Effect of Foliar Application of Nano-Fertilizer, Putrescine, and Plant Growth Regulators on Some Vegetative and Chemical Traits of Grafted Apricot *(prunus armeniaca L.)* Seedlings

Alaa Waleed Abdul Al-Kadhim[1] Hadi Kadhim Al-Jubouri[2]

College of Agriculture, Al-Qasim Green University, Iraq

Alaa.waleed@agre.uoqasim.edu.iq
Hadi.kadum@agre.uoqasim.edu.iq

Abstract

This study was conducted in the wooden shade house of the Department of Horticulture and Landscape Engineering, College of Agriculture, Al-Qasim Green University, during the period from 15 March 2025 to 15 January 2026. The experiment was carried out on seven-month-old apricot seedlings grafted on to seedling peach rootstock to investigate the effect of foliar application of plant growth regulators at four levels (0, NAA 75 mg L^{-1}, cytokinin 100 mg L^{-1}, and NAA 75 mg L^{-1} + cytokinin 100 mg L^{-1}). The second factor included (0, Nano-fertilizer 1.5 g L^{-1}, and putrescine 100 mg L^{-1}). Their interaction effects on vegetative growth and chemical characteristics of apricot seedlings were evaluated.

The experiment was arranged as a factorial trial (4 × 3) according to a Randomized Complete Block Design (RCBD). The results indicated that the application of the studied treatments, whether individually or in combination, significantly increased vegetative growth parameters, including seedling height, number of leaves, leaf area, and number of branches. Regarding chemical characteristics, treatments with plant growth regulators significantly enhanced most traits, except nitrogen content. Moreover, all chemical parameters recorded their highest values under the application of nano-fertilizer at 1.5 g L^{-1} and putrescine at 100 mg L^{-1} compared with the control treatment.

Keywords: Nano-fertilizer, Putrescine, Plant Growth Regulators, NAA, Cytokinin, Apricot.

1_ Introduction

Apricot (*Prunus armeniaca L.*) is a temperate deciduous fruit tree belonging to the family Rosaceae. Trees typically reach 2–5 m in height, while mature specimens may exceed 8 m. Although Armenia was historically considered the primary center of origin, recent phylogenetic and biogeographical studies indicate that apricot originated in a broad region

ISSN 2072-3857

extending from Central and Western Asia to China, from where it spread to the Mediterranean basin and Europe. The crop later expanded to North Africa, North America, and Australia, becoming an economically important fruit species in temperate and semi-arid regions worldwide (5,14]..

In Iraq, apricot represents a valuable fruit crop, with over one million fruit-bearing trees producing more than 34,000 tons annually[9]. Despite its economic and nutritional importance, productivity remains influenced by seedling vigor, graft compatibility, and nutrient management strategies. Apricot fruits are consumed fresh or dried and are characterized by significant nutritional value, containing carbohydrates, dietary fiber, potassium, calcium, magnesium, and bioactive compounds [4].

Successful establishment and economic productivity of fruit trees largely depend on vigorous nursery seedlings. However, grafted seedlings frequently exhibit slow post-grafting growth due to temporary physiological imbalance, incomplete vascular differentiation at the graft union, or stock–scion incompatibility. Nutrient deficiencies further exacerbate this limitation, negatively affecting vegetative growth and metabolic efficiency . [27] Therefore, improving nutrient availability and hormonal balance during early growth stages is essential for enhancing graft success and subsequent field performance.

Nanotechnology has recently emerged as a promising approach in sustainable agriculture. Nano-fertilizers enhance nutrient use efficiency, improve foliar absorption, and reduce environmental losses compared with conventional fertilizers[2,26]. Due to their high surface area and controlled nutrient release properties, nano-formulations can enhance photosynthetic activity, metabolic processes, and overall plant productivity [18,21] . Nevertheless, limited information is available regarding their combined interaction with plant growth regulators in grafted apricot seedlings .

Putrescine, a polyamine compound, plays a fundamental role in cell division, membrane stabilization, antioxidant defense, and regulation of endogenous auxin levels. Polyamines are known to delay senescence, enhance stress tolerance, and improve cellular metabolism under various environmental conditions [24] . Similarly, plant growth regulators such as auxins (NAA) and cytokinins are central to cell division, vascular differentiation, apical dominance regulation, and branching induction. Their application has been shown to enhance graft union formation and

ISSN 2072-3857

vegetative development in fruit crops [20] .

