Journal homepage
www.ajas.uoanbar.edu.iq
Anbar Journal of Agricultural Sciences
(University of Anbar – College of Agriculture)

IMPROVING THE PRODUCTIVITY AND QUALITY OF FIG TREES VIA FOLIAR APPLICATION OF ORGANIC, CHEMICAL AND BIO FERTILIZERS

R. A. Medan [1]*   **W. F. A. Mosa [2]**

[1] Hortic. and Landscape Design Dept., College of Agric., University of Kirkuk, Iraq.

[2] Plant Production Department (Horticulture-Pomology), Faculty of Agriculture, Saba Basha, Alexandria University, Alexandria 21531, Egypt.

***Correspondence to:** Raad Ahmed Medan, Hortic. and Landscape Design Dept., College of Agric., University of Kirkuk, Iraq.
Email: Raad132@uokirkuk.edu.iq

Article info

Received: 2024-12-18
Accepted: 2025-02-24
Published: 2025-06-30

DOI-Crossref:
10.32649/ajas.2025.186646

Cite as:
Medan, R. A., and Mosa, W. F. A. (2025). Improving the productivity and quality of fig trees via foliar application of organic, chemical and bio fertilizers. Anbar Journal of Agricultural Sciences, 23(1): 326-338.

Abstract

The inferior quality, small size, and low yields of fig fruits are among the problems facing producers in Iraq. This study investigated the effect of spraying of 0-, 2-, and 3-ml L^{-1} liquid organic fertilizer, 0 and 3 g L^{-1} nanocomposite fertilizer, and 0-, 2- and 4-mL L^{-1} of EM^{-1} biofertilizer on 8-year-old fig trees cv. Khalo Baziani. RCBD was used as a factorial experiment with three factors and three replications. Fruit weight, number, yield, size, and total soluble solids significantly increased after spraying with 3 mL L^{-1} organic fertilizer concentration to 22.65 g fruit^{-1}, 807.50 fruits tree $^{-1}$, 18.27 kg tree^{-1}, 36.07 cm^3, and 18.49%. The 3 g L^{-1} nano-composite fertilizer concentration led to a significant increase in the same traits at 22.86 g fruit $^{-1}$, 739.53 fruits tree $^{-1}$, 16.90 kg tree^{-1}, 34.68 cm^3, and 17.85%, respectively. The 4 mL L^{-1} biofertilizer concentration produced a significant increase in fruit weight and total yield at 23.08 gm fruit^{-1} and 16.78 kg tree^{-1}, respectively. This study recommends using liquid organic fertilizer, NPK nanoparticles, and EM^{-1} biofertilizer as an integrated approach to improve fig tree productivity and fruit quality in locations having conditions similar to the experiment areas.

Keywords: Organic, Chemical, Bio fertilizers, Fig.

تحسين إنتاجية وجودة ثمار اشجار التين بالرش الورقي للأسمدة العضوية والكيميائية والحيوية

رعد أحمد ميدان [1]* وليد فضيله عبدالجليل موسى [2]

[1] قسم البستنة وهندسة الحدائق، كلية الزراعة، جامعة كركوك، العراق.

[2] قسم الإنتاج النباتي (البساتين – الفاكهة)، كلية الزراعة سابا باشا، جامعة الإسكندرية، الإسكندرية 21531، مصر.

***المراسلة الى:** رعد أحمد ميدان، قسم البستنة وهندسة الحدائق، كلية الزراعة، جامعة كركوك، العراق.

البريد الالكتروني: Raad132@uokirkuk.edu.iq

الخلاصة

انخفاض جودة ثمار التين وصغر حجمها وقلة الحاصل من المشاكل التي تواجه المزارعين في العراق. نفذ هذا البحث في أحد البساتين الخاص الواقعة في ناحية ليلان التابعة لمحافظة كركوك على أشجار التين صنف (خالو بازياني) بعمر 8 سنوات خلال 2023، وتضمنت الدراسة تأثير ثلاث عوامل: العامل الأول الرش بثلاث تراكيز من السماد العضوي السائل (0 و2 و3 مل لتر$^{-1}$) والعامل الثاني الرش بتركيزين من السماد المركب النانوي NPK (0 و3 غم لتر$^{-1}$) والعامل الثالث الرش بثلاث تراكيز من السماد الحيوي EM^{-1} (0 و2 و4 مل لتر$^{-1}$)، والتصميم المستخدم في البحث هو تصميم القطاعات العشوائية الكامل كتجربة عاملية في ثلاثة مكررات. أدى الرش بتركيز 3 مل لتر$^{-1}$ من السماد العضوي الى زيادة معنوية في صفات (وزن وعدد الثمار والمحصول وحجم الثمرة ونسبة المواد الصلبة الذائبة الكلية) التي سجلت 22.65 غم ثمرة$^{-1}$ و739.53 ثمرة شجرة$^{-1}$ و16.90 كغم شجرة$^{-}$ و36.07 سم^{3} و18.49% بالتتابع وتفوق تركيز 3 غم لتر$^{-1}$ من السماد المركب النانوي الى زيادة معنوية في وزن الثمرة وعدد الثمار والحاصل الكلي وحجم الثمرة ونسبة المواد الصلبة الذائبة الكلية) التي سجلت 22.86 غم ثمرة$^{-1}$ و739.53 ثمرة شجرة$^{-1}$ و16.90 كغم شجرة$^{-1}$ و34.68 سم^{3} و17.85 % بالتتابع بينما تفوق تركيز 4 مل لتر$^{-1}$ من السماد الحيوي في صفة الوزن الثمرة وحاصل الكلي إذ بلغ 23.08 غم ثمرة$^{-1}$ و16.78 كغم شجرة$^{-1}$ على التوالي. وكان للتداخلات الثنائية والثلاثية تأثير معنوي في معظم الصفات المدروسة.

