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Effect of Bio and Organic Fertilizers on Yield and Quality of Date palm (*Phoenix dactylifera,* cv Sakkoti) fruit grown in Aswan Governorate and their Contents of Iron and Zinc

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Abstract: Date palm (*Phoenix dactylifera* L.) fruit plantlets grown in arid region face several kinds of environmental stress. The vast majority of date palms in Egypt are planted in sandy calcareous soils, which are generally low in fertility beside of their extremely low values of the cation exchange capacity that facilitate either leaching and /or fixing the nutrients applied to theses soils as fertilizers. Such conditions might reduce both tree yield and fruit quality. An experiment was conducted during the 2022/2023 season on Sakkoti palm trees using chemical fertilizers (the recommended dose of nitrogen, phosphorus, and potassium), organic fertilizers (compost and humic substances), and biofertilizers. The biofertilizers included *Thiobacillus* bacteria, which work to dissolve sulfur, which improves the palm's absorption of elements and bacteria. *Bacillus megatherum*, which works to dissolve rock phosphate when added to the soil as a source of phosphorus in agriculture. This is to find out the extent to which these additions are possible improve nutrient uptake, date yield per tree and fruit quality. (e.g., fruit weight and size, TSS, and acidity). The experiment was designed according to a completely randomized design (CRD) with three replications. The results showed that treatment No.7 (T7) (Compost + EDTA + *Thiobacillus* + *Bacillus megatherium* + sulfur + rock phosphate + humic substances) had the highest yield of date fruits, which reached 116.7 kg/tree, and the bunch weight was 14.8 kg. Total sugars reached 73.8%, and the crude fibers reduced to 1.15%. In addition, to increasing the iron contents of the date fruit to 135 mg/kg, as well as zinc, its concentration in the date fruit increased to 81 mg/kg. Also, the results showed that T7 contained the highest numbers of total count bacteria, actinomycetes, and fungi during different time periods in the root zone, in addition to, an increase dehydrogenase and phosphatase enzymes activity during the same different time periods in the root zone compared to treatment No. 1 (T1) (recommended dose of NPK). It can be concluded; organic fertilizer and bio fertilizers are promising tool to enhancement productivity and quality fruits of date palm comparison with chemical fertilizers.

Keywords: *Sakkoti date palm, influence of exogenous Zn and Fe, organic fertilizers, biofertilizers, Humic substances*

1.Introduction

One of the oldest crops, date palm (*Phoenix dactylifera L.*) fruit has been grown for thousands of years in dry and semi-arid areas of northern Africa, the Middle East, the Horn of Africa, Australia, South Asia, and California.

In Egypt, date palm trees are extremely valuable both nutritionally and socioeconomically. In addition to its practical uses, additionally, date palm is valued as an ornamental plant in Arab countries, contributing to the beautification of the environment. Therefore, developing and enhancing the date palm production chain, which includes cultivars, growing, production, fruit quality, post-harvest technology, and marketing, is a top national priority in Egypt. However, plants grown in arid regions often face various environmental stresses, such as drought, salt, and heat stresses **(Farag, 2002)**. In Egypt, the country that leads the world in date production, the crop covers a vast area extending from Aswan in the south to the North Delta. According to recent statistics, there are 148,656,310 female palm trees and their yield amounts approximately 17,106,030Mg. Aswan Governorate is particularly noteworthy for its dry date production, with **M.A.L.R. (2020)** ranking it among the top Egyptian Governorates in this regard. In Egypt, the most important variety of dry dates is the Sakkoti date palm, as it thrives under even the most extreme environmental conditions. However, the soil type and orchard management can affect the growth of the tree and the quality of the fruit **(Al-Wasfy *et al.,* 2022)**.

Environmental stresses share a common mechanism in their impact on plant performance. Under stress conditions, the generation of free radicals and reduced nutrient uptake can lead to damage and dysfunction of plant cells. Therefore, there is a pressing need to find tools that can support plants in dealing with stress **(Bohnert *et al.,* 1995 and Nilsen and Orcutt, 1996)**.

Dates (*Phoenix dactylifera*) are regarded as a fruit with a high nutritional value and are advantageous because they are rich in vitamins, fibre, anti-cancer agents (flavonoids), and a high percentage of minerals including iron, copper, zinc, and selenium. As a result, they can help with kidney stones, cough, diarrhoea, anaemia, cardiovascular disease, cancer, and renal weakness **(Al-Farsi *et al.,* 2007; Al-Farsi and Lee, 2008; Vayalil, 2012; Zen and Pertiwi, 2013; Sadeghi and Kuhestani, 2014; Mousavi *et al.,* 2014; Rahmani *et al.,* 2014; Heba and Abeer, 2015; Al-Alawi *et al.,* 2017 and Bentrad and Ferhat, 2020)**.

The utilization of organic and biofertilizers in cultivating high-value crops has a favorable effect on the quality and production metrics **(Onofrei *et al.,* 2017; Nada *et al.,* 2022 and El-Beltagi *et al.,* 2023)**. Organic farming aims to improve soil nutrient status and lessen the usage of chemical fertilizers, and organic fertilization is a successful method for enhancing soil physical properties and chelating nutrients **(Singh *et al.,* 2024)**. Organic farming methods result in horticultural crops of higher quality, yielding safe products for human consumption **(Nada *et al.,* 2022; Abou Elhassan *et al.,* 2023 and Awad *et al.,* 2024)**. Previous research demonstrated that applying organic fertilization improved the plant vegetative growth, flowering characteristics, and chemical composition **(Kheiry *et al.,* 2016; EL-Zawawy *et al.,* 2021 and Filipović *et al.,* 2023)**. Microbial inoculants, such as bacteria, algae, and fungi, are applied to seeds or soil as biofertilizers, which solubilize potassium, phosphorus and fix nitrogen, increase soil fertility, and stimulate plant growth and flowering traits **(Farid *et al.,* 2023; Al-sayed *et al.,* 2024 and El-Naqma *et al.,* 2024)**.

