J.Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 7(10): 767- 774, 2016

Effect of Organic Manures, Biofertilizers and NPK on Vegetative Growth, Yield, Fruit Quality and Soil Fertility of Eureka Lemon Trees (*Citrus limon* (L.) Burm).

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ABSTRACT

A field experiment was carried out during the years 2013, 2014 and 2015 on Eureka lemon at El-Nubaria region, El-Beheira governorate, to study the effect of farmyard manure and biofertilizers with NPK dose on soil fertility, growth, yield, fruit quality and leaf nutrient content of Eureka lemon trees. Eleven treatments were arranged in a randomized complete block design with three replicates. Results revealed significant differences amongst various growth attributes, fruit yield, fruit quality, leaf mineral content and soil nutrients availability due to farmyard manure and biofertilizers application. Also, farmyard manure and biofertilizers could compensate for the 50% reduction of chemical fertilizers, and increasing yield compared to chemical fertilizers with significant differences. Therefore, treatment of 50% NPK + 55 kg farmyard manure + biofertilizers is recommended for growers. This treatment gave the best growth, yield and fruit quality of Eureka lemon trees. Moreover, this treatment improved the nutritional status of the trees, through the beneficial effects of organic and biofertilizers which enhanced the availability of most nutrients in the soil.

Keywords: *farmyard manure, inorganic fertilizers, citrus, lemon biofertilizers.*

INTRODUCTION

Lemons are one of the most popular citrus fruits in the world, and are widely used for culinary purposes, good source of vitamins and minerals, also lemon is an important export crop for foreign markets and source for cash currency. Citrus requires sixteen essential elements for normal growth, production and quality. Adequate supply of nitrogen, phosphorus and potassium are important for citrus tree growth and productivity (Quaggio *et al*., 2002). Nitrogen is the key component in mineral fertilizers applied to citrus trees; it has more influence on tree growth, yield and fruit quality. Potassium is necessary for basic physiological functions such as translocation of sugars, synthesis of proteins and cell division and growth. It is important in fruit growth and enhances its size, flavor and color. Phosphorus is necessary for many life processes such as photosynthesis, synthesis and breakdown of carbohydrates and the transfer of energy within the plant. To day, chemical fertilizers are an indispensible in fruit crop nutrition, but excessive and indiscriminate use of chemical fertilizers have deleterious effects on soil, water and atmosphere pollution, and reflected on animal and human health, it had also adversely affected the soil fertility, water quality, yield and quality of the products (Srivastava, 2012). Therefore, use of organic manure and biofertilizers has assumed great importance for sustainable production and to improve the soil physical, chemical and biological properties. Also organic manures and biofertilizers are a good alternative to reduce uses of chemical fertilizers. In this respect, several workers reviewed the significant role of organic manures and biofertilizers in influencing the soil properties and enhancing the growth, yield and quality of citrus (Dheware and Waghmare, 2009 on Sweet orange; Kumar *et al*., 2011 on lemon; Khehra and Bal, 2014 on lemon; Lal and Dayal, 2014 on acid lime and Khehra and Bal, 2016 on lemon). Soil microbes play an important role in many critical ecosystem processes, including nutrient cycling and homeostasis, decomposition of organic matter, as well as promoting plant health and growth as bio-fertilization (Hayat *et al*., 2010; El Khayat and Abdel Rehiem, 2013; Khehra, 2014; Babita *et al*., 2015 and Hadole *et al*., 2015). The objectives of this study are mainly to reduce the amount of chemical fertilizers applied to soil and replacing them by others such as organic and biofertilizers, besides, evaluating tree growth, yield and fruit quality under the new reclaimed land conditions.

MATERIALS AND METHODS

A field experiment was conducted in a private orchard at El-Nubaria region, El-Beheira governorate, Egypt on fourteen years old Eureka lemon (*Citrus limon* L.) trees budded on sour orange (*Citrus aurantium* L.) rootstock, planted at 5 x 5 meter apart with 168 trees/feddan, during 2013, 2014 and 2015 years. The first year was considered as a preliminary trail to prepare the trees to response to treatments. The soil is sandy in texture and the Nile water was used in trees irrigation under drip irrigation system. The results of soil and farmyard manure analysis according to Page *et al*., (1982) are given in Table (1). All chosen trees were similar in size and shape and received the recommended agriculture practices except fertilization. Ninty nine trees were arranged in a randomized complete block design, each treatment replicated three time with three tree per replicate.