تنصح الدراسة باستخدام السماد العضوي السائل والسماد المركب النانوي NPK والسماد الحيوي EM^{-1} كنهج متكامل لتحسين إنتاجية شجرة التين وجودة الثمار في ظروف مناطق مشابه لظروف التجربة.

كلمات مفتاحية: الاسمدة العضوية، الكيميائية، الحيوية، التين.

Introduction

The fig *Ficus carica* L. is a member of the genus Ficus and the family Moraceae. Fig derives from the Indian name Feg, while Carica originates from the area in western Anatolia that was well-known for producing and cultivating the fruit (25). The Arabian Peninsula is said to have been the fig's original home because there are still wild woods there (4). Following the Islamic conquests, fig farming expanded in areas around the

Mediterranean Sea, including North Africa, Spain, France, Portugal, Greece, and Italy (17). The fruit is consumed fresh, dried, or in juices. It is also used in the manufacture of alcoholic beverages and has many medical uses. It helps treat indigestion, relieves and treats headaches and chronic constipation. Its leaf extract is used to reduce blood cholesterol levels and for other medical uses (26). Fig production for the 2020 season in Iraq is estimated at 9322 tons, with average productivity per tree at about 32.56 kg. Saladin Governorate ranked first in terms of production, followed by the Nineveh and Wasit governorates (10).

Organic fertilizers help lessen pollution in the environment and harm to both human and animal health, in addition to their positive effect in improving plant growth and increasing their productivity (5). They contain many mineral elements and other compounds necessary for plant growth, enabling the possibility of using them to supplement chemical fertilizers (21). The issue of declining fruit orchard nutrition and agricultural soil owing to contamination from chemical fertilizer residues is one of the many challenges that agricultural systems face globally. The availability of balanced amounts of essential nutrients that are compatible with the needs of tree growth is essential for improving growth and productivity (16).

Researchers have endeavored to enhance the efficacy of fertilizer application while mitigating loss and pollution. Nanotechnology has emerged as a valuable tool in the advancement of agriculture, particularly in the domain of fertilization, as nanofertilizers serve as a substitute for conventional fertilizers by reducing the amounts of chemical fertilizers used and expediting their absorption. As a result, it can be stored in the plant for longer, which enhances crop quality, ensures crop sustainability, and boosts productivity (7 and 13). Biofertilization with EM^{-1}, or effective micro-organisms, is used in many countries around the world, and is a natural liquid biofertilizer containing five groups of beneficial microorganisms. Foliar spraying with it is considered more effective than EM^{-1} ground fertilization (28), as it leads to an increase in the number of beneficial microorganisms on the leaf surface. Moreover, photosynthetic bacteria work to increase the rate of photosynthesis and fix nitrogen in the plant by accelerating the absorption of simple organic substances that enhances plant growth and productivity within a short period. The bacteria and yeasts accumulate on the leaf surface, protecting the plant from leaf burn due to increased exposure to sunlight, while compounds from the metabolic processes of the beneficial microorganisms on the leaf surfaces are absorbed directly from the plant surfaces (15 and 18).

Adding liquid organic fertilizer to apricot seedlings at 1 and 2 g L^{-1} levels improved the area and dry weight characteristics of leaves (8), while spraying apple trees with 3.5 g L^{-1} nanocomposite fertilizer concentration enhanced fruit weight and size (15). Meanwhile, there was a significant increase in weight and size of fruits from persimmon trees sprayed with EM1 at 4 ml L^{-1} concentrations compared to the 0 comparison and 3 ml L^{-1} levels (11). Therefore, the low quality, small size, and poor fruit yields are among the issues facing fig producers in Iraq.

The aim of this research was to determine the appropriate concentrations of individual or combinations of fertilizers that will positively impact the qualitative characteristics and yield of fig trees of the Khalo Baziani cultivar.

Materials and Methods

This study was conducted in a private orchard in the Kirkuk Governorate's Laylan district about 19 km southeast of the city of Kirkuk from 15 January to 15 September 2023. It involved 8-year-old Khalo Baziani cultivar fig trees that were relatively homogenous in size and growth conditions. They were planted in plots of 4 x 4 m raised in an open middle method. Regular agricultural service operations were carried out including weeding, removing bushes, and plowing the soil, and pruning was done in January 2023.