Using sulfur with *Thiobacillus* in the soil works to lower the pH in the soil by oxidizing the sulfur and forming sulfuric acid, which leads to the facilitation of the elements in the soil and increases the plant's ability to absorb nutrients **(Dialami and Garshasbi, 2018)**. *Bacillus megatherium* bacteria secrete organic acids in the soil, such as acetic and formic, which leads to the conversion of the insoluble form of phosphorus into the soluble form. It also works to dissolve rock phosphate when it is added to the soil as a source of phosphorus **(Hussein *et al.,* 2019)**.

Humic substances are natural substances that improve the soil's biological and physicochemical properties, beside of increasing soil water-retention capabilities. This substance also boosts plants' tolerance to environmental stress and yields positive effects on the growth of plants, which are comparable to growth regulators' ones such as IAA, GA, and cytokine. Specifically, humic substances promote the growth of the root structure and increases the plant's nutrient absorption. By utilizing humic substances, it is possible to decrease the reliance on mineral fertilizers **(Amro, 2023)**. The growth of plants can be improved with the use of humic

substances, it causes a rise in the absorption of essential elements such as nitrogen, phosphorus, potassium, magnesium, iron, zinc, and copper **(El-Banna and Fouda, 2018)**.

Thus, the purpose of this research was to ascertain the impact of exogenous Zn and Fe, as well as organic fertilizers on the intake of nutrients, overall production per tree, and fruit quality of 'SAKKOTI' date palm trees.

2. Materials and methods

This research was done during the season 2022/2023 on Sakkoti date palms planted in a private date palm orchard in Adwa village of Kom Ombo of Aswan Governorate, Egypt, with the aim of increasing productivity of palms, enhancing fruit quality, and increasing their content of iron and zinc elements. These palms were characterized by normal bearing, uniform vigor, health, excellent physical health, devoid of insects, infections, and harms. The Nile water is used to irrigate the soil through a surface system with spacing between each plant and the other one plants 7 meters. The typical and customary horticultural techniques already applied to each of the selected palm plants in the orchard. To prevent metaxinia residues, the ratio of bunches to leaves was kept at 1:8 ratio. Pollination was also done consistently across sources, dates, and methods. After the female spathe had cracked for two days, five male strands were inserted into the female spathe during hand pollination. By removing extra earliest, latest, and smallest ones, the number of female spathes per palm became 10 spathes.

2.1. Materials

2.1.1. Soil characteristics

The experimental soil's physicochemical characteristics were measured and calculated according to **Horneck *et al*. (2011)**. Table (1) provides more information on these physicochemical properties.

Table 1. Physicochemical, and biological properties of the test soil.

Character	Unit	Soil
Distribution of particle size		
Clay	%	31.21
Silt	%	32.94
Fine sand	%	20.54
Coarse sand	%	15.31
Textural class		Loam clay
pH (1: 2.5) soil -water suspension		7.94
EC (saturation paste extract)	dS/m	2.43
Total $CaCO_3$	mg/kg	23100
Total N	mg/kg	1600
Total P	mg/kg	1300
Total K	mg/kg	2400
Soluble cations		
Ca^{++}	$mmol_c\ L^{-1}$	6.84
Mg^{++}	$mmol_c\ L^{-1}$	4.55
Na^{+}	$mmol_c\ L^{-1}$	11.87
K^{+}	$mmol_c\ L^{-1}$	1.05
Soluble anions		
$CO_3^{=}$	$mmol_c\ L^{-1}$	-
HCO_3^{-}	$mmol_c\ L^{-1}$	0.93
Cl^{-}	$mmol_c\ L^{-1}$	20.84
$SO_4^{=}$	$mmol_c\ L^{-1}$	2.54
Microbiological properties		
Total bacterial count	$cfu/g \times 10^6$	1.83
Total actinomycetes	$cfu/g \times 10^3$	1.12
Total fungi	$cfu/g \times 10^3$	0.88

cfu/g: Colony forming unit/gram

2.1.2. Compost

In this study, the composted materials were a mixture of agricultural wastes and cow dung that had been composted for 12 weeks. The physicochemical and biological parameters of the compost are shown in Table (2), as per **APHA (1989)**. Potassium, phosphorus, and total nitrogen in dry sample were measured, according

to **Black (1965)**. The **Difico Manual (1985)** was used to determine the *Salmonellae, Shigella*, total and faecal coliform bacteria in compost. According to **Jirillo *et al.* (2014)**, parasitic organisms were identified in compost. **Yu *et al.* (2010)** reported looking at weed seeds in compost, and **Rice *et al.* (2017)** reported looking at nematodes.

2.1.3. Humic substances preparation

The humic substances were taken out of the previously prepared compost using the techniques outlined by **Sanchez-Monedero *et al.* (2002)**. Data shown in Table (3) show the elemental composition of the humic substances. According to **Dragunova (1958)**, total acidity was calculated. **Schintzer and Gupta's (1965)** methodology was used in order to determine the carboxyl groups. The phenolic groups were identified according to **Kononova (1966)**.

2.1.4. Microorganisms

The bacterial strains used in this study were *Thiobacillus* and *Bacillus megatherium* obtained from Agric. Microbiology Dept., ARC, Giza, Egypt.

2.1.5. Sulfur, mixture EDTA (Kare Combi) and Rock phosphate

Sulfur, mixture EDTA (Kare Combi) and Rock phosphate were supplied by the Al-Ahram Company in the Giza Governorate.

Table 2. Physiochemical and biological analysis of compost.

Character	Unit	Compost
Physical analysis		
Density	kg/ m^3	605
Moisture content	%	27
Dry matter	%	73
pH (1:10)		7.19
EC (1:10)	dS/m	3.54
Chemical analysis		
N-NH_4	mg kg^{-1}	72
N-NO_3	mg kg^{-1}	398
Total nitrogen	mg kg^{-1}	17.1
Organic matter	gkg^{-1}	556.2
Organic carbon	gkg^{-1}	322.6
Ash	%	44.38
C/N ratio		18.87: 1
Total phosphorus	mg kg^{-1}	13.2
Total potassium	mg kg^{-1}	11.6
Biological analysis		
Total bacterial count	cfu/g × 10^6	2.9
Total actinomycetes	cfu/g × 10^4	195
Total fungi	cfu/g × 10^4	127
Total coliform	cfu/g	Not detected
Faecal coliform	cfu/g	Not detected
Salmonella* and *Shigella	cfu/g	Not detected
Nematode larva	Larava/200g	Nill
Parasitic		Nill
Weeds seeds		Nill

cfu/g: Colony forming unit/gram

Table 3. Properties of humic substances prepared out of the composted.