The experiment included eleven treatments as follows:

T_1 100% NPK control (1000:250:500 g N, P_2O_5 and K_2O/tree/year),

T_2 75% NPK /tree + 27.5kg farmyard manure/year.

T_3 75% NPK /tree + 27.5kg farmyard manure/year + *Azotobacter* 25g/tree.

T_4 75% NPK /tree + 27.5kg farmyard manure/year + A*zospirillum* 25g/tree,

T_5 75% NPK /tree + 27.5kg farmyard manure/year + *Bacillus circulans* 25g/tree.

T_6 75% NPK /tree + 27.5kg farmyard manure/year + *Azotobacter* 25g/tree + *Azospirillum* 25g/tree + *Bacillus circulans* 25g/tree.
T_7 50% NPK /tree + 55kg farmyard manure/year.
T_8 50% NPK /tree + 55kg farmyard manure/year + *Azotobacter* 25g/tree.
T_9 50% NPK /tree + 55kg farmyard manure/year + *Azospirillum* 25g/tree.
T_{10}50% NPK /tree + 55kg farmyard manure/year + *Bacillus circulans* 25g/tree.
T_{11} 50% NPK /tree + 55kg farmyard manure/year + *Azotobacter* 25g/tree + *Azospirillum* 25g/tree + *Bacillus circulans* 25g/tree.

Mineral fertilization of NPK at 1000:250:500 g/tree/year were applied as 4.85 kg/tree ammonium sulphate (20.6% N), 1.60 kg/tree super phosphate (15.5% P_2O_5) and 1.00 kg/tree potassium sulphate (48% K_2O). Nitrogen fertilizer was added on three doses, at March, the first of June and at the end of August. Whereas, potassium was applied on two doses, at the first of March and at the end of August with nitrogen fertilization. At the end of December farmyard manure 27.5 or 55 kg/tree and 25g/tree for each one of bacteria as biofertilizers were added once in two trenches 100 cm length x 50 cm width x 50 cm depth on the two sides of the tree in both seasons. Biofertilizers which obtained from the Agricultural Research Center (ARC, Giza, Egypt) were N_2-fixing free living bacterial cultures *Azotobacter chroococcum, Azospirillum lipoferum,* phosphate dissolving bacterial culture *Bacillus megatherium* (add to all treatments except T_1 control) and potassium solublizing bacteria *Bacillus circulans* which in peat moss carrier, the counts of these microbial were 5 x 10^7 cfu/g peat moss for each bacteria.

Table 1. Some physical and chemical analysis of the experimental soil and farmyard manure used.

Soil analysis		Farmyard manure analysis	
parameters	**Value**	**Parameters**	**value**
Sand %	88.47	Cubic meter weight kg	650.00
Silt %	4.84	Moisture %	35.00
Clay %	6.69	Organic matter %	23.60
Texture	Sandy	Organic carbon %	13.72
pH 1:2.5	8.34	pH 1:10	8.70
EC dSm^{-1} 1:5	2.40	EC mmohs/cm	1.70
Organic mater %	0.43	C/N ratio	15.40
K^+ meq/l	0.24	N %	0.89
Ca^{++} meq/l	1.30	P %	0.32
Mg^{++} meq/l	0.45	K %	0.92
Na^+ meq/l	1.45	Ca %	1.82
HCO_3^- meq/l	1.05	Mg %	0.96
Cl^- meq/l	1.55	Fe ppm	750.00
SO_4^{--} meq/l	0.84	Mn ppm	420.00
		Zn ppm	53.00

The following data was recorded:

1. Vegetative growth:

Shoot length (cm) was measured for five shoots at spring and summer growth cycles, leaf area (cm^2) was measured by using a leaf area meter Model Li 3100 area- meter, and canopy volume (m^3) was measured and calculated according to the formula: 0.5238 x tree height x diameter square (Turrell, 1946).

2. Fruit set and fruit drop (%):

Fruit set percentages was calculated according the equations:

Initial fruit set % = (No. of fruitless ÷ Total No. of flowers) x 100
Final fruit set % = (No. of fruits ÷ Total No. of flowers) x 100

The percentage of June and preharvest drop were calculated according the equations:

June drop % = (number of dropping fruits ÷ No. of fruits in April) x 100
Preharvest drop % = (No. of dropping fruits ÷ No. of fruits at mid September) x 100.

3. Yield: at harvest time (first week of December in both seasons); the fruit yield of each tree was recorded as weight (kg) and ton/feddan.