The study included the effect of three factors. The first involved spraying with three concentrations of the liquid organic fertilizer Folikin 0, 2, and 3 ml L^{-1} (designated S0, S2, and S3) comprising free amino acids (6.5%), organic nitrogen (1.2%), reducing sugars (9.5%), seaweed (16.6%) . The second was spraying with two concentrations of the nanocomposite fertilizer NPK equivalent to 20:20:20 (0 and 3 g L^{-1}) and designated K0 and K3. The third factor involved spraying with three concentrations of the biofertilizer EM^{-1} at 0, 2, and 4 ml L^{-1} designated as A0, A2, and A4. The EM^{-1} biofertilizer is a dark brown liquid solution comprising 5% fungi, 5% bacteria, 5% seaweed, 75% humic acid, and 10% water, in addition to more than 80 types of beneficial microorganisms. It also contained 23 mg L^{-1} nitrate nitrogen, 489 mg L^{-1} ammonia nitrogen, 8.06 mg L^{-1} phosphorus, and 2.34 mg L^{-1} potassium.

Altogether 54 trees were selected with one tree for each experimental unit. They were sprayed until completely wet over 21 days beginning 5/15/2023, and with a one-day interval between spraying treatments.

The dispersing agent (Hocklin Super) was added at 0.01% concentration to reduce the surface tension of the water. The randomized complete block system (RCBD) was used in the experiment with three factors and three replications, and the data analyzed according to the Duncan multinomial test at the 0.05% probability level.

Traits studied:

1. Fruit weight (gm): Determined using a sensitive electrical balance and calculating the average weight of 10 fruits per experimental unit.
2. Number of fruits per tree (fruit. $tree^{-1}$): Calculated by dividing the total yield of a single tree by the average weight per fruit.
3. Yield (kg $tree^{-1}$): Calculated by adding the weight of the fruits per tree in each pound
4. Fruit size (cm^3): Calculated using the water-displacement method from the inserted glass cylinder

Total soluble solids (TSS %): Determined using a hand refractometer.

Results and Discussion

Fruit weight (g): As seen in Table 1, organic fertilizer spraying was significantly superior in all experimental treatments for fruit weight, with the S3 concentration reaching 22.65 g, 3.14% greater than the S0 treatment, while the S2 concentration had the lowest rate at 21.81 g. Also, fruit weight increased significantly when sprayed with nano-composite fertilizer, with the K3 treatment having the highest weight at 22.86 g or 6.77% above the 21.41 g for the K0 treatment which had the lowest weight.

Spraying with biofertilizer improved fruit weight markedly with the A4 concentration having the highest average at 23.08 g, or 6.31% more than the A0 treatment, while the A2 concentration had the lowest average fruit weight of 21.71 g. The double interaction of spraying with organic and nano-composite fertilizers showed a significant effect on average fruit weight. The S3K3 interaction outperformed the others at 23.65 g, an increase of 10.30%, while the S2K0 treatment registered the lowest average fruit weight at 21.17 g.

The double interaction between spraying with organic fertilizer and biofertilizer showed a significant effect on average fruit weight, with the S3A4 treatment outperforming all the treatments giving the highest values at 23.87 g, a 8.54% increase over the comparison treatment, while the S0A2 interaction gave the lowest at 21.00 g. As for the double interaction between the nanocomposite fertilizer and biofertilizer, there was a significant increase in average fruit weight, with the K3A4 binary interaction outperforming the others at 23.50 g, or a 13.96% increase, while the K0A0 treatment had the lowest at 21.62 g. The triple interaction between spraying with organic, nano-composite, and bio- fertilizers produced a significant effect on fruit weight with the S3K3A4 outperformed the others at 25.55 g, an increase of 26.73% over the S0A0K0 which had the lowest value at 20.16 g.

Table 1: Effect of Spraying Organic Fertilizer, Nanocomposite Fertilizer, and Biofertilizer on Fruit Weight (g).

Organic fertilizer (mL^{-1})	Bio fertilizer (mL^{-1})	Nano fertilizer (gL^{-1})		Bio Organic fertilizer * fertilizer
		K_0	**K_3**	
S_0	**A_0**	20.16 h	20.50 gh	**21.99 cd**
	A_2	23.66 bc	23.81 b	**21.00 e**
	A_4	21.50 efg	22.15 def	**22.90 b**
S_2	**A_0**	20.50 gh	20.86 gh	**21.30 de**
	A_2	22.15 def	22.10 def	**21.66 cde**
	A_4	22.46 de	22.80 bcd	**22.47 bc**
S_3	**A_0**	21.19 fgh	21.53 efg	**21.86 cd**
	A_2	22.20 def	22.53 cde	**22.21 bc**
	A_4	22.88 bcd	25.55 a	**23.87 a**
Organic fertilizer * Nano fertilizer	**Organic fertilizer * Nano fertilizer**			**Organic fertilizer Mean**
	S_0	21.44 c	22.48 b	**21.96 b**
	S_2	21.17 c	22.45 b	**21.81 b**
	S_3	21.64 c	23.65 a	**22.65 a**
Nano fertilizer * Bio fertilizer	**Nano fertilizer * Bio fertilizer**			**Bio fertilizer Mean**
	A_0	20.62 c	20.96 c	**21.71 b**
	A_2	22.67 b	22.81 b	**21.62 b**
	A_4	22.28 b	23.50 a	**23.08 a**
Nano fertilizer Mean		21.41 b	22.86 a	

