Tikrit Journal for Agricultural Sciences
ISSN:1813-1646 (Print); 2664-0597 (Online)
Journal Homepage: http://www.tjas.org
E-mail: tjas@tu.edu.iq
DOI: https://doi.org/10.25130/tjas.25.4.8

TJAS
Tikrit Journal for Agricultural Sciences

Effect of Foliar Spraying with Benzyl Adenine and Nano-Calcium on Some Vegetative Growth and Fruiting Traits of Al-Ubaid Fig Trees

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KEY WORDS:
Fig, Al-Obaid, benzyl adenine, nano-calcium, vegetative traits, yield

Received: 10/02/2025
Revision: 20/08/2025
Proofreading: 12/10/2025
Accepted: 21/09/2025
Available online: 31/12/2025

ABSTRACT

Al-Obaid is a fig cultivar known in Saudi Arabia that has recently entered Iraq. There are not much published articles about it here, so this experiment was conducted to determine the response this cultivar to spraying with benzyl adenine and nano-calcium, in the research station belonging to the Department of Horticulture and Landscape Design, College of Agriculture, Tikrit University, Salah al-Din Governorate during the 2024 season. Three concentrations of growth regulator benzyl adenine (0, 75 and 150 mg L^{-1}) and three concentrations of nano calcium (0, 1.25 and 2.50 g L^{-1}) were sprayed three times through the season. Data of some growth parameters, number of fruits per tree and the yield were collected and statistically analyzed. The results indicated that the effect of spraying with benzyl adenine was significant in most of the studied traits and the concentration of 150 mg L^{-1} recorded the highest average of leaf area (182.27 cm^2), number of fruits (91.00 fruit $tree^{-1}$) and yield (1940.63 g $tree^{-1}$), but this treatment caused a significant decrement of shoot length when gave the lowest average (79.74 cm). The foliar spray with nano calcium of 2.5 g L^{-1} recorded the highest average of leaf area (213.73 cm^2) and dry matter of leaves (41.36%) and exceeded the control treatment significantly. The interaction treatments affected significantly on some studied traits but this effect is not stable at one treatment.

تأثير الرش بالبنزل أدينين ونانو الكالسيوم على بعض صفات النمو الخضري وإنتاجية أشجار التين الصنف العُبيد

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الخلاصة

يُعد صنف التين العُبيد من الأصناف المعروفة في المملكة العربية السعودية، وقد ادخل العراق مؤخرًا. ونظرًا لندرة الأبحاث المنشورة حوله، فقد تم إجراء هذه التجربة لدراسة استجابة هذا الصنف للرش بالبنزل أدينين والكالسيوم النانوي، في محطة الأبحاث التابعة لقسم البستنة وهندسة الحدائق، كلية الزراعة، جامعة تكريت، محافظة صلاح الدين، خلال موسم 2024. تم رش الاشجار بثلاثة تراكيز من منظم النمو البنزل أدينين (0، 75، 150 ملغم لتر$^{-1}$) وثلاثة تراكيز من الكالسيوم النانوي (0، 1.25، 2.50 غم لتر$^{-1}$) ثلاث مرات خلال الموسم. تم جمع بيانات بعض الصفات الخضرية، وعدد الثمار لكل شجرة، والإنتاجية، ثم تحليلها إحصائيًا. أشارت النتائج إلى أن تأثير الرش بالبنزل أدينين كان معنويًا في معظم الصفات المدروسة، حيث سجل التركيز 150 ملغم لتر$^{-1}$ أعلى متوسط لمساحة الورقة (182.27 سم^2) وعدد الثمار (91.00 ثمرة شجرة$^{-1}$) والإنتاجية (1940.63 غم شجرة$^{-1}$)، وهذه المعاملة أدت إلى انخفاض معنوي في طول الفرع، حيث سجلت أقل متوسط (79.74 سم). أما الرش الورقي بالكالسيوم النانوي بتركيز 2.5 غم لتر$^{-1}$فقد سجل أعلى متوسط لمساحة الورقة (213.73 سم^2) والمادة الجافة للأوراق (41.36%)، متفوقًا معنويًا على معاملة المقارنة. وأثرت معاملات التداخل معنويًا في بعض الصفات المدروسة، إلا أن هذا التأثير لم يكن مختصا في معاملة محددة.