4. Fruit quality:

30 fruits were taken at random at harvest time for determination of physical and chemical characteristics such: fruit length and diameter (cm), which measured as fruit weight (gm), juice (%), peel thickness (mm), total soluble solids by hand refractometer, total acidity as citric acid according to (A. O. A. C., 1985), ascorbic acid as mg/100 ml/juice by using 2, 6 dichlorophenol indophenol according to Jacobs 1951).

5. Leaf nutrient contents:

Fully mature leaves were separated from nonbearing shoots, washed, cleaned and oven dried to constant weight at 60-65C° and weighted. The dried leaves samples of each replicate were grounded and digested with H_2SO_4 and H_2O_2 according to Evenhuis and DeWaard (1980). In digested solution samples N, P, K, Fe, Mn and Zn were determined. Nitrogen was determined by micro-Kjeldahl method (A.O.A.C. 1985), K by flame photometer, P colorometrically by spectrophotometer, Fe, Mn and Zn were assayed with Atomic Absorption spectrophotometer (Unican SP 1900) according to Chapman and Pratt (1961).

6. Soil nutrient contents:

At the end of experiment, soil samples were taken from each treatment at major root zone (0 – 60 cm depth). Soil samples were dried, sieved through a 2 mm and analyzed for available N, P, K, Fe, Mn and Zn. N was extracted by 1N KCl, P was extracted by 0.5N $NaHCO_3$, K was extracted by 1N NH_4AC and Fe, Mn, Zn were extracted by DTPA according to Page *et al.* (1982).

Statistical analysis:

The obtained data were subjected to analysis of variance according to Snedecor and Cochran, (1990). Duncan's multiple range test (Duncan, 1955) at 5% level was used to compare the mean values.

RESULTS AND DISCUSSION

1. Vegetative growth:

Data in Table 2 showed that, spring and summer shoot length, leaf area and canopy volume of Eureka lemon were significantly affected by biofertilizers in combination with farmyard manure and NPK doses in both seasons. The highest values of shoot length, leaf area and canopy volume were recorded with T_6 and T_{11} treatments followed by T_3 in both seasons. The lowest values were obtained with T_1, T_2 and T_7 while, the other treatments were found to be at par during both seasons. These results agree with those of Dahiya *et al*., (2013) who revealed that sweet orange trees fertilized with 70 kg farmyard manure + 850 g urea/tree produce more leaves, shoot length and tree spread. Also, Khehra and Bal (2014) stated that the combination among farmyard manure, inorganic fertilizer and biofertilizer led to improving vegetative growth parameters of lemon tree in terms of plant height, trunk diameter and tree spread. In this respect, El-Khawaga and Maklad, (2013) found that appling biofertilizers namely *Azotobacter chroococcum*, *Bacillus megatherium* and *Bacillus circulans* combined with 140 units of inorganic nitrogen increased growth parameters in Valencia orange trees as compared to tree fertilized by nitrogen only.

Table 2. Effect of organic manure, biofertilizers and NPK on vegetative growth of lemon trees in 2014 and 2015 seasons.

Treatments	Spring shoot length (cm)		Summer shoot length (cm)		Leaf area (cm^2)		Canopy volume (cm^3)	
	2014	2015	2014	2015	2014	2015	2014	2015
T_1	21.5b	21.8c	29.9c	34.9f	40.3d	41.32f	35.6f	40.3d
T_2	22.5b	22.9c	30.0c	35.9f	43.5bc	43.52de	39.8e	42.3cd
T_3	25.6a	25.9ab	35.2ab	41.2bc	49.2a	50.22b	44.6c	47.2b
T_4	25.8a	26.2ab	34.9ab	38.9d	44.3bc	45.65c	44.6c	46.5b
T_5	25.8a	26.2ab	30.6c	36.7ef	41.6bcd	44.52cd	40.2e	45.5bc
T_6	25.9a	26.3ab	36.8a	43.4a	51.6a	53.45a	50.2a	51.6a
T_7	21.8b	22.3c	29.5c	35.7f	40.5d	43.50de	36.4f	40.5d
T_8	24.8a	24.5b	34.2b	39.9cd	44.4b	45.65c	43.2cd	45.8bc
T_9	25.5a	25.5ab	30.3c	38.4de	43.6bc	42.25ef	42.5d	45.8bc
T_{10}	24.7a	25.5ab	30.2c	36.5ef	41.4cd	44.23cd	38.5e	42.2cd
T_{11}	26.4a	26.6a	36.1ab	43.2ab	50.6a	52.36a	48.5b	49.5ab

Means followed by different letter are significantly different within columns by Duncan's multiple range test, P ≤ 0.0.5