Character	Carbon (%)	Nitrogen (%)	Hydrogen (%)	Oxygen (%)	Sulfur (%)	Total Acidity (mmol/100g)	Total Carboxylic Groups (mmol/100g)	Total Phenolic Groups (mmol/100g)
Content	51.30	4.25	4.82	37.82	1.81	613	264	349

2.2. Experimental treatments

The trial treatments were organized in Completely Randomized Design (CRD) with three replications as follows:

T1: Full NPK (recommended dose needed to date palm was roughly 1231 g of nitrogen, 462 g of phosphorus and 1308 g of potassium per tree) + EDTA (150 g/tree) (control).

T2: Compost (50 kg/tree) + EDTA (150 g/tree).

T3: Compost (50 kg/tree) + EDTA (150 g/tree) + *Thiobacillus* (100 ml culture) + sulfur (3.0 kg/tree).

T4: Compost (50 kg/tree) + EDTA (150 g/tree) + *Bacillus megatherium* (100 ml culture) + rock phosphate (3.0 kg/tree).

T5: Compost (50 kg/tree) + EDTA (150 g/tree) + *Thiobacillus* (100 ml culture) + *Bacillus megatherium* (100 ml culture) + sulfur (3.0 kg/tree) + rock phosphate (3.0 kg/tree).

T6: Compost (50 kg/tree) + EDTA (150 g/tree) + humic substances (2 Liters/tree).

T7: Compost (50 kg/tree) + EDTA (150 g/tree) + *Thiobacillus* (100 ml culture) + *Bacillus megatherium* (100 ml culture) + sulfur (3.0 kg/tree) + rock phosphate (3.0 kg/tree) + humic substances (2 L/tree).

The transactions took place in the months of February and March, with the compost being added once to all the transactions in February and the remaining additions being added twice, the first in February and the second in March. An EDTA mixture containing zinc, iron, and manganese was added to all treatments; this mixture was marketed as Kare Combi for every tree in the winter using the Chalkood method of localised installation.

2.3. Determinations

The following criteria were assessed.

According to **Martin (1950)**, actinomycetes **(Williams and Davis, 1965)**, fungi, and total bacterial count **(Allen, 1959)**, were measured at the7th, 15th, 30, 60 and 90 days from the beginning of the experiment.

The dehydrogenase activity (µg/g dry soil/day) **(Skujins, 1976)** and total phosphatase (mg/ PNP/g dry soil) **(Tabatabai, 1982)**, were determined at the days mentioned above i.e.7, 15, 30, 60 and 90 days from the beginning of the experiment.

Determinations of the macro and micro elements (N, P, K, Mn, Zn and Fe) in leaves were determined as follows

According to **Martin-Préval *et al.* (1984)** and **Ibrahim (2010)**, a six-month-old labelled leaf per palm was plucked (every year during the first week of August). The medium four leaflets were then taken, rinsed with distilled water, and air-dried at 70 °C for 72 hours. After the leaflets were crushed, 0.5 g of the material was digested with H_2SO_4 and H_2O_2 to produce a transparent solution **(Martin-Préval *et al.,* 1984)**. After being quantitatively transferred to a 100 mL volumetric flask, the digested solution was filled to the full 100 mL with distilled water. Following that, the following was established to be the contents of N, P, K, Mn, Zn, and Fe: **Martin-Préval *et al.* (1984)** modified microkejldahl technique was used to determine nitrogen. The colorimetric approach, as reported by **Walsh and Beaton (1986)**, was used to determine phosphorus. While Mn, Zn, and Fe were determined using the atomic absorption method **(Martin-Préval *et al.,* 1984)**, potassium was determined flame photometrically following the method described by **Martin-Préval *et al.* (1984)**.

Bunches of Sakkoti date palm were selected during the ideal commercial harvesting season under Aswan region conditions **(Mahmoud, 2017)**.

Average weight of fruit was estimated using top pan balance of 0.01g sensitivity, flesh weight was recorded, and the % values of the flesh were calculated. Fruit dimensions (height and diameter (cm) were measured, using vernier caliper. Edible (flesh weight) to non-edible portions (seed weight) was computed (flesh/seed) according to **Ibrahim (2010).**

Determination of fruits chemical properties were carried out as follows

A100 gram weight of fruit flesh was added to 100 mL distilled water and stand 4 hours, then was minced well with electric blender, the T.S.S % was determined by using hand refractometer. Total and reduced sugars% were determined by using Lane and Eynonevolumetric method **(Rangana, 1977)**. The non-reduced sugars were calculated. Total acidity % was determined by titration against 0.1 NaOH using phenolphthalein as an indicator **(A.O.A.C, 1995**). Crude fiber % was measured by using acetic acid glacial and nitric acid at 10:1 solution according to **A.O.A.C. (1995)**.

2.4. Statistical analysis

To ascertain the significance of treatment effects, analysis of variance was conducted on all obtained data using **statistix 10 software package 2013**. Multiple range tests and the F-LSD at 0.05 threshold of significant technique were employed to compare among the means according to **Snedecor and Cochran (1991)**.

3. Results

3.1. Yield and bunch weight (kg)

Table (4) shows that total yield per tree was notably increased by the applied fertilizers compared to the control, traditional treatment of NPK. Values for every treatment were greater than those for the control. It is important, however to indicate that the treatment T7 resulted in the highest values for all the tested parameters followed by the T5. Bunch weight averaged 14.8 kg/bunch due to treatment T7 while the bunch weight averaged only 11.6 kg/bunch due to the traditional treatment of NPK i.e.T1. The average total fruit yield was 116.70 kg/tree for T7 followed by that achieved due to the treatment T6 which106.50 kg per tree. The corresponding average value attained due to the treatment T5 was 94.5 kg/tree, while the least average value for yield per tree was 43.65 kg/tree owing to the traditional NPK treatment.