الكلمات المفتاحية: التين، العُبيد، البينزيل أدينين، نانو الكالسيوم، الصفات الخضرية، الإنتاجية.

INTRODUCTION

The fig (*Ficas carica* L.) is a semi-tropical plant belonging to the Moraceae family and the Ficus genus, which includes a large number of evergreen species, with the exception of the well-known fig (Carica), which is a deciduous species and a staple crop worldwide for fresh and dried consumption (Ahmed and Lateef, 2025). The fig tree has a spherical or pyramidal shape, and the average lifespan of the tree is between 50 and 60 years. The nature of fig bearing is that the flower buds of figs are borne laterally on two types of wood: on one-year-old branches, which is considered the primary crop, and on newly growing branches, which is called the main crop (Abdullah, 2023). They are often grown with multiple stems, and the branches are not intertwined, and the leaves are relatively large (Farhangi *et al*., 2014; Ahmed and Lateef, 2025).

Benzyl adenine is considered one of the high stability plant growth regulators (PGR) that affect the growth, development and branching of the plant, as they help in cell division and development, in addition to their effect on apical dominance, as they reduce or prevent the effect of apical increase and increase a number of branches to load more fruits (Al-Khafaji, 2014). The beneficial effect of cytokinin was approached by many authors as Harhash *et al*. (2017), when they sprayed apple trees with cytokinin (Sitofex) of 10 mg L^{-1}, mentioned a respectable increase in shoot length, diameter, and leaf area. Medan and Al-Douri (2021) reported an increase in length and diameter of shoots, leaf area and dry weight of apricot leaves resulted of spraying 15 mg L^{-1} of cytokinin three times during a growing season.

The traditional and commonly accepted method of fertilization is root-based nutrient absorption, which adequately supplies the plant with nutrients, resulting in significant and excessive losses in the amount of fertilizer added. Especially in large agricultural areas, which prompted researchers to find complementary solutions for adding fertilizers to reduce the loss of nutrients caused by washing, fixation, and volatilization, including foliar fertilization (Ali, 2014). Jampilek and Kráľová (2018) stated that the application of nanotechnology in the field of agriculture through fertilizer production reduces the loss of added nutrients, in addition to the speed of plant utilization, as fertilizers prepared using nanotechnology are environmentally friendly and of crucial importance to

promoting sustainable agricultural development, as this technology enables the retention and provision of nutrients and their slow release in accordance with the plant's need for them. Therefore, these fertilizers are called smart fertilizers (Benzon *et al*., 2015). Calcium plays major and important roles because it enters into the protection of cell walls and has an important biochemical function and supports many metabolic processes and activates many enzyme systems (El-Habbasha and Ibrahim, 2015). The leaf area and shoot length of three cultivars of pomegranate were increased significantly affected by foliar spraying with 2% nano calcium during three successive seasons (El-Salhy *et al*., 2022). Ahmed and Lateef (2025) showed in a study that spraying fig trees with nano-calcium at a concentration of 75 g L^{-1} achieved a significant increase in leaf area, leaf dry matter percentage, and fruit number, weight, and size. Calcium increases the hardness of cell walls, thus reducing fruit cracking and undesirable acidity in the taste, a physiological disease affecting fig fruits.

The study aimed to know the effect of spraying with benzyl adenine and calcium oxide nanoparticles and their interaction on the vegetative growth and yield of Al-Obaid fig trees.

MATERIALS AND METHODS

An experiment was conducted in the station of greenhouse/ Department of Horticulture and Landscape/ College of Agriculture / Tikrit University during 2024 growing season, to investigate the role of benzyl adenine and nano calcium on some characteristics of vegetative growth and yield of fig plant of Al-Obaid cultivar. The plants were planted at 2 × 2 m apart and irrigated with drip irrigation method. The characteristics of field soil are presented in table (1).