In general, the obtained increase in vegetative growth as a result of T_6 and T_{11} treatments maybe due to high nutrient and mineral content present in the combination of organic, inorganic fertilizers with biofertilizers, this might also be attributed to the improved nutrient use efficiency as use of different sources of nutrients. Application of farmyard manure and biofertilizers improved the soil cation exchange capacity (CEC) and porosity due to bulkiness in nature, which in turn helped the plant root development and enhanced the uptake of available nutrients resulting into faster cell division and cell elongation; and consequently increased the tree growth and size. These observations were corroborated with the findings of Barakat *et al*., (2012) and Lal and Dayal, (2014) in Newhall navel orange and Acid lime. In this respect, Bottini *et al*., (2004) concluded that nitrogen-fixing bacteria such as *Azospirillum spp.* and *Azotobacter spp*. enhancing the nitrogen and produce different GAs specially GA_1, GA_3, GA_9, GA_{19} and GA_{20} that are responsible for plant growth promotion that occurs upon inoculation onto plants.

2. Fruit set and fruit drop (%):

It appeared from data presented in Table 3 that, initial and final fruit set percentage were significantly increased by the different fertilization treatments compared to control treatment (T_1) in both seasons. T_6 exhibited the high initial and final fruit set percentages followed by T_{11} and T_3 in the first season, and T_8 in the second season. The differences were not significant among them in both seasons. On the other hand, $T_1$and T_2 gave the lowest values of initial and final fruit set percentages in both seasons, respectively. These results are in harmony with those obtained by Sharaf *et al*., (2011) and Garhwal *et al*., (2014) on Washington navel orange and Kinnow mandarin. In this respect, Uddin, (2005) revealed that organic and inorganic fertilizers had highly positive effect on record number of flowers and fruit set % of lemon trees as compared with inorganic fertilizers only. The data obtained in Table 3 show the percentages of June fruit drop and preharvest fruit drop were significantly affected by all treatments in both seasons. The lowest percentage of dropped fruit in June and preharvest fruit were found on trees fertilized by T_6, T_{11} and T_3 respectively in both seasons. On contrary, the highest fruit drop determine in June and preharvest fruit were observed on treatment T_1 followed by T_7 and T_{10} respectively. Similar results were obtained by El-Saady and El-Abd, (2012) and Ahmed *et al*., (2013) they reported organic, biofertilizers and NPK alone or combined together significantly decreased the percentages of June drop and preharvest drop in navel orange.

Generally, data in Table 3 revealed that, initial fruit set, final fruit set, June fruit drop and preharvest drop of Eureka lemon trees were positively affected by organic and biofertilizers with doses of NPK in both seasons. In this respect, organic and bio-fertilizers gave the best fruit set and also reduced June drop and

preharvest drop especially T_6 and T_{11} compared to other treatments. This is because farmyard manure and bacteria not only adds organic matter and macro and micronutrients to soil, but also improves the physical and chemical properties of soil; and hence causes nutritional balance of the soil as well as the plant. Thus, the improved plant growth and development caused by nutritional balance increases fruit set % and reduces June fruit drop and preharvest drop. Such conclusion came true with our data in Tables 2 and 7 and those obtained by Saleem *et al*., (2005) and Abdel-Sattar *et al*., (2011) they found that organic fertilization maintained adequate mineral contents in leaves during growth cycles of Washington navel orange and mandarin; it also increased fruit set percentage and reduced fruit dropping waves. Moreover, increasing nutrient availability from farmyard manure, phosphorus through phospho bacteria and IAA from *Azospirillum* which may have increased various endogenous hormonal levels in plant tissue which might be responsible for enhancing flowering, pollen germination and pollen table which might have ultimately increased fruit set (Bottini *et al*., 2004 and Gabr and Nour El-Din, 2012).

Table 3. Effect of organic manure, biofertilizers and NPK on fruit set and drop percentages of lemon trees in 2014 and 2015 seasons.