3.2. Fruit physical properties

Every physical characteristic of the fruit of the date palm, Sakkoti variety i.e. Fruit measurements include weight, length, diameter, and percentage of flesh were improved, however, the treatment T7 resulted in the highest fruit quality followed by the treatments T5, T6, T4, T3, T2 and finally the control treatment due to T7 better contents of nutrients and microorganisms, (Table 4).

Table 4. Yield (kg/palm) of Sakkoti date fruits, bunch weight, variety and its quality (fruit weight, diameter and flesh percentage of the fruit, grown in Aswan governorate and treated with different fertilizers.

Treatments	Bunch weight (kg)	Yield of fruit (kg/palm)	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Flesh (%)
T1	11.6 ^{b}	43.65 ^{f}	7.6 ^{c}	3.5 ^{c}	1.7 ^{a}	86.73 ^{b}
T2	11.9 ^{b}	38.70 ^{f}	8.4 ^{bc}	3.8 ^{bc}	1.9 ^{a}	89.73 ^{ab}
T3	12.2 ^{b}	54.32 ^{e}	9.2 ^{abc}	4.1 ^{abc}	2.1 ^{a}	90.36 ^{ab}
T4	12.6 ^{ab}	77.84 ^{d}	9.7 ^{abc}	4.4 ^{abc}	2.2 ^{a}	91.28 ^{a}
T5	13.3 ^{ab}	94.50 ^{c}	10.5 ^{ab}	4.8 ^{ab}	2.4 ^{a}	92.87 ^{a}
T6	12.4 ^{b}	106.50 ^{b}	10.2 ^{ab}	4.5 ^{abc}	2.3 ^{a}	91.92 ^{a}
T7	14.8 ^{a}	116.70 ^{a}	11.2 ^{a}	5.1 ^{a}	2.6 ^{a}	93.31 ^{a}
LSD (0.05)	**2.25**	**5.16**	**2.26**	**0.94**	**0.99**	**3.70**

3.3. Fruit chemical properties

Table (5) describe the quality of date fruits variety Sakkoti and its composition grown in Aswan governorate and treated with different fertilizers. It is very clear that the addition of different organic and biofertilizers as shown in Table (5) improved the TSS and total sugars content of the Sakkoti date fruits. T7 gave the height values for TSS and Total sugars contents. T7 gave the value of 74.7 %b of TSS followed by 72.9% for T5 while T1 gave the least TSS percentage 66.7% only. In the same manner the total sugars content followed the same trend and T7 gave 73.8 % total sugars content while the NPK gave the least values in all treatments for the sugar contents 61.4% only. Also, the reducing sugars and non-reducing sugars measured in this experiment followed the same trend and treatment T7 gave the highest value of reducing sugars followed by T5 and T1 gave the least value for reducing sugars content.

Table 5. Quality of date fruit Sakkoti variety grown in Aswan governorate and treated with different fertilizers

Treatments	TSS (%)	Total Sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)	Total acidity (%)	Crude fiber (%)
T1	66.7 ^{f}	61.4 ^{f}	37.9 ^{c}	23.5 ^{b}	0.376 ^{a}	1.83 ^{a}
T2	68.9 ^{e}	64.6 ^{e}	40.2 ^{bc}	24.4 ^{ab}	0.333 ^{b}	1.66 ^{b}
T3	70.4 ^{de}	65.3 ^{de}	40.4 ^{bc}	24.9 ^{ab}	0.286 ^{c}	1.59 ^{b}
T4	70.9 ^{cd}	67.2 ^{cd}	41.7 ^{abc}	25.5 ^{ab}	0.234 ^{d}	1.44 ^{c}
T5	72.9 ^{ab}	71.4 ^{b}	44.1 ^{ab}	27.3 ^{ab}	0.197 ^{ef}	1.27 ^{d}
T6	72.3 ^{bc}	68.6 ^{c}	42.4 ^{abc}	26.2 ^{ab}	0.206 ^{e}	1.32 ^{d}
T7	74.7 ^{a}	73.8 ^{a}	45.6 ^{a}	28.2 ^{a}	0.191 ^{f}	1.15 ^{e}
LSD (0.05)	**1.84**	**2.09**	**5.20**	**4.57**	**0.01**	**0.15**

In Table (5) the total acidity was higher in treatment T1 0.376 (%) and T7 showed the least acidity content 0.191 (%). In the same manner the fiber content was higher in T1 and showed 1.83 (%) while T7 has only 1.15 (%). As can be seen from the information in Table (5), that T7 which has given the highest quantity and quality of date fruits and this of course because its content and enriched with organic and biofertilizers.

3.4. Elemental composition of macro and some micronutrients of date fruit

Date palm trees responded positively to fertilization treatments and its yield quantity and quality improved in all treatments. Table (6) shows that Elemental composition of macro and some micro nutrients of date fruit Sakkoti variety grown in Aswan governorate and treated with different fertilizers was greatly increased by the applied fertilizers contrasted with the control, traditional treatment of NPK. All treatments showed higher values above the control. In the same manner treatment T7 gave the highest values for all parameters tested followed by T5. The nitrogen content in the fruits was 2.11 for T7 and only1.48% for traditional treatment of NPK. The same trend was in Phosphorus where T7 showed 0.34% while NPK treatment showed only 0.125%. Also, potassium content in the fruits showed a concentration of 1.56 % while NPK treatment showed only 1.13%.

Concentration of Iron in T7 gave the height concentration in all treatments and it was 135.0 $mg.kg^{-1}$, while for T1 it was only 31.0 $mg.kg^{-1}$. Also, concentration of zinc was higher in T7 than other treatments while T1 gave the least concentration of Zn. These results reflect the consequence of organic and biological fertilizers on the solubility of trace elements, especially Iron, and zinc which is very important to enrich the dight of children and

deficient people of these important nutrients. Also, Mn followed the same trend in which the T7 gave the highest concentration of 84 mg.kg^{-1} while T1 has only 30.0 mg.kg^{-1} fruits. The results obtained by several studies.