Despite individual reports on nano-fertilizers, polyamines, or plant growth regulators, studies evaluating their combined influence on vegetative and physiological performance of grafted apricot seedlings remain scarce. Understanding these interactions is particularly important for overcoming slow growth following graft establishment and improving stock–scion compatibility[9,10].

Research Hypothesis

It was hypothesized that foliar application of Nano-fertilizer, putrescine, and plant growth regulators—either individually or in combination—would synergistically enhance vegetative growth, chlorophyll content, and nutrient accumulation in grafted apricot seedlings by improving nutrient uptake efficiency and stimulating cellular division and differentiation processes.

Objectives of the Study

The present study aimed to:

1. Evaluate the effects of foliar application of nano-fertilizer, putrescine, and plant growth regulators on vegetative growth and selected chemical traits of grafted apricot seedlings.
2. Investigate the individual and interactive effects of these treatments in mitigating post-grafting growth retardation improving physiological performance.

2_Materials and Methods

2_1 Plant Material and Experimental Design

A total of 144 uniform, seven-month-old apricot *(Prunus armeniaca L .)* seedlings grafted onto seedling peach rootstock were selected for the experiment. Seedlings were grown in plastic pots (4 kg capacity) and were carefully chosen to ensure uniformity in height, stem diameter, and overall vigor.

The study was conducted as a factorial experiment (4 × 3) arranged in a Randomized Complete Block Design (RCBD) with three replicates. The two experimental factors were as follows:

Factor A: Plant Growth Regulators (PGRs)

1-A_1

2-A_2

3-A_3

ISSN 2072-3857

4-A_4

Factor B: Nano-fertilizer and Putrescine

1. Control (no application)
2. Nano-fertilizer at 1.5 g L^{-1}
3. Putrescine at 100 mg L^{-1}

Treatments were applied as foliar sprays, and applications were repeated at approximately one-month intervals throughout the experimental period.

Each treatment combination was represented in three replicates, and each replicate consisted of an equal number of seedlings randomly distributed within each block to minimize environmental variability

2 Studied Growth Parameters

Vegetative Traits

Seedling Height (cm)

Seedling height was measured from the graft union to the apical tip using a metric measuring tape. The average height of the seedlings within each experimental unit was calculated and considered as the final mean for statistical analysis

Number of Leaves (leaf seedling^{-1})

The total number of leaves per treatment was counted, and the average number of leaves per seedling was calculated by dividing the total leaf number by the number of seedlings within the same treatment
.

Leaf Area per Seedling (cm²)

Leaf area was estimated by first calculating the mean area of a single leaf using the following equation:

)Maximum leaf length × Maximum leaf width × 0.66(

According to the method described by Chon G. (1966).

The total leaf area per seedling was then obtained by multiplying the mean leaf area by the total number of leaves per seedling. Finally, the average leaf area per treatment was calculated.

Mean Total Number of Branches (branch seedling^{-1})

ISSN 2072-3857

All lateral branches attached to the main stem of each seedling within the experimental units were counted. The overall mean number of total branches per seedling was then determined.

Chemical Traits

_1 Total Leaf Chlorophyll Content (SPAD Units)

Five leaves per seedling were randomly selected from the lower, middle, and upper portions of each seedling within a treatment. Chlorophyll content was measured using a German-made SPAD chlorophyll meter. Measurements were recorded for all seedlings within each experimental unit, and the mean value per treatment was calculated.

Total Carbohydrates Percentage (%)

Total carbohydrate percentage in leaves was determined after drying and grinding the samples. A 0.250 g sample of the dried material was placed in a test tube and brought to a final volume of 10 mL with distilled water. The samples were centrifuged for 10 minutes, filtered, and the volume was completed again to 10 mL with distilled water. One milliliter of the filtrate was mixed with 1 mL of 5% phenol solution and 5 mL of 80% sulfuric acid. The solution was allowed to cool for 25 minutes according to the method described by [17] . Absorbance was measured using a spectrophotometer at a wavelength of 490 nm.

Determination of Total Nitrogen Percentage in Leaves (%)

Total nitrogen percentage was determined using the Kjeldahl method with a Kjeldahl apparatus, following the procedure described by [6]..