Treatments	Initial fruit set %		Final fruit set %		June fruit drop %		Preharvest fruit drop %	
	2014	2015	2014	2015	2014	2015	2014	2015
T_1	30.92e	32.20d	8.12f	9.15f	19.82a	17.52a	9.22a	9.82a
T_2	33.15d	34.15cd	8.92e	10.11e	18.55b	12.94d	7.72c	8.66c
T_3	38.23ab	39.12a	9.75abc	11.19bc	11.63f	10.83f	6.55f	6.55f
T_4	37.16ab	37.25ab	9.33cde	10.92bc	12.51e	11.58e	6.53f	6.50f
T_5	36.17bc	37.16ab	9.12de	10.33de	12.73e	11.82e	7.45d	7.52d
T_6	38.65a	39.58a	10.16a	12.80a	10.76g	10.50f	5.93g	5.90g
T_7	32.30de	32.30d	8.36cde	9.36f	19.75a	15.64b	8.82b	8.84b
T_8	37.23bc	39.16a	9.56bcd	11.16bc	14.83d	12.82d	6.78e	6.92e
T_9	34.23cd	36.17bc	9.25de	10.75cd	17.64c	12.80d	6.78e	7.58d
T_{10}	34.14cd	36.16bc	9.16de	10.22e	19.21ab	14.51c	7.53d	8.67bc
T_{11}	38.50a	39.14a	9.92ab	11.22b	11.55f	10.59f	5.90g	6.51f

Means followed by different letter are significantly different within columns by Duncan's multiple range test, P ≤ 0.05

3. Yield:

Data in Table 4 showed that, organic manure and biofertilizers treatments with NPK dose were found to be significantly superior for enhanced Eureka lemon fruit yield expressed as kg/tree and ton/feddan compared to NPK only. T_6, T_{11} and T_4 had the highest significant values of yield during the two seasons compared with control (T_1) and other treatments. However, T_1, T_7 and T_{10} produced the minimum yield in both seasons. These results are in agreement with those obtained by Mansour and Shaaban (2007), Cerda *et al*., (2012) and Perungkotturselvi and Koilraj, (2015). In this respect, Abd El-Migeed *et al*., (2007) on Washington navel orange and Dheware and Waghmare, (2009) on sweet orange, they reported that, number of fruits per tree and average weight of fruits significantly increased with organic, inorganic fertilizers and inoculation by *Azospirillum* and phosphate solublizing bacteria *(Bacillus megatherium).* Also, Lal and Dayal, (2014) revealed that acid lime tree fertilized with 50% NPK + 50% goat manure bearing higher yield (kg/tree) than that fertilized with 100% NPK only. The beneficial effect of organic and biofertilizers on improving yield of Eureka lemon maybe due to positive effect on nutrients uptake (Table 7) which reflected on active vegetative growth parameters in Table 2. Also the positive response of yield as a result of biofertilizers treatments maybe due to the high ability of these microbes in nitrogen fixation and the secretion of several compounds that increase soil fertility, and organic matter increase bacteria activity, number of this bacteria, thus it can fix atmospheric nitrogen, increase phosphorus availability in soil and enhanced absorb elements by Eureka lemon tree, that reflected to tree's ability to grow and increase productivity. This conclusion agree with the result obtained by Kumer *et al*., (2011) and Hadole *et al*., (2015) resulted that Nagpur mandarin tree gave the maximum fruit yield with the application of 100% NPK + VAM (500 g/plant) + PSB (100 g/plant) + *Azospirillum* (100 g/plant) compared to control 100% NPK only.

Table 4. Effect of organic manure, biofertilizers and NPK on yield of lemon trees in 2014 and 2015 seasons.

Treatments	yield kg/tree		yield ton/feddan	
	2014	2015	2014	2015
T_1	63.70h	64.30 h	11.12e	11.22d
T_2	75.85ef	80.45 f	12.20cd	12.32cd
T_3	80.33c	85.71d	12.85bc	13.23bc
T_4	83.26b	87.19c	13.42b	13.64b
T_5	77.45de	83.42e	12.36bcd	12.89bc
T_6	91.23a	98.97a	14.80a	15.49a
T_7	72.10g	80.85f	11.45de	12.25cd
T_8	80.38c	75.76g	12.80bc	13.25bc
T_9	78.50cd	84.33e	12.48bcd	13.12bc
T_{10}	74.47f	80.87f	11.87cde	12.28cd
T_{11}	89.30a	96.83b	14.45a	15.15a

Means followed by different letter are significantly different within columns by Duncan's multiple range test, P ≤ 0.05

4. Fruit quality:

a. Physical characters:

Data in Tables 5 show clearly that, farmyard manure and biofertilizers with dose of NPK were significantly effects on fruit quality. The highest values of fruit length (cm), fruit diameter (cm), fruit weight (g) and juice % obtained with Eureka lemon trees fertilized with T_6 followed by T_{10} and T_3 as compared with control trees and other treatments in both seasons. Similar results were obtained by Elhassan *et al*., (2011), Dahiya *et al*., (2013) and Garhwal *et al*., (2014).

Table 5. Effect of organic manure, biofertilizers and NPK on physical fruit quality of lemon trees in 2014 and 2015 seasons.