Number of fruits (fruit $tree^{-1}$): As shown in Table 2, organic fertilizer application had a significant impact on fruit yield with treatment S3, averaging 807.50 fruits, outperforming the S0 or control which had the lowest average yield at 658.43 fruits by 22.64%. Additionally, the number of fruits was found to be significantly impacted by the application of nanocomposite fertilizer, with the 739.53 fruit count in the K3 treatment outperforming the 707.98 for the K0 treatment by 4.45%. Spraying with biofertilizer did not show any significant effect between the experimental treatments compared to the A0 treatment. Table 2 indicates that the binary interaction between organic fertilizer and nanocomposite fertilizer produced a significant increase in fruit number with the S3A0 being superior at 822.24 fruits, an increase of 35.23% over the S0A0 comparison treatment which gave the lowest value at 607.99 fruits.

The dual interaction between organic and biofertilizer spraying resulted in significant superiority of the treatments, with the S3A0, S3A2, and S3A4 recording the highest averages at 820.41, 808.44, and 793.65 fruits, respectively, while the S0A0 treatment gave the lowest at 617.11. Also, nanocomposite fertilizer and biofertilizer spraying had a significant effect on fruit numbers with the K3A4 intervention having 754.37 fruits, an increase of 5.86% over the K0A0, but did not differ significantly with the K0A4 treatment had the lowest fruit value of 745.69. The triple intervention treatments of the study factors showed a significant effect on the average number of fruits. The triple intervention treatment S3K0A0 was superior with the highest rate of 848.11 fruits, an increase of 41.38%, while the intervention treatment S0A0K0 had the lowest average number of fruits at 599.86.

Table 2: Effect of Spraying Organic Fertilizer, Nanocomposite Fertilizer, and Biofertilizer on Number of Fruits (fruit tree^{-1}).

Organic fertilizer (mL^{-1})	Bio fertilizer	Nano fertilizer (g L^{-1})		Organic fertilizer * Bio fertilizer
		K_0	**K_3**	
S_0	**A_0**	599.86 g	604.96 g	**617.11 c**
	A_2	619.16 g	634.35 g	**681.11 b**
	A_4	757.25 cde	735.00 def	**677.08 b**
S_2	**A_0**	689.70 f	695.21 f	**709.12 b**
	A_2	696.26 f	728.56 def	**696.34 b**
	A_4	697.46 f	724.93 ef	**710.59 b**
S_3	**A_0**	848.11 a	834.51 ab	**820.41 a**
	A_2	784.10 bcd	792.70 bc	**808.44 a**
	A_4	782.37 bcd	803.19 abc	**793.65 a**
Organic fertilizer * Nano fertilizer	**Organic fertilizer * Nano fertilizer**			**Organic fertilizer Mean**
	S_0	607.99 d	708.87 c	**658.43 c**
	S_2	693.72 c	716.98 c	**705.35 b**
	S_3	822.24 a	792.75 b	**807.50 a**
Nano fertilizer * Bio fertilizer	**Nano fertilizer * Bio fertilizer**			**Bio fertilizer Mean**
	A_0	712.56 c	711.56 c	**715.54 a**
	A_2	699.84 c	718.53 bc	**728.63 a**
	A_4	745.69 ab	754.37 a	**727.11 a**
Nano fertilizer Mean		707.98 b	739.53 a	

Total yield (kg tree^{-1}): As seen in Table 3, fig yield benefited significantly from the application of organic fertilizer. Specifically, the S3 concentration produced the highest yield, reaching 18.27 kg tree^{-1}, a 26.52% increase over the lowest S0 treatment of 14.44 kg tree^{-1}. Also, total yield of the trees increased significantly from nanocomposite fertilizer spraying with the K3 concentration producing the highest at 16.90 kg tree^{-1}, an increase of 11.47% over the unsprayed trees, while the K0 concentration had the lowest value at 15.16 kg tree^{-1}. It was also noted that spraying with biofertilizer significantly increased total yield, with the A4 treatment giving the highest at 16.78 kg tree^{-1}, an increase of 7.97% over the A0 control treatment's lowest value at 15.54 kg tree^{-1}.

Also, spraying with organic and nanocomposite fertilizers significantly increased tree yield. The S3 K3 intervention treatment produced the highest yield rate at 18.76 kg tree^{-1}, a 43.97% increase over the comparison S0K0 which had the lowest rate at 13.03 kg tree^{-1}. The binary interaction between biofertilizer and organic fertilizer demonstrates a notable superiority in tree yield at 18.96 kg tree^{-1}, with S3A4 producing the highest values, or a 39.41% increase over the control treatment. Conversely, the S0A0 treatment produced the lowest values for overall yield at 13.60 kg tree^{-1}. Total yield increased significantly from the binary interaction of biofertilizer and nanocomposite fertilizer concentrations. The K0A0 treatment produced the lowest yield (14.73 kg per tree) while the K3A4 had the highest at 17.75 kg tree^{-1}, a 20.50% increase over the control.