Table 6. Elemental composition of date fruit, Sakkoti variety grown in Aswan governorate and treated with different fertilizers.

Treatments	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Fe (mg.kg^{-1})	Zn (mg.kg^{-1})	Mn (mg.kg^{-1})
T1	1.48 ^{d}	0.12 ^{d}	1.13 ^{e}	31 ^{e}	27 ^{e}	30 ^{f}
T2	1.72 ^{c}	0.16 ^{d}	1.23 ^{de}	43 ^{e}	37 ^{de}	41 ^{ef}
T3	1.81 ^{bc}	0.18 ^{cd}	1.26 ^{cde}	61 ^{d}	41 ^{d}	49 ^{de}
T4	1.86 ^{bc}	0.25 ^{bc}	1.33 ^{bcd}	72 ^{d}	49 ^{cd}	57 ^{cd}
T5	1.98 ^{ab}	0.29 ^{ab}	1.45 ^{ab}	119 ^{b}	67 ^{b}	75 ^{ab}
T6	1.93 ^{b}	0.28 ^{ab}	1.39 ^{bc}	102 ^{c}	55 ^{bc}	67 ^{bc}
T7	2.11 ^{a}	0.34 ^{a}	1.56 ^{a}	135 ^{a}	81 ^{a}	84 ^{a}
LSD (0.05)	**0.18**	**0.09**	**0.14**	**12.02**	**13.90**	**14.89**

3.5. Elemental composition of macro and some micronutrients in soil following the harvest of date fruit

The addition of organic and biofertilizers to date palm trees improved soil fertility and date palm tree growth. In Table (7) it is very clear that treated soil with organic fertilizers e.g., compost and humic acids improved its pH toward neutrality and reduced its electrical conductivity. Also, T7 gave the best figures for pH and EC in Table (7) pH and EC values for T1 above all and shoed higher values for pH and EC. Additionally, there is organic matter in the soil improved due to the addition of compost and biofertilizers, T7 showed the highest organic matter content of 0.73 while for T1 it was only 0.53.

Table 7. Some chemical properties of soil and its contents of the macronutrients N, P, K beside of the micronutrients Fe, Mn and Zn after harvesting the date fruit Sakkoti variety grown in Aswan governorate and treated with different fertilizers.

Treatments	pH (1:2.5)	EC (ds/ m)	O.M (%)	Available macronutrients (mg.kg^{-1})			Available micronutrients (mg.kg^{-1})		
				N	P	K	Fe	Mn	Zn
T1	7.97 ^{a}	2.53 ^{a}	0.53 ^{d}	31.3 ^{e}	3.55 ^{e}	169 ^{d}	2.89 ^{c}	1.73 ^{c}	0.57 ^{c}
T2	7.73 ^{b}	2.29 ^{b}	0.61 ^{c}	36.5 ^{d}	4.21 ^{d}	175 ^{d}	2.96 ^{bc}	1.81 ^{bc}	0.59 ^{c}
T3	7.60 ^{bc}	2.21 ^{b}	0.63 ^{bc}	41.9 ^{c}	4.66 ^{c}	191 ^{c}	2.99 ^{abc}	1.84 ^{abc}	0.63 ^{bc}
T4	7.55 ^{bc}	2.18 ^{b}	0.66 ^{abc}	42.5 ^{c}	4.72 ^{c}	193 ^{c}	3.03 ^{abc}	1.88 ^{abc}	0.64 ^{bc}
T5	7.46 ^{cd}	2.11 ^{bc}	0.69 ^{ab}	50.9 ^{b}	5.18 ^{b}	207 ^{b}	3.11 ^{ab}	1.95 ^{ab}	0.69 ^{ab}
T6	7.51 ^{cd}	2.15 ^{bc}	0.67 ^{abc}	49.8 ^{b}	4.91 ^{bc}	196 ^{c}	3.09 ^{ab}	1.91 ^{ab}	0.65 ^{abc}
T7	7.33 ^{d}	1.97 ^{c}	0.73 ^{a}	53.6 ^{a}	5.63 ^{a}	217 ^{a}	3.14 ^{a}	1.99 ^{a}	0.74 ^{a}
LSD (0.05)	**0.22**	**0.19**	**0.08**	**1.74**	**0.39**	**6.07**	**0.15**	**0.16**	**0.09**

In Table (7) macro and micro nutrients have been improved and all treatments came above the control. T7 gave the highest content of macro and micronutrient and followed by T5 while T1 came at lowest values for all figures tested in this experiment.

3.6. Effect of some nutrient treatments on total counts of bacteria, actinomycetes and fungi in tested soil

Fig. (1) shows that the total counts bacteria (cfu/g soil), increased due to all treatments with time through which the teatmentT7 resulted in the highest total bacterial counts, followed by T5, while T1 caused the lowest corresponding values. Fig. (2) also reveals that the total counts of actinomycetes, increased with time due to all treatments, however, the treatment T7 resulted in the highest count, followed by T5, while T1 showed the

lowest count 4.5 × 10^3 cfu/g soil. The total count of fungi also increased owing to the all treatments with time ,however, the treatment T7 gave the highest number of fungi counts 47 × 10^3 cfu/g soil followed by T5 while, T1 resulted in the lowest count (Fig., 3).Thus, it can be noticed that the T7 treatment exhibited the highest counts of bacteria, fungi, and actinomycetes hence its content of humates is known to stimulate microbial activity in soil to extents depending on the species, culture medium, and environment.