Treatments	Fruit length Cm		Fruit diameter cm		Fruit weight g		Juice %	
	2014	2015	2014	2015	2014	2015	2014	2015
T_1	7.64f	6.70f	5.73g	5.10d	120.5h	135.7f	37.11f	40.42f
T_2	7.93def	7.60de	5.95f	5.70c	135.1f	140.8e	40.30cde	41.58e
T_3	8.44abc	8.80c	6.33cd	6.60b	149.9b	156.2b	43.61ab	45.13c
T_4	8.27bc	7.81d	6.20cde	5.86c	138.9d	143.5d	41.14c	42.17d
T_5	8.14cde	7.70de	6.13e	5.78c	136.0e	142.9d	40.71cd	42.13d
T_6	8.69a	9.95a	6.52b	7.55a	154.6a	158.7a	44.65a	48.14a
T_7	7.70f	7.40e	6.78a	7.55a	131.6g	137.0f	39.50e	40.71f
T_8	8.32bc	8.79c	6.24cde	6.59b	147.7c	151.3c	43.12b	45.12c
T_9	8.23bcd	7.81d	6.17de	5.86c	138.9d	142.9d	41.14c	42.13d
T_{10}	7.85ef	7.50de	5.89fg	5.63cd	133.3g	137.0f	39.89de	41.27e
T_{11}	8.49ab	9.18b	6.37bc	6.81b	150.8b	156.3b	43.82ab	46.16b

Means followed by different letter are significantly different within columns by Duncan's multiple range test, P ≤ 0.05

b. Chemical characters:

Data in Table 6 indicated that there were statistically significant differences among treatments in both seasons. Trees treated with T_7 gave fruits with higher TSS and acidity, while trees fertilized with T_6 gave the highest values vitamin C compared to control (T_1) in both seasons. These results agree with those of Abdel-Sattar *et al*., (2011) on Washington navel orange and El-Khawaga and Maklad, (2013) on Valencia orange.

Generally, farmyard manure and biofertilizers with NPK doses had a significant effect led to improve fruit quality in terms of fruit length, fruit diameter, fruit weight, juice % by weight and vitamin C compared to NPK only as control in both seasons. Concerning fruit TSS and acidity percentages, it seems that there was no trend consistent due to treatments during the two seasons. Similar results were obtained by Quaggio *et al*., (2006) and Mosa *et al*., (2014). It is obvious from data in Tables (5 and 6) that, organic manure and biofertilizers with NPK dose significantly enhanced Eureka lemon fruit quality.

Table 6. Effect of organic manure, biofertilizers and NPK on chemical fruit quality of lemon trees in 2014 and 2015 seasons.

Treatments	Total soluble solids %		Total acidity %		Vitamin C mg/ 100 ml juice	
	2014	2015	2014	2015	2014	2015
T_1	8.10 cd	8.75c	6.25 b	6.55a	40.25 f	36.86e
T_2	7.75 e	7.55g	5.98 d	5.82f	41.41 cd	40.13cd
T_3	8.45 b	7.90d	6.52 a	6.09c	43.43 b	44.84b
T_4	8.50 b	9.00b	6.55 a	6.44b	41.99 c	40.97c
T_5	8.00 d	7.65f	6.17 c	5.90e	41.86 c	40.54cd
T_6	8.40 b	8.80c	6.48 a	6.39b	44.46 a	49.83a
T_7	8.70 a	9.85a	6.51 a	6.60a	40.54 ef	39.34d
T_8	8.00 d	7.75e	6.17 c	5.98d	42.94 b	44.83b
T_9	8.10 cd	7.80e	6.25 b	6.01d	41.86 c	40.97c
T_{10}	7.80 e	7.00h	6.01 d	5.40g	41.10 de	39.73cd
T_{11}	8.15 c	7.90d	6.28 b	5.09h	43.64 b	45.96b

Means followed by different letter are significantly different within columns by Duncan's multiple range test, P ≤ 0.05

5. Leaf nutrient contents:

Data in Table 7 show the effect of farmyard manure and biofertilizers on leaf N, P, K, Fe, Mn and Zn content of Eureka lemon trees. Leaf nitrogen content increased with the application of different treatments as compared to control. T_6 recorded maximum leaf nitrogen content followed by T_{10} and T_3 in both seasons. The significant effect of NPK in combination with farmyard manure and biofertilizers was noted on the nitrogen content of Eureka lemon leaves. It may be concluded that level of soil nutrients record a positive relationship with the leaf nutritional status. In this respect, T_6 followed by T_{10} and T_5 increases the phosphorus concentration of Eureka lemon leaves and exhibited maximum phosphorus content without significant differences. This may be due to presence of organic manures increased microorganisms population and organic acids which causes better availability of soil phosphorus and better plant uptake. With regard to potassium, data revealed that T_6 gave the highest value of potassium followed by T_{10} and T_3 in both seasons, respectively. This may be due to the balanced nutrients which encourage potassium uptake. These result agree with those obtained by Sharaf *et al*., (2011) and El-