Table 1. Some physical and chemical properties of soil

Properties and unit	Depth 0-30cm	Depth 0-60cm
Texture	clay loam	clay loam
pH	7.41	7,46
EC dS m^{-1}	4.84	4.38
N (mg kg^{-1})	63	41
P (mg kg^{-1})	136	95
K (mg kg^{-1})	325	289

The experiment includes two factors, the first is three concentrations of benzyl adenine (0, 75 and 150 mg L^{-1}), and the second is three concentrations of nano calcium as calcium oxide (0, 1.25 and 2.5 g L^{-1}). Foliar spraying with benzyl adenine and calcium were done three times in the season at 15-day interval, the first spraying was with nano calcium on 4/4/2024 when the shoots grew to a length of 15 cm, meanwhile the spraying with benzyl adenine was began after three days.

The treatments were arranged according to Randomized Completely Block Design (RCBD) with tree replicates, and a collected data was analyzed statistically by computer and SAS program (SAS, 2000), and the means were compared according to Duncan's test at a probability level of 0.05 (Al-Rawi and Khalaf Allah, 2000).

Studied characteristics:

Leaf area (cm^2): leaf area of ten leaves was measured by electrical leaf area meter, and their average was calculated.

Dry matter in the leaves (%): the fresh weight of ten leaves was taken by electrical balance firstly, and these leaves dried in oven at 70° C for 72 hours, and weighted again. The dry matter in leaves was calculated as percent.

Number of shoots (shoot $tree^{-1}$): The annual shoots grew on branches of fig tree were counted in mid of August.

Length of shoots (cm): the shoots length was measured with a metric tape from the older branches to the tip, in mid of August.

Number of fruits (tree $fruit^{-1}$): This was done by calculating the number of fruits harvested from each experimental unit from the date of the first harvest 6/30 to the date of the last harvest 8/15.

The yield (g $tree^{-1}$): the average weight of 15 fruits of every tree were measured, and multiplied by the number of own fruits were harvested, to determine the yield of tree.

RESULTS AND DISSCUSION

The results of table (2) indicate that the leaf area increased with increasing levels of benzyl adenine spraying, giving an average of 165.41 and 182.27 cm^2 for addition levels 75 and 150 mg L^{-1}, respectively, while the treatment without benzyl adenine spraying recorded the lowest average of 149.06 cm^2. The results of same table indicate that the aera of single leaf fig plant increased with increasing the level of addition of nano-calcium, with an average of 166.22 and 213.74 cm^2 for levels 1.25 and 2.50 g L^{-1} of nano-calcium respectively, while the treatment without addition recorded the lowest average of 116.78 cm^2. The bi-interaction between the study factors recorded significant differences between most of the treatments, as treatment B_2C_2 gave the highest average in this interaction, reaching 232.09 cm2, with an increase of 41.91% compared to control treatment, which gave an average of 97.94 cm^2.

Table 2. Effect of foliar spraying with benzyl adenine and nano calcium and their interaction on leaf area (cm^2) of fig trees, AL-Obaid cultivar

Benzyl adenine	Nano calcium			Average of benzyl adenine
	C_0	C_1	C_2	
B_0	97.94 f	156.22 de	193.01 bc	149.06 C
B_1	111.71 f	168.41 cd	216.12 ab	165.41 B
B_2	140.69 e	174.02 cd	232.09 a	182.27 A
Average of nano calcium	116.78 C	166.22 B	213.74 A	

Different letters within any group refer to a significant difference ($p<0.05$)

The results of Table (3) show that the spraying with benzyl adenine treatments did not record any significant difference on the control treatment. Nano calcium spraying led to a significant increase in the dry matter percentage in the leaves, as the addition levels (1.25 and 2.50 g L^{-1}) gave an average of 41.22 and 41.36%, respectively and exceeded the control treatment significantly, which recorded 38.57%. Bi-interaction between the benzyl

adenine and nano calcium spray factors showed clear significant differences between most of the treatments, where the C_2B_2 interaction treatment recorded the highest average of 42.01%, and it significantly outperformed the control and B_2C_0 treatments which they gave the lowest average of dry matter in leaves (39.98 and 38.19% respectively).