The findings demonstrate that spraying with organic, bio, and nanocomposite fertilizers in three different combinations significantly affected the overall output of trees. The triple interaction S3A4K3 recorded the highest value at 20.52 kg tree^{-1}, an increase of 69.72% over the comparison S0A0K0 treatment which had the lowest at 12.09 kg tree^{-1}.

Table 3: Effect of Spraying Organic Fertilizer, Nano-Composite Fertilizer, and Bio Fertilizer on Total Yield (kg tree^{-1}).

Organic fertilizer (mL^{-1})	Bio fertilizer	Nano fertilizer (g L^{-1})		Organic fertilizer * Bio fertilizer
		K_0	**K_3**	
S_0	**A_0**	12.09 h	12.39 h	**13.60 f**
	A_2	14.61 fg	15.10 ef	**14.32 e**
	A_4	16.25 cd	16.22 cd	**15.42 cd**
S_2	**A_0**	14.13 g	14.50 fg	**15.11 d**
	A_2	15.42 def	16.10 cd	**15.08 d**
	A_4	15.66 cde	16.51 c	**15.97 c**
S_3	**A_0**	17.97 b	17.97 b	**17.92 b**
	A_2	17.40 b	17.86 b	**17.94 b**
	A_4	17.91 b	20.52 a	**18.96 a**
Organic fertilizer * Nano fertilizer	**Organic fertilizer**			**Organic fertilizer Mean**
	S_0	13.03 e	15.86 c	**14.44 c**
	S_2	14.68 d	16.09 c	**15.39 b**
	S_3	17.78 b	18.76 a	**18.27 a**
Nano fertilizer * Bio fertilizer	**Bio fertilizer**			**Bio fertilizer Mean**
	A_0	14.73 d	14.95 d	**15.54 b**
	A_2	15.81 c	16.35 b	**15.78 b**
	A_4	16.60 b	17.75 a	**16.78 a**
Nano fertilizer Mean		15.16 b	16.90 a	

Fruit size (cm^3): According to Table 4, the concentration of organic fertilizer significantly affected fruit size. The S3 treatment outperformed the others at 36.07 cm^3, an increase of 11.01% over S0 treatment which had the smallest fruit size at 32.49 cm^3. The application of nanocomposite fertilizer also yielded significantly larger fruits with

K3 at 34.68 cm^3 outperforming the K0 control treatment's lowest size at 33.16 cm^3 by 4.58%. Spraying with biofertilizer produced a marked increase in fruit size, the largest being for the A4 concentration at 34.10 cm^3, similar to the A0, while the A2 treatment had the lowest fruit size at 33.56 cm^3.

The binary interaction between the organic and nanocomposite fertilizers also yielded superior fruit sizes. The S3K3 interaction excelled with fruit size of 36.64 cm^3, a 16.57% increase over the S0K0 comparison treatment at 31.43 cm^3. Meanwhile, the double interaction between the organic fertilizer and biofertilizer concentrations had a significant positive effect on fruit size. The S3A0 interaction outperformed the others at 37.02 cm^3, an increase of 13.76% over the control, while the S0A2 produced the lowest fruit size at 31.80 cm^3.

There was also a significant superiority in the results for the dual interaction between nanocomposite fertilizer and biofertilizer spraying. The K3A2 treatment outperformed the others at 35.56 cm^3, an increase of 8.91% over the K0A0 control treatment which produced the smallest fruit size at 32.65 cm^3. Fruit size also gained significantly from the triple interaction between spraying with organic, biofertilizer, and nano-composite fertilizers (Table 3). The S3A2K3 treatment had the largest average fruit size at 38.50 cm^3, 25.77% more than the lowest for the S0A0K0 control treatment's 30.61 cm^3.

Table 4: Effect of Spraying Organic Fertilizer, Nano-Composite Fertilizer, and Biofertilizer on Fruit Size (cm^3).

Organic fertilizer (mL^{-1})	Bio fertilizer	Nano fertilizer ($g\ L^{-1}$) K_0	K_3	Organic fertilizer * Bio fertilizers
S_0	A_0	30.61 h	31.00 hg	**32.54 d**
	A_2	32.67 ef	34.46 cd	**31.80 e**
	A_4	32.61 ef	33.60 de	**33.13 cd**
S_2	A_0	31.80 fg	32.82 ef	**32.76 d**
	A_2	33.00 e	33.72 de	**33.28 cd**
	A_4	33.74 de	34.12 d	**33.56 c**
S_3	A_0	35.53 bc	35.47 bc	**37.02 a**
	A_2	35.51 bc	38.50 a	**35.59 b**
	A_4	35.72 b	35.70 b	**35.61 b**
Organic fertilizer * Nano fertilizer	**Organic fertilizer**			**Organic fertilizer Mean**
	S_0	31.43 e	33.56 c	**32.49 c**
	S_2	32.54 d	33.86 c	**33.20 b**
	S_3	35.50 b	36.64 a	**36.07 a**
Nano fertilizer * Bio fertilizer	**Bio fertilizer**			**Bio fertilizer Mean**
	A_0	32.65 d	33.10 d	**34.10 a**
	A_2	33.73 c	35.56 a	**33.56 b**
	A_4	34.02 bc	34.47 b	**34.10 a**
Nano fertilizer Mean		33.16 b	34.68 a	