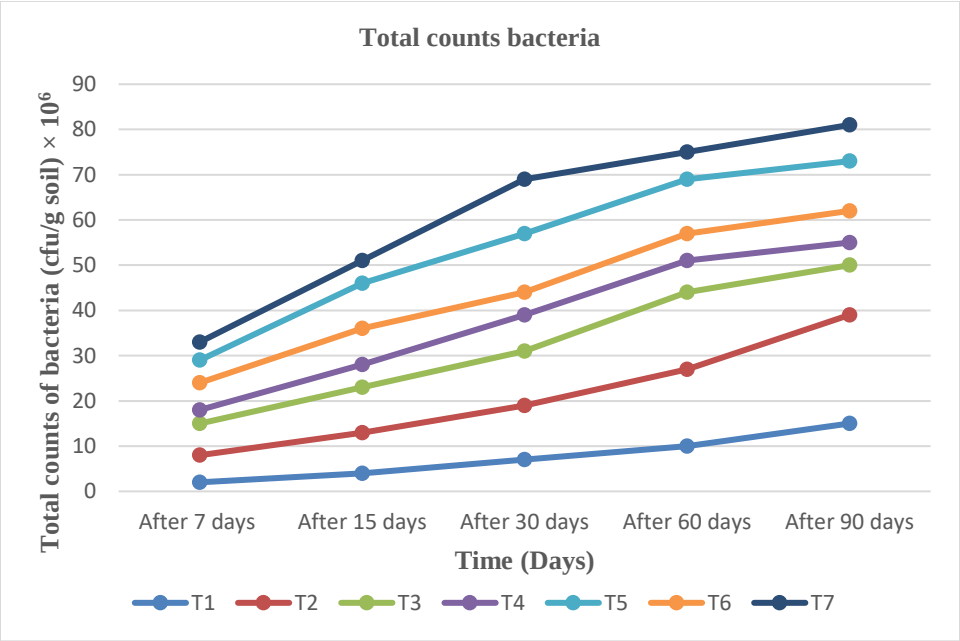

Fig. 1. Total counts of bacteria (cfu/g soil) in tested soil with the treatment aging.

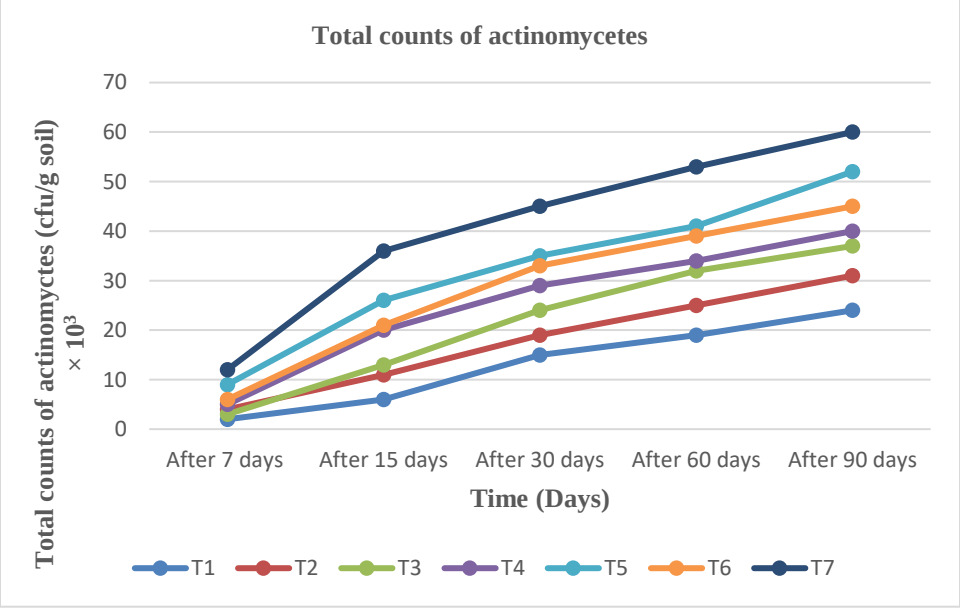

Fig. 2. Total counts of actinomycetes (cfu/g soil) in tested soil with the treatment aging.

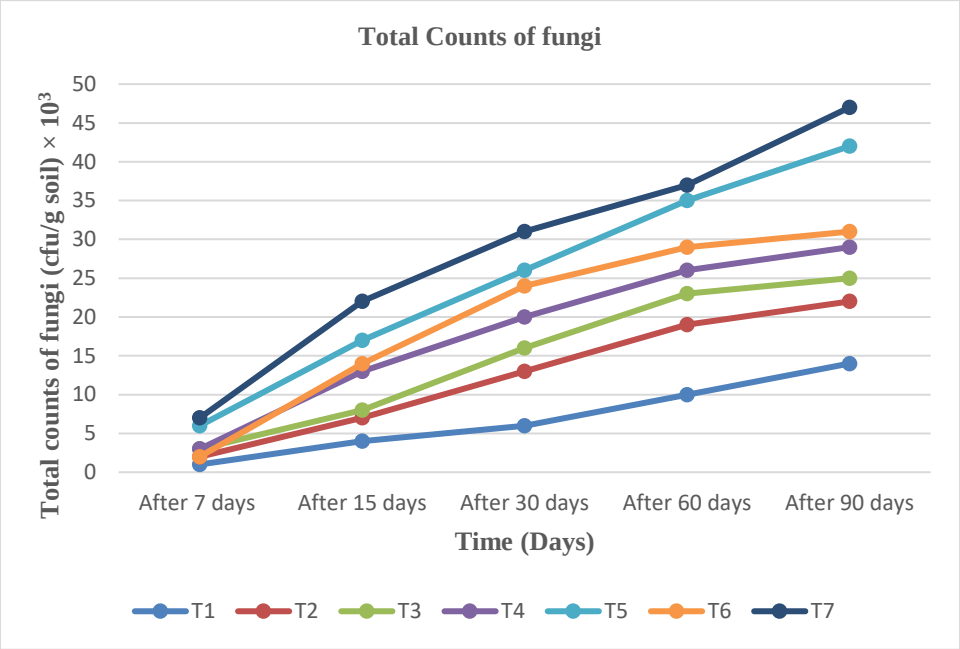

Fig. 3. Total counts of fungi (cfu/g soil) in tested soil with the treatment aging.

3.7. Effect of some nutrient treatments on dehydrogenase and phosphatase activity in the tested soil

Fig. (4), reveals a substantial increase in dehydrogenase enzyme activity due to nearly every treatment in contrast to the control (T1). The highest enzymatic activity values occurred due to the treatment T7, with 59.2 µg/g dry soil/day, while the treatment T1 caused the lowest value (15.7 µg/g dry soil/day).