Table 3. Effect of foliar spraying with benzyl adenine and nano calcium and their interaction on dry matter (%) in fig leaves, Al-Obaid cultivar

Benzyl adenine	**Nano calcium**			**Average of benzyl adenine**
	C_0	**C_1**	**C_2**	
B_0	39.98 bc	40.80 a-c	40.697 a-c	39.92 A
B_1	38.53 bc	41.20 a-c	41.38 ab	40.37 A
B_2	38.19 c	42.38 a	42.01 a	40.86 A
Average of nano calcium	38.57 B	41.22 A	41.36 A	

Different letters within any group refer to a significant difference ($p<0.05$)

The results in table (4) indicated that the number of shoots emerged on fig tree increased with increasing the concentration of benzyl adenine solution, and the foliar spray of 150 mg L^{-1} treatment gave the greater number of shoots (17.56) exceeded the control treatment which was give the smallest number of shoots (10.33). The foliar spray of nano calcium treatments had no significant effect on this characteristic. On the other hand, the interaction treatment B_2C_0 outperformed significantly all interaction treatment and it gave the largest number of shoots (25.00).

Table 4. Effect of foliar spraying with benzyl adenine and nano calcium and their interaction on the number of shoots (shoot tree^{-1}) of fig trees, Al-Obaid cultivar

Benzyl adenine	**Nano calcium**			**Average of benzyl adenine**
	C_0	**C_1**	**C_2**	
B_0	9.00 b	9.33 b	12.67 b	10.33 B
B_1	11.33 b	17.00 b	12.33 b	13.55 AB
B_2	25.00 a	11.00 b	16.67 b	17.56 A
Average of nano calcium	15.11 A	12.44 A	13.89 A	

Different letters within any group refer to a significant difference ($p<0.05$)

The results of Table (5) indicate that spraying fig trees with 150 mg L^{-1} benzyl adenine gave the lowest length of shoots (79.58 cm) and it reduced significantly on the control treatment which gave the height length of shoots (107.89 cm). The results of the same table also indicate that increasing the concentration of spraying with nano calcium gave a non-significant increase in the length of shoots. The interaction between benzyl adenine and calcium levels affected significantly, that the treatment B_2C_0 recorded the lowest average of 68.69 cm and decreased significantly on the control treatment (B_0C_0) which was gave 105.21 cm as an average of shoot length.

Data in table (6) shows that the number of fig fruits increased with increasing the level of benzyl adenine spraying with an average of 71.89 and 91.00 fruit tree^{-1} for levels 75 and 150 mg L^{-1} respectively. It is also noted from the same table that spraying with calcium nano- particles did not record any significant differences between the treatments. The bi-interaction treatments between the study factors showed significant superiority between some treatments, and treatment B_2C_0 recorded the highest average of 114.00 fruit tree^{-1}, while treatment B_0C_0 recorded the lowest average of 44.33 fruit tree^{-1}.

Table 5. Effect of foliar spraying with benzyl adenine and nano calcium and their interaction on the shoots length (cm) of fig trees, Al-Obaid cultivar

Benzyl adenine	Nano calcium			Average of benzyl adenine
	C_0	C_1	C_2	
B_0	105.21 a	107.82 a	110.64 a	107.89 A
B_1	93.96 a-c	93.22 a-c	99.55 ab	95.58 A
B_2	68.69 c	96.00 ab	74.52 bc	79.74 B
Average of nano calcium	89.29 A	99.01 A	94.90 A	

Different letters within any group refer to a significant difference ($p<0.05$)

Table 6. Effect of foliar spraying with benzyl adenine and calcium nanoparticles and their interaction on the number of fruits of Al-Obaid fig trees (fruit tree^{-1})

Benzyl adenine	Nano calcium			Average of benzyl adenine
	C_0	C_1	C_2	
B_0	44.33 d	48.67 cd	48.33 cd	47.11 C
B_1	58.33 a-c	87.67 a-c	69.67 b-d	71.89 B
B_2	114.00 a	67.00 b-d	92.00 ab	91.00 A
Average of nano calcium	72.22 A	67.78 A	70.00 A	

Different letters within any group refer to a significant difference ($p<0.05$)

The results of Table (7) showed that spraying benzyl adenine affected the yield of tree, as the levels 75 and 150 mg L^{-1} recorded an average of 1430.16 and 1940.63 g tree^{-1} respectively, with an increase of 77.57 and 113.52% compared to the no-spray treatment, which gave a lowest average of 805.4 g tree^{-1}.Spraying with nano-calcium led to a non-significant decrease in the total yield. The bilateral interactions between benzyl adenine and nano-calcium showed significant differences between the treatments, and the interaction treatment B_2C_0 recorded the highest average in this interaction, reaching a value of 2500.0 g tree^{-1}, while control treatment (B_0C_0) recorded the lowest average, reaching 727.4 g tree^{-1}.