Total soluble solids (TSS %): As illustrated in Table 5, total dissolved solids in the fruit was significantly impacted by organic fertilizer application with the S3 concentration producing the highest rate at 18.49%, compared to the lowest at 16.66% for the S0 concentration. For nanocomposite fertilizer spraying, the K3 concentration had the highest TSS at 17.85%, while K0 had the lowest at 17.00%. However, biofertilizer spraying did not significantly impact the TSS of the treatments compared to the comparison A0 treatment.

The amount of total dissolved solids in the fruit increased significantly due to the binary interaction between the organic and nanocomposite fertilizer applications. The S3K3 concentration had the highest value at 19.10% while S0K0 had the lowest at 16.27%. Total dissolved solids in the fruit increased significantly from the bilateral interaction of the organic and bio fertilizers, with the S0A2 concentration producing the lowest average at 16.25%, while the S3A0 concentration had the highest at 19.06%. Significant superiority was also recorded in total dissolved solid amounts in the fruit from the double interaction of nanocomposite and bio fertilizer spraying with the K3A2 having the highest value at 18.51%, while K0A0 had the lowest at 16.85%.

The threefold interaction between organic and biofertilizer sprays, and nano-composite fertilizer produced a significant effect on total dissolved solids in the fruit. The triple interaction treatment S3A2K3 had the highest rate of solids at 20.21% while S0A0K0 had the lowest TSS at 15.98%.

Table 5: Effect of Spraying Organic Fertilizer, Nano-Composite Fertilizer, and Bio Fertilizer on Total Dissolved Solids (%).

Organic fertilizer (mL^{-1})	Bio fertilizer	Nano fertilizer ($g\ L^{-1}$)		Organic fertilizer * Bio fertilizer
		K_0	K_3	
S_0	A_0	15.98 h	16.13 gh	**16.90 c**
	A_2	16.70 efgh	17.81 bcd	**16.25 d**
	A_4	16.36 fgh	17.00 defg	**16.85 c**
S_2	A_0	16.66 efgh	16.76 efgh	**17.09 c**
	A_2	17.08 cdef	17.52 cde	**16.97 c**
	A_4	17.18 cdef	17.51 cde	**17.30 c**
S_3	A_0	17.92 bc	17.88 bcd	**19.06 a**
	A_2	17.88 bcd	20.21 a	**18.21 b**
	A_4	18.54 b	18.54 b	**18.21 b**
Organic fertilizer * Nano fertilizer	**Organic fertilizer**			**Organic fertilizer Mean**
	S_0	16.27 e	17.06 cd	**16.66 c**
	S_2	16.84 d	17.40 c	**17.12 b**
	S_3	17.89 b	19.10 a	**18.49 a**
Nano fertilizer * Bio fertilizer	**Bio fertilizer**			**Bio fertilizer Mean**
	A_0	16.85 d	16.92 cd	**17.68 a**
	A_2	17.22 bcd	18.51 a	**17.14 b**
	A_4	17.36 bc	17.68 b	**17.45 ab**
	Nano fertilizer Mean	17.00 b	17.85 a	

Discussion:

As seen in Tables 1–5, spraying with organic fertilizer produced significantly superior fruit characteristics in terms of their weight, number, total yield, size, and TSS percentage due possibly to the positive effect of these fertilizers. Organic fertilizers contain almost 50% amino acids such as methionine and glutamic acids which have an important role in promoting the germination of pollen grains and in the development of the pollen tube (20 and 29). This raises the percentage of set fruits and provides sufficient amounts of food, which leads to an increase in the number of fruits, loose fruits and fruits remaining on the tree (19 and 23). The results agree with (2) on Royal Apricot trees, and (3) on fig trees c.v. Aswad Diyala and White Adriatic.

The tables also show that foliar spraying with nanocomposite fertilizer significantly enhanced the studied characteristics of fruit size, weight, total dissolved solids, and total yield. This is mainly due to their response to nitrogen and potassium. Nitrogen contributes significantly to the formation of molecules of nucleic acids and proteins, while potassium is involved in transporting carbohydrates to storage sites in the branches and stem (22 and 23). This increases the width of the branches and subsequently their carbohydrate content and rate of synthesis which stimulates future plant growth and flowering (14). These findings are consistent with (27) on fig trees c.v. Aswad Diyala, and with (9 and 15) on c.v. Anna and c.v. Abrahami apple trees, respectively.