Also, the phosphatase activity was greatly enhanced due to the all treatments as compared with the control treatment which received the inorganic NPK (Fig., 5). The treatment T7 gave the maximum amount of the phosphatase activity **(**0.87 mg/ PNP/g dry soil) while the corresponding lowest value **(**only 0.33 mg/ PNP/g dry soil**)** was attained due to the treatment T1.

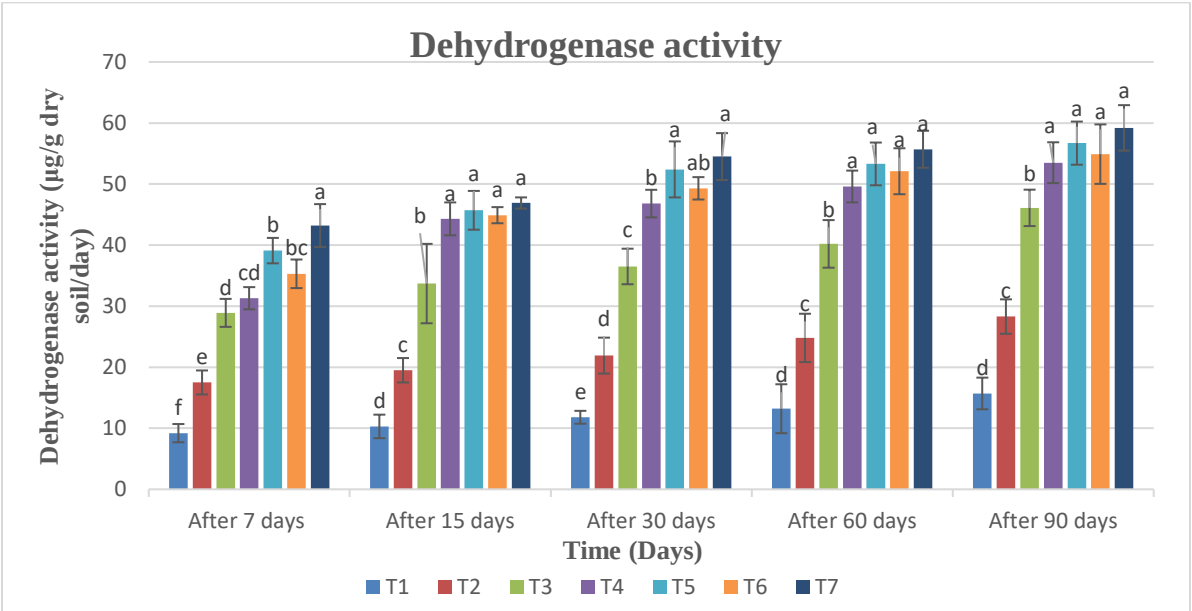

Fig. 4. Dehydrogenase activity in tested soil with the treatment aging.

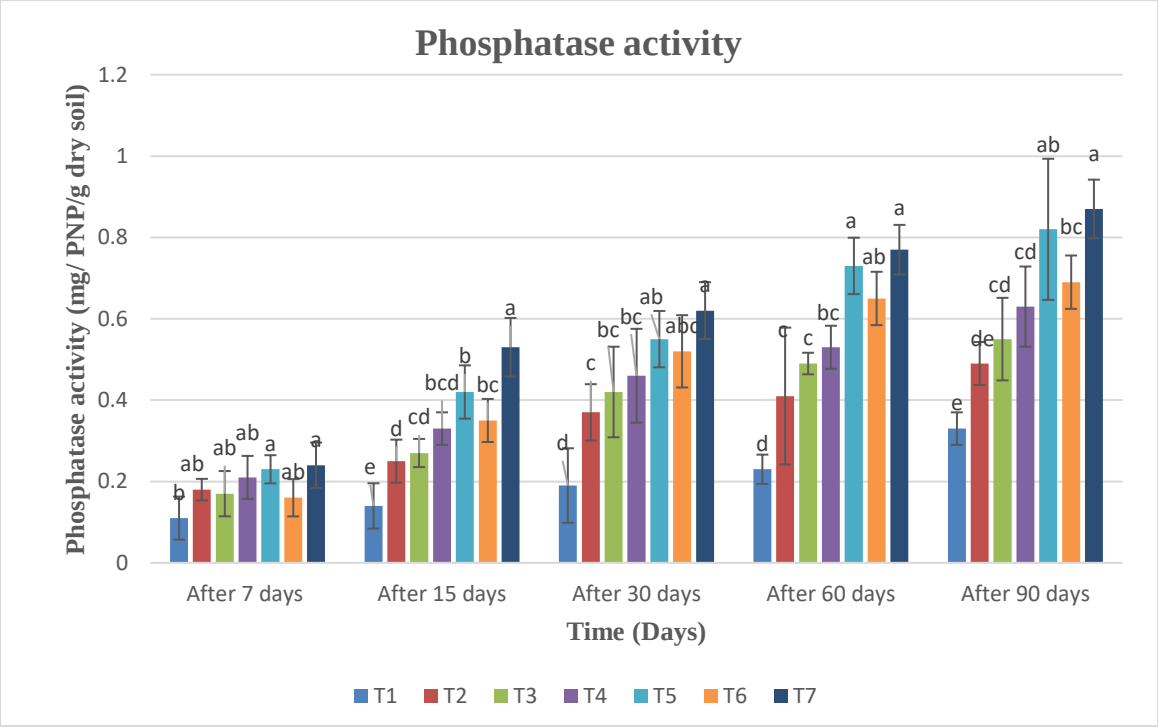

Fig. 5. Phosphatase activity in tested soil with the treatment aging.

4. Discussion

Utilizing bio- and organic fertilizers promotes growth and improves nutritional status; this is primarily due to the positive outcomes of these fertilizers on soil structure, aggregation, microflora activity, water-holding capacity, organic matter, humus concentration of soil, and nutrient accessibility. Additionally, these results may be explained by the way that biofertilizers and organic manure increase soil acidity, decrease nitrogen loss through drainage water, and improve nutrient availability, respectively. It can also give palms the majority of the nutrients they need for the entire growing season. Increased nutrient absorption results in increased cell division and organic food production **(Kannainyan, 2002; Kannainyan, 2002 and Yang *et al.,* 2019 and El-Salhy *et al.,* 2021)**. Overall, the results show how crucial organic fertilization, nitrogen management, and biofertilization are for fostering sustainable agriculture through increased plant growth, nutrient availability, and soil fertility. Plant growth characteristics are improved by each treatment in a different way, which eventually results in higher yield and productivity **(Shabana *et al.,*2024)**.