Sheikh, (2014) on Washington navel orange and lemon trees. These result could be attributed to *Azotobacter*, *Azospirillum*, *Bacillus megatherium* and *Bacillus circulans* by increasing leaf nitrogen, phosphorus and potassium content which indicated that the biofertilizers might have created certain microbial environment in the root rhizosphere zone for better uptake of NPK. Such conclusion was confirmed by Srivastava *et al*., (2002). As regard to micronutrients showed in Table 7 that the uptake of Fe and Mn were improved with the application of T_6. While, the Zn content uptake was improved with the application of T_{11}. These findings are in line with those of Selvamani and Manivannan, (2009).

Table 7. Effect of organic manure, biofertilizers and NPK on leaf mineral content of lemon trees in 2014 and 2015 seasons.

Treatments	N %		P %		K %	
	2014	2015	2014	2015	2014	2015
T_1	2.13e	2.18g	0.125d	0.129d	1.38d	1.40de
T_2	2.35d	2.43e	0.128cd	0.139bcd	1.39d	1.48cd
T_3	2.73a	2.64b	0.145abc	0.157ab	1.51bc	1.59ab
T_4	2.55b	2.63b	0.145abc	0.154ab	1.50bc	1.61ab
T_5	2.50bc	2.57c	0.150ab	0.159a	1.48bc	1.56bc
T_6	2.76a	2.79a	0.155a	0.160a	1.59a	1.68a
T_7	2.21e	2.31f	0.128cd	0.133cd	1.30e	1.38e
T_8	2.56b	2.62bc	0.140abcd	0.151abc	1.51bc	1.58abc
T_9	2.45bcd	2.49d	0.135bcd	0.147abcd	1.47c	1.56bc
T_{10}	2.38cd	2.36f	0.144abcd	0.155ab	1.45cd	1.55bc
T_{11}	2.70a	2.65b	0.150ab	0.155ab	1.56ab	1.68a
Treatments	**Fe ppm**		**Zn ppm**		**Mn ppm**	
	2014	**2015**	**2014**	**2015**	**2014**	**2015**
T_1	57.29g	63.44g	30.85e	30.70e	31.88e	33.71e
T_2	63.48f	71.75ef	33.30e	34.32d	31.74e	32.16f
T_3	78.64d	80.94c	36.74cd	37.50c	41.13c	42.18c
T_4	75.20de	77.33cd	39.16bc	39.88b	40.19c	42.14c
T_5	94.56bc	96.55ab	40.24b	40.80b	38.11d	38.72d
T_6	98.46a	98.85a	41.32ab	41.38b	47.20a	48.15a
T_7	57.77g	68.52f	32.92e	33.30d	37.13d	38.19d
T_8	91.49c	93.47b	36.58cd	37.43c	37.26d	39.42d
T_9	78.51d	80.97c	36.62cd	37.44c	36.24d	39.10d
T_{10}	73.18e	75.31de	36.11d	37.62c	31.14e	33.79e
T_{11}	96.18ab	99.50a	43.16a	44.30a	44.17b	45.30b

Means followed by different letter are significantly different within columns by Duncan's multiple range test, P ≤ 0.05

6. Available nutrients in the soil:

Data presented in Table 8 clearly indicate that there was a positive effect of bio-fertilizers in combination with farmyard manure and NPK dose. It is clear that the highest available nitrogen content in soil was observed in T_6 treatment followed by T_{11} and T_3 respectively. However, T_6 and T_{11} were found to be significantly superior to all other treatments. The lowest values of nitrogen was noticed in the control treatment. Also, T_6 and T_5 exhibited the high soil phosphorus followed by T_{11} respectively. Moreover, application of T_6, T_{11} and T_3 significantly increased the concentration of potassium, respectively. It is obvious from data in Table 8 that soil nitrogen, phosphorus and potassium contents were higher under treatments of 75 or 50% NPK + 27.5 or 55 kg farmyard manure with biofertilizers (T_{11} and T_6). The application of biofertilizers with farmyard manure and different dose of NPK was effective to maintain the nitrogen, phosphorus and potassium levels of the soil. Similar result was also found by Sahu *et al*., (2014) in guava and concluded that effect of organic manure and *Azospirillium*, decreased soil pH and EC and had an increase in soil of N, P and K. With regards to the available soil Fe, Zn and Mn, it was observed from Table 8 that available soil Fe and Zn were significantly increased by the application of T_{11} followed by T_6 and T_5. The treatment T_{11} was seemed to be superior to all other treatments and recorded maximum Fe and Zn, while, Mn content increased by application of T_6 followed by T_{11} and T_3. Similar results were reported by Mir *et al*., (2013).