Tables 1 and 3 indicate that foliar spraying with biofertilizer has a significant effect on fruit weight and total yield. The use of the EM^{-1} biofertilizer may be attributed to its significant role in increasing fruit weight and yield as a regulator that enhances the metabolic processes of crop plants. It promotes productivity and improves fruit quality, in addition to reducing acidity in fruits (6 and 21). These results are consistent with studies on trees of the c.v. Le-Conte pears (1), the Beauty and Santa Rosa (8) and Red Haven (24) peach varieties, and c.v. Sultani figs (12).

Conclusions

Spraying fig trees with organic fertilizer, nano-composite fertilizer, and biofertilizer led to an increase in fig productivity and improved fruit quality due to their rapid impact and abundance of nutritional elements. The best results were achieved when the trees received 3 mL L^{-1} of organic fertilizer, 3 g L^{-1} of nano-composite fertilizer, and 4 mL L^{-1} of bio-fertilizer.

Supplementary Materials:

No Supplementary Materials.

Author Contributions:

R. A. Medan: methodology, writing-original draft preparation; Walid F. A. Mosa: writing-review and editing. All authors have read and agreed to the published version of the manuscript.

Funding:

This research received no external funding.

Institutional Review Board Statement:

The study was conducted following the protocol authorized by the Head of the Ethics Committee, University of Kirkuk, Iraq Republic.

Informed Consent Statement:

No Informed Consent Statement.

Data Availability Statement:

All data availability statement.

Conflicts of Interest:

The authors declare no conflict of interest.

Acknowledgments:

We would like to express our deep gratitude and appreciation to the Colleague of Agriculture, University of Anbar for their scientific support and provision of resources necessary for the completion of this research. Their valuable contributions were essential in achieving the objectives of this study.

Disclaimer/Journal's Note:

The statements, opinions, and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of AJAS and/or the editor(s). AJAS and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions, or products referred to in the content.

References

1. Abd-El-Latif, F. M., El-Gioushy, S. F., Ismail, A. F., and Mohamed, M. S. (2017). The impact of biofertilization, plant extracts and potassium silicate on some fruiting aspects and fruit quality of" Le-Conte" pear trees. Middle East Journal of Applied Sciences, 7(2): 385-397.
2. Al-Aa'reji, J. M. (2017). Effect of some liquid organic and (NPK) fertilizers on growth and fruiting of apricot trees" Prunus armeniaca L." cv. Royal. Kirkuk University Journal for Agricultural Sciences (KUJAS), 8(4): 7-24.
3. Alalaf, A. H., and Shayal Alala, A. T. (2014). Effect of organic fertilizer Nutrgreen and salicylic acid foliar spray on growth of Fig transplants c.v. Aswad Diala and White Adritic. Mesopotamia J. Agric, 42(1): 21-30.
4. Al-Bitar, A. D. (2015). Fruit Trees-The Basics of Their Cultivation, Care, and Production. Al-Quds Open University-Deanship of Scientific Research and Graduate Studies.
5. Al-Doori, M. F., and Hussein, S. A. (2023). Effect of Adding with Organic Nutrient (Complex-Groop) and Spraying with Kinetin on Some Characteristics of Vegetative Growth and Yield of Pomegranate Trees *Punica granatum* L. Cv. Salimi. In IOP Conference Series: Earth and Environmental Science, 1252(1): p. 012079. DOI: 10.1088/1755-1315/1252/1/012079.
6. Al-Hassan, M. A., Baghdadi., M, Muhammad, M., and Mazen, W. (2018). The effect of foliar and ground fertilization with the biofertilizer EM1 on some chemical and physical characteristics of two varieties of peaches *(Prunus salicina* L). Hama University Journal, 1(6): 12-20.
7. Al-Hchami, S. H., and Alrawi, T. K. (2020). Nano fertilizer, benefits and effects on fruit trees: a. plant archives, 20(1): 1085-1088.
8. AL-Janabi, A. S. A., Hasan, A. K., and Neamah, S. S. (2016). Effect of biofertilizer (EM-1) and organic fertilizer (Acadian) on vegetative growth of many cultivars of apricot seedling (*Prunus armeniaca* L.). Euphrates Journal of Agriculture Science, 8(4): 23-32.
9. Aly, M. A. M., Muhsin, A. T., Abdel Salam, N. R., and Mosa, W. (2022). Effect of Some Nano Fertilizers on Yield and Fruit Quality of Apple. Egyptian Academic Journal of Biological Sciences, H. Botany, 13(2): 59-64. https://doi.org/10.21608/eajbsh.2022.253552.