As a consequence, it can be concluded that applying organic fertilizers in addition to biofertilizers along with some minerals improved the characteristics of the crop and increased production due to better fruit retention and flower bud formation as well as decreased fruit falling. The experiment's outcomes are entirely consistent with **Awad *et al.,* 2005; Bohnert *et al.,* 1995 and Nilsen and Orcutt, 1996**. According to **Kassem *et al.* (1997)**, nitrogen rates (0, 3, 4, 5, and 6 kg per palm annually) enhanced the yield of all cultivars in the second season as opposed to the control. Conversely, **Al-Juburi *et al.* (1991)** found that applying 600 g of nitrogen per palm annually increased fruit yield per tree. Furthermore, **Soliman and Osman (2003)** found that nitrogen and potassium fertilization significantly boosted yield. In order to make soil nutrients like nitrogen, phosphorus, and potassium more accessible to plants, potassium humate functions as an organic chelator by creating complexes with these elements. These humic materials may also have enhanced microbial activity, soil structure, and water retention, all of which would promote growth **(Abd El-Hady *et al.,* 2024)**.

The study also demonstrated how using biological and organic fertilizers improved the fruit's physical characteristics and, consequently, its quality. These findings agree, to some extent, comparing reported by **El-Merghany *et al.* (2014)** and **El-Salhy *et al.* (2021)**.

Furthermore, the enhancement of TSS, total sugars, total acidity, and crude fiber in dates resulting from the application of organic fertilizer in conjunction with biofertilizer sources may be attributed to a well-balanced growth and fruiting cycle, as well as the accumulation of more carbohydrates, which become more readily available to aid in the ripening process. These findings are consistent with those reported by **Awad *et el.,* 2005; Bohnert *et al.,* 1995; Nilsen and Orcutt, 1996; El-Merghany *et al.* (2014) and El-Salhy *et al.* (2021)** to some extent.

The concentration of macro- and microelements in date fruits increased as a result of fertilization with organic and biofertilizers. Due to the organic and biological fertilizer's ability to provide these elements in a form that is easy for plants to absorb, there was a noticeable increase in iron and zinc, which increased the amount of these elements stored in date fruits. Using this technique could assist us in solving the issue of iron absorption and transmission in date palms, as the injection of iron into the trunk delivers this element straight to the corresponding portions of the plant. Plants that have access to adequate amounts of Fe experience an increase in photosynthesis and the movement of carbohydrates. As a result, the output yield increases **(Mengel and Kirkby, 1978; Abo-Rady *et al.,* 1987; Peryea and Kammereck, 1997; Tindall *et al.,* 1996; Malakouti and Samar, 1998; Malakouti and Tabatabaei, 1999 and Rasouli and Malakotti, 1999)**. They are in full agreement with our findings.

By the time the experiment was over and the dates were harvested, it was discovered that adding organic and biofertilizers to the soil along with some minerals improved the soil's physical-chemical characteristics and increased the amount of macro- and microelements in a form that plants could easily assimilate. The outcomes were in line with what was published by **El-Merghany *et al.* (2014)**, who also found similar outcomes.

When humic acid is present, the multiplication of advantageous bacteria and fungus can enhance the biological growth of plants. In addition to humic acid, which has been demonstrated to reduce pH to a more impartial degree and increase the availability of nutrients, these bacteria are great root stimulators. Humate-treated plants thus typically have higher levels of health, strength, and insect resistance **(Huck *et al.,* 1991)**. According to **Afifi (2010)**, the best humic acid to use for considerably increasing the overall bacterial counts, actinomycetes, and fungal counts in soil was humic acid recovered from compost (10 mg/kg with 25 mg/kg of nitrogen, respectively; 185 × 10^5, 255, and 102 × 10^5 cfu/g). In several respects, their findings concur with those of **Shahein *et al.* (2015)**.

Dehydrogenases (DHA) are enzymes found within living cells and serve as crucial indicators of the microbial activity in soil **(Trasar-Cepeda *et al.,* 1999)**. The improvement occurred in dehydrogenase activity in the plots treated with compost might be attributable up to the more advanced organic material content present in these areas **(Wlodarczyk *et al.,* 2002)**. Soil to which compost and farmyard manure were added had an increase in the activity of the dehydrogenase enzyme associated to the soil to which mineral fertilizers were added **(Marten *et al.,* 1992 and Marinari *et al.,* 2000)**. These results, for the most part, agree with those published by (**Mohammadi (2011); Shahein *et al.* (2015) and Elsoury *et al.* (2015)**.

Some studies have shown that adding organic fertilizers to the soil causes a rise in the activity of the phosphatase enzyme in this soil **(Martens *et al.,* 1992 and Tarafdar *et al.,* 1994)**. **Giusquian *et al.* (1994)** found that the activity of the phosphatase enzyme increased by adding compost to the soil at a rate of 37 tons per acre, and the activity of the phosphatase enzyme continued to increase by adding compost until the addition rate reached 112 tons per acre in one of the field experiments. **Jin *et al.* (2009)** found that the process of plowing agricultural soil has positive effects on increasing the activity of soil enzymes. These results are somewhat consistent conforming to presented by **Afifi *et al.* (2014)**.

4. Conclusion

In this research paper, we found that date palm trees absolutely respond to the adding of all types of fertilizers under study, however, the treatment received NPK only i.e. T1 resulted in the least values for all the measured properties of the plant and fruit components while the treatments that contained organic compost and other microbial inoculant gave higher corresponding values for quality and quantity of date fruits. Likewise, date palm trees can be improved upon application of Zinc and Iron. Finally, more experiments on the use of chemical, organic and biofertilizers need to be carried out for more years before these treatments can be recommended for other fruit crop under different climatic conditions.

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