1)]*Valueswithin each interaction or means having different letters are significantly different at 0.05 level of probability according to DMRT.*

Table (5): Interactive effects of cattle manure and chemical fertilizer levels on macronutrient content of strawberry leaves.

Cattle manure level (ton/ ha)	Chemical fertilizer level (kg/ha)				Mean
	0	**20**	**60**	**100**	
N %					
0	1.88 b [(1)]	2.28 ab	2.34 ab	2.20 ab	**2.18 b**
40	2.29 ab	2.47 ab	2.43 ab	2.24 ab	**2.36 ab**
60	2.42 ab	2.48 ab	2.46 ab	2.57 ab	**2.48 a**
80	2.51 ab	2.48 ab	2.45 ab	2.60 a	**2.51 a**
Mean	**2.28 a**	**2.42 a**	**2.42 a**	**2.40 a**	
P (ppm)					
0	784 a	787 a	794 a	791 a	**789 a**
40	781 a	798 a	799 a	767 a	**786 a**
60	786 a	805 a	792 a	764 a	**787 a**
80	806 a	806 a	791 a	810 a	**803 a**
Mean	**789 a**	**799 a**	**794 a**	**783 a**	
K (ppm)					
0	430 ab	442 ab	427 b	434 ab	**433 b**
40	443 ab	437 ab	441 ab	448 a	**442 a**
60	445 ab	436 ab	438 ab	447 ab	**441 a**
80	435 ab	445 ab	437 ab	441 ab	**439 a**
Mean	**438 a**	**440 a**	**436 a**	**443 a**	

[(1)] Valueswithin each interaction or means having different letters are significantly different at 0.05 level of probability according to DMRT.

Table (6): Interactive effects of cattle manure and chemical fertilizer levels on micronutrient content of strawberry fruits.

Cattle manure level (ton/ ha)	Chemical fertilizer level (kg/ha)				Mean
	0	**20**	**60**	**100**	
Fe (ppm)					
0	42.6 e [(1)]	42.7 e	48.1 e	47.8 e	**45.3 b**
40	70.4 d	72.2 bcd	72.1 bcd	76.1 abcd	**72.7 a**
60	69.5 d	71.6 cd	72.9 bcd	83.1 a	**74.3 a**
80	78.7 abcd	81.3 ab	80.7 abc	83.0 a	**80.9 a**
Mean	**65.3 b**	**67.0 b**	**68.5 ab**	**72.5 a**	
Mn (ppm)					
0	44.7 d	54.8 bcd	62.4 abcd	51.4 cd	**53.3 b**
40	71.7 abcd	68.8abcd	79.2 abc	83.4 ab	**75.8 a**
60	74.2 abc	77.7 abc	91.1 a	65.1abcd	**77.0 a**
80	74.7 abc	72.0abcd	82.5 ab	89.4 a	**79.7 a**
Mean	**66.4 a**	**68.3 a**	**78.8 a**	**72.3 a**	
Zn (ppm)					
0	15.2 a	15.4 a	15.5 a	15.6 a	**15.4 b**
40	15.3 a	15.6 a	15.5 a	15.7 a	**15.5 ab**
60	15.4 a	15.6 a	15.6 a	15.8 a	**15.6 a**
80	15.4 a	15.7 a	15.6 a	15.7 a	**15.6 a**
Mean	**15.3 a**	**15.6 a**	**15.5 a**	**15.7 a**	

[(1)] *Valueswithin each interaction or means having different letters are significantly different at 0.05 level of probability according to DMRT.*

Table (7): Interactive effects of cattle manure and chemical fertilizer levels on micronutrient content of strawberry leaves.

Cattle manure level (ton/ ha)	Chemical fertilizer level (kg/ha)				Mean
	0	**20**	**60**	**100**	
Fe (ppm)					
0	420 b [(1)]	422 b	427 b	429 b	**424 a**
40	411 b	410 b	409 b	416 b	**411 a**
60	425 b	417 b	435 b	431 b	**427 a**
80	420 b	426 b	436 b	496 a	**444 a**
Mean	**419 b**	**419 b**	**427 ab**	**443 a**	
Mn (ppm)					
0	316 bc	437 abc	475 ab	588 a	**454 a**
40	259 c	423 abc	438 abc	545 ab	**416 a**
60	429 abc	435 abc	527 ab	540 ab	**483 a**
80	398 abc	464 abc	488 ab	572 a	**480 a**
Mean	**350 c**	**440 bc**	**482 ab**	**561 a**	
Zn (ppm)					
0	42 b	52 a	52 a	52 a	**50 a**
40	53 a	53 a	53 a	53 a	**53 a**
60	53 a	53 a	53 a	54 a	**53 a**
80	54 a	54 a	54 a	54 a	**54 a**
Mean	**51 a**	**53 a**	**53 a**	**53 a**	

[(1)] Valueswithin each interaction or means having different letters are significantly different at 0.05 level of probability according to DMRT.

Summary and Recommendations

An experiments were carried out at Mu'tah University Agricultural Research Station to investigate growth, yield, quality and nutrients uptake of lettuce and strawberry crops in response to organic manure and chemical fertilizers during fall seasons.

1. Yield and yield components of the two crops were increased by increasing application rates of organic manure and chemical fertilizers. The higher yield in strawberry (13.8 ton/ha) was obtained by adding 60 ton/ha of organic manure and 60 kg/ha of chemical fertilizers. The use of organic and chemical fertilizers to- gather produced about 109 to 156 % for strawberry yield for the different combination over the control treatment. On the other hand, head diameter of fruit number of strawberry increased by increasing the application rate of organic manure and chemical fertilizers.Chlorophyll contents of lettuce leaf, vitamin C and TSS % contents in strawberry fruits were found to be higher in response to organic manure treatments than chemical fertilizers treatments. Fresh and dry weight as well as leaf area of strawberry plants enhanced by organic manure more than chemical fertilizer treatments.
2. Strawberry plants are sensitive to high rates of chicken manure, it cause a vital injuries to the plants. An excess amount of chicken manure applied to the strawberry could be resulted in a nutrient imbalance, and high soil-soluble salts content.
3. These present studies suggest that manure can be used as an alternative system for chemical fertilizers in an intensive agricultural production system to provide most nutrient requirement for strawberry productions. The major limiting factors for excessive utilization of the organic manure compost produced in Jordan would be the problems of plant toxicity due to high salt concentration in amended soil. The use of high rates of organic manure will lead to increase soil organic matter accumulation.
4. Further investigations are needed to determine optimal rates, improving organic manure quality, developing method of manure utilization, and placement of organic manure in commercial vegetable crops production systems with reducing inorganic fertilizers rates while simultaneously maintaining optimal yields.

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