10. Central Bureau of Statistics. (2020). Summer Fruit Production Report. Ministry of Planning, Directorate of Agricultural Statistics. Department of Publishing and Public Relations, Baghdad. Iraq.
11. Dababo, E. M. B., Baghdadi, D. M., and Maroff, D. A. (2019). Effect of foliar Application of Yeast Extract and EM-1 Bio-Fertilizer on Fruit Quality and Yeild of Persimmon (*Diospyros kaki* L.) cv. "Hachyia and quot. Journal of Hama University, 1(6).
12. Elamary, E., and Elsayed, A. E. R. (2021). Effect of foliar spray some micronutrients mixture and biofertilizers (em) on growth, yield and fruit quality on sultani fig in north west coast. Egyptian Journal of Desert Research, 71(2): 129-147. https://doi.org/10.21608/ejdr.2021.55251.1078.
13. Hakeem, H. M., khalaf Al-ecehagy, J. M., and Medan, R. A. (2023). Effect of humic acid and Nano-NPK on vegetative growth of young trees of date palm cultivars *Phoenix dactylifera* L. In IOP Conference Series: Earth and Environmental Science, 1252(1): p. 012098. DOI: 10.1088/1755-1315/1252/1/012098.
14. Hakeem, H., Khalaf, J., and Medan, R. (2023). Effect of Humic Acid and NPK Nanocomposite on the Chemical Content of Fronds of Three Cultivars of Young Palm Trees *Phoenix Dactylifera* L.. Kirkuk University Journal For Agricultural Sciences, 14(2). doi: 10.58928/ku23.14219.
15. Hasan, Q. J., and Khalaf, J. M. (2022). The effect of fertilizing with humic acid and spraying with NPK nanofertilizer on some characteristics of apple tree yield. Journal of Kirkuk University for Agricultural Sciences, 13(3).
16. Hassan, H. S. A., Sarrwy, S. M. A., and Mostafa, E. A. M. (2010). Effect of foliar spraying with liquid organic fertilizer, some micronutrients, and gibberellins on leaf mineral content, fruit set, yield, and fruit quality of "Hollywood" plum trees. Agriculture and Biology Journal of North America, 1(4): 638-643.
17. Herre, E. A., Jan, K. C., and Machado, C. A. (2008). Evolutionary ecology of fig leaves extra, Recent pro grass and out staneling Puzles. Annual Review of Ecology, Evolution, and Systematics, 37: 438-456.
18. Hussein, S. A., and Al-Doori, M. F. (2025). Effect of pruning and fertilization with bio fertilizer (Mycorrhiza) on some growth characteristics and yield of grape vines (*Vitis vinifera* L.) cv. Francy. IOP Conference Series: Earth and Environmental Science, 1487(1): 012061.
19. Hussien, A. M., El Maghraby, T. A., Sherif, H. M., and El Shal, S. A. (2005). Effect of liquid organic fertilization techneqes on yield and chemical composition of pear and apricot trees grown on sandy sols at south tahrir province. Fayoum Journal of Agricultural Research and Development, 19(2): 224-236.
20. Jaff, A. A. O., and Medan, R. A. (2024). Effect of organic fertilizers and amino acids on the vegetative growth of young pomegranate trees Punica granatum L. cv."Wonderful". HORIZON, 11(3): 377-382. https://doi.org/10.14719/pst.3588.
21. Lateifa, S. A. (2012). Biofertilizer and its role in reducing water pollution problems with chemical fertilizers. Libyan Agriculture Research Center Journal international, 3(2): 1457-1466.

22. Al-Janabi, A. M. I. (2024). Impact of gibberellic acid and boron trioxide nanoparticles foliar spraying on growth, yield and fruit quality of "zaghinia" apricot trees. Anbar Journal of Agricultural Sciences, 22(2): 1557-1569.
23. Mahmood, J. M., Al-Joboory, W. M., and Abed, I. A. (2024). Role of organic, bio and mineral fertilizers in enviromental sustainability and enhancing lettuce productivity. Anbar Journal of Agricultural Sciences, 22(2): 1139-1154.
24. Makhoul, G., and Sirin, A. Z. (2023). The effect of spraying with EM1 biofertilizer and Casperfix marine algae extract on tree crown size and leaf chlorophyll content of the Red Haven peach cultivar. Tishreen University Magazine. Biological sciences, 45(3): 409-419.
25. Mars, M., Chatti, K., Saddoud, O., Salhi-Hannachi, A., Trifi, M., and Marrakchi, M. (2008). Fig cultivation and genetic resources in Tunisia, an overview. Acta Horticulturae, 798: 27-32.
26. Mitra, S. K. (1997). Postharvest physiology and storage of tropical and sub-tropical fruits. CAB. INT. Nadia. West Bengal, India.
27. Mseer, S. A., Al-Ibrahimi, M. S., and Al-Miahy, F. H. (2020). The effect of spraying with nano fertilizers NPK and gibberellin GA3 on the physical, chemical and physiological characteristics on the vegetative growth and fruit yield of fig trees, black diyala cultivar *Ficus Carica* L. Int. J. Agricult. Stat. Sci., 16(1): 1793-1797.
28. Osman, S. O., Moustafa, F. M. A., Abd El-Galil, H. A., and Ahmed, A. Y. M. (2011). Effect of yeast and effective microorganisms (EM1) application on the yield and fruit characteristics of Bartamuda date palm under Aswan conditions. Assiut J. of Agric. Sci, 42(5): 332-349.
29. Zaili, Sh. A., Salman, A. D., Muhanna, T. J., and Hikmat, S. (2024). Effect of acids and organic nutrients on cauliflower growth and yield and water use efficiency and fertilizer productivity of a modified nft hydroponics system. Anbar Journal of Agricultural Sciences, 22(2): 1651-1661. https://doi.org/10.32649/ajas.2024.185831.