Table 7. Effect of foliar spraying with benzyl adenine, nano calcium and their interaction on yield of Al-Obaid fig tree (g tree^{-1})

Benzyl adenine	Nano calcium			Average of benzyl adenine
	C_0	C_1	C_2	
B_0	727.4 c	824.5 c	864.3 c	805.4 C
B_1	1282.1 bc	1651.7 b	1356.7 bc	1430.16 B
B_2	2500.0 a	1368.7 bc	1953.2 ab	1940.63 A
Average of nano calcium	1503.16 A	1281.63 A	1391.4 A	

Different letters within any group refer to a significant difference ($p<0.05$)

The foliar spray with benzyl adenine improved a vegetative growth characteristic such as leaf area and the number of shoots per plant, and the number of fruits and the yield of tree, this effect may be due to its role in stimulating cell division and elongation, determining an apical dominance and break down a dormancy of lateral buds to result more grown shoots. Also, benzyl adenine as cytokinin participate in building proteins and stimulate the maturation of chromoplasts (George *et al*., 2008). Since the fig tree loads its fruits on new branches (shoots), the more grown shoots mean an increase in the number of fruits, and this is reflected in the tree's yield. Moghadam *et al*. (2013) found that the weight of pear fruits "Spadana cultivar" increased statistically as a result of foliar spray of pear trees with benzyl adenine 300 mg L^{-1}. On the other hand, Cytokinin stimulates the formation of some enzymes such as ribonuclease, catalase, alpha amylase etc. and activates the building of protein and RNA in cells as a result of activating of genes responsible for these prosses (Abu Zaid, 2000). In addition, cytokinin stimulates the formation of flowers in plants that require a long day or a cold period, as well as stimulates the formation of parthenogenetic fruits in a number of plants, like common fig (Al-Khafaji, 2014). These results were in line of Medan and Al-douri (2021) when they investigated the effect of Sitofex cytokinin on apricot growth and productivity.

The above tables indicated that the leaf area and the percentage of dry matter in leaves were superior to foliar application of nano- calcium. Calcium one of an essential element that plant required in its life cycle. It is a structural nutrient, that is provides stability to cell walls and membranes by forming cross-links with pectin in the cell walls. The calcium ion concentration acts as a key intracellular messenger, coordinating plant responses to developmental and environmental stimulators. These responses are mediated through calcium-binding proteins like calmodulin and calcium-dependent protein kinases (White and Broadley, 2003). Ca absorption dependent on transpiration, so under low transpiration situations such as high humidity, young leaves and in fruits, the plant or an organ suffers Ca deficient, therefore the foliar spray regard a success option. (Bekreij *et al*., 1992). Nano calcium fertilizers may also be superior to traditional calcium fertilizers in their effect, as sources indicate that: nano-fertilizers are a new phase, applied at very low rates with a high absorption rate compared to other fertilizers, and that they help plants develop rapidly and improve the ecosystem (Ahmed and Lateef, 2025). Nano-calcium nanoparticles interact more efficiently in plant cells, accelerating their absorption and distribution in plant tissues. They have the ability to penetrate cell membranes more

quickly and deeply compared to conventional fertilizers (Qureshi *et al*., 2018; Ahmed and Lateef, 2025). Nano-calcium enhances the rigidity of cell walls, increases resistance to diseases, water stress, heat stress, and environmental conditions, and contributes to improved metabolism (Kah, 2015).

CONCLUSION

The spraying fig trees Al-Obaid cultivar with benzyl adenine and calcium had a beneficial effect in improving the studied characteristics of vegetative growth, number of fruits per tree and yield, but the best effect was for spraying with benzyl adenine. However, the interaction treatments between them were more effective as it gave the highest values compared to un-treated trees.

CONFLICT OF INTEREST

There are no conflicts of interest associated with this manuscript.

ACKNOWLEDGMENTS

We would like to express our profound gratitude to the employees in the Department of Horticulture and Landscape Design's labs and fields for their help in finishing this study.

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