Table 8. Effect of organic manure, biofertilizers and NPK on available soil nutrients of lemon orchard at the end of experiment.

Treatments	N mg/kg soil	P mg/kg soil	K mg/kg soil	Fe mg/kg soil	Zn mg/kg soil	Mn mg/kg soil
T_1	114.70f	6.55g	148.29d	12.95e	14.50c	9.35d
T_2	117.31ef	8.56f	148.50d	13.26e	17.11bc	9.66d
T_3	144.60c	12.88c	159.98b	15.74e	19.49ab	10.63ab
T_4	130.14d	12.97c	154.73c	28.87cd	19.56ab	10.23bc
T_5	119..75ef	14.97a	150.88d	32.49abc	19.56ab	10.19c
T_6	159.63a	15.11a	165.24a	33.24ab	19.85ab	10.92a
T_7	115.15f	8.11f	148.63d	26.76d	15.42c	9.45d
T_8	129.67d	9.66e	156.27c	28.36cd	19.56ab	10.24bc
T_9	121.94e	11.91d	148.89d	29.99bcd	17.15bc	9.70d
T_{10}	117.48ef	12.35d	148.84d	31.29abc	15.45c	9.53d
T_{11}	153.74b	13.84b	163.46ab	34.36a	21.41a	10.65ab

Means followed by different letter are significantly different within columns by Duncan's multiple range test, P ≤ 0.05

CONCLUSION

Consequently from the previously mentioned results, it was clear the main role of farmyard manure and biofertilizers with different doses of NPK on Eureka lemon trees grown in sandy soil, for supply nutrients which indispensable for improvement of growth and the nutritional status of the Eureka lemon trees and production of maximum yield with a good quality. Also, farmyard manure and biofertilizers could compensate 50% of chemical fertilizer without significant reduction in yield. Therefore, this treatment is recommended (50% NPK + 55 kg farmyard manure + biofertilizers). This treatment gave the best growth, yield, fruit quality and nutritional status of Eureka lemon trees. Besides, increasing soil content of most nutrients without side harmful effects on the tree and environment.

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تـاثير الاسـمدة العضـوية و الحيويـة والمعدنيـة (النيتـروجين و الفوسـفور و البوتاسـيوم) علـى النمـو الخضـرى و المحصول و جودة الثمار و خصوبة التربة لاشجار الليمون الاضاليا صنف يوريكا.

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أجريت تجربة حقلية خلال أعوام 2013 و 2014 و 2015 على أشجار الليمون الأضاليا صنف يوريكا في منطقة النوبارية محافظة البحيرة. لدراسة تأثير السماد البلدي و الأسمدة الحيوية مع دفعات من النيتروجين و الفسفور و البوتاسيوم المعدني على خصوبة التربة و النمو الخضري و المحصول و جودة الثمار ومحتوى الأوراق من العناصر الغذائية. تم توزيع إحدى عشر معاملة في تصميم قطاعات كاملة العشوائية على ثلاثة مكررات. أظهرت النتائج وجود فروق عالية المعنوية بين صفات النمو الخضري و المحصول و جودة الثمار و محتوى الأوراق من العناصر و محتوى التربة من العناصر الميسرة وهذا راجع إلى السماد البلدي و الأسمدة الحيوية. أيضا إستطاع السماد البلدي مع الأسمدة الحيوية تعويض خفض الأسمدة الكيماوية إلى 50% مع زيادة المحصول بالمقارنة مع الأسمدة الكيماوية (الكنترول 100% (KPN) مع وجود فروق ذات دلالة إحصائية. و لذلك ينصح باستخدام المعاملة 50% KPN + 55 كجم سماد بلدي لكل شجرة + السماد الحيوي و التي أعطت أفضل نمو خضري و محصول و جودة ثمار و عناصر غذائية لأشجار الليمون الاضاليا صنف يوريكا. بالإضافة إلى زيادة خصوبة التربة .