Determination of Leaf Iron (Fe) Content

Leaf iron content (mg kg^{-1} dry weight) was determined using an Atomic Absorption Spectrophotometer (AAS). The methodology described by [11,26]. was followed. The analyses were performed at the U-Science Laboratory in Al-Qadisiyah Province

3_ Results and Discussion

: Vegetative Growth Parameters

Mean Seedling Height (cm)

The results presented in Table (1) indicate that the application of plant growth regulators to grafted apricot seedlings significantly affected seedling height. The highest mean height was recorded under treatment A4, reaching 143.58 cm, compared with the lowest mean height observed in treatment A1, which recorded 122.09 cm.

Regarding the second factor, the application of Nano-fertilizer and putrescine also exerted a significant effect on seedling height. The highest mean height was achieved under treatment B2, reaching 135.77 cm, whereas the lowest value was recorded under treatment B1 at 119.68 cm.

Furthermore, the interaction between the studied factors had a significant effect on seedling height. The maximum height was obtained under the combined treatment A4B2, which reached 161.77 cm, compared with the minimum value observed under treatment A1B1, which recorded 114.60 cm

.

Table (1). Effect of Nano-fertilizer, putrescine, and plant growth regulators on mean seedling height (cm).

B				factor A
average	**B3**	**B2**	**B1**	
122.09	130.04	121.63	114.60	**A1**
123.34	128.32	125.33	116.37	**A2**
128.76	127.79	134.37	124.13	**A3**
143.58	145.34	161.77	123.63	**A4**
	132.87	**135.77**	**119.68**	Avereage
A 11.88	**B** 10.29		**lnteraction** 20.57	**L.S.D** **0.05**

A:Plant Growth Regulators

B: Nano Fertilizer

Number of Leaves (leaf seedling^{-1})

ISSN 2072-3857

The results presented in Table (2) revealed that the application of plant growth regulators to grafted apricot seedlings did not produce a significant effect on the number of leaves.

Similarly, the application of Nano-fertilizer and putrescine showed no significant effect on this trait when applied individually.

However, the interaction between the studied factors exhibited a significant effect on the number of leaves. The highest mean value was recorded under the combined treatment A4B2, reaching 162.66 leaves seedling^{-1}, compared with the lowest mean value observed under treatment A1B1, which recorded 106.43 leaves seedling^{-1}.

Table (2). Effect of nano-fertilizer, putrescine, and plant growth regulators on the mean number of leaves (leaf seedling^{-1}).

b				factor
average	**B3**	**B2**	**B1**	**A**
116.09	118.17	123.67	106.43	**A1**
135.97	137.11	142.43	128.39	**A2**
125.83	127.09	131.72	118.70	**A3**
146.42	144.59	162.66	132.01	**A4**
	131.74	**140.12**	**121.38**	Average
interaction	**B**		**A**	**L.S.D**
NS NS		53.96		**0.05**

A: Plant Growth Regulators

B: Nano Fertilizer

ISSN 2072-3857

3 Leaf Area per Seedling (cm^2)

The results presented in Table (3) indicate that the application of plant growth regulators to grafted apricot seedlings had a significant effect on leaf area per seedling. The highest mean leaf area was recorded under treatment A4, reaching 2422.11 cm^2, compared with the lowest mean value observed under treatment A1, which recorded 1725.53 cm^2.

Likewise, the application of Nano-fertilizer and putrescine significantly influenced this trait. The highest mean leaf area was obtained under treatment B2, reaching 2601.23 cm^2, whereas the lowest mean value was recorded under treatment B1 at 1666.82 cm^2.

Furthermore, the interaction between the studied factors showed a significant effect on leaf area per seedling. The maximum value was achieved under the combined treatment A4B2, which reached 3062.43 cm^2, compared with the minimum value recorded under treatment A1B1, which was 1498.81 cm^2.

Table (3). Effect of nano-fertilizer, putrescine, and plant growth regulators on leaf area per seedling (cm^2).

B				Factor
average	**B3**	**B2**	**B1**	**A**
1725.53	1754.19	1923.61	1498.81	**A1**
2056.02	1843.64	2687.12	1637.31	**A2**
2188.97	2096.83	2731.76	1738.32	**A3**
2422.11	2411.05	3062.43	1792.87	**A4**
	2026.42	2601.23	1666.82	average
A	**B**	**interaction**		**L.S.D**
61.114 98.003		56.201		**0.05**

A:Plant Growth Regulators

B: Nano Fertilizer

ISSN 2072-3857

Mean Number of Branches (branch seedling^{-1})

The results presented in Table (4) demonstrate that the application of plant growth regulators to grafted apricot seedlings had a significant effect on the number of branches. The highest mean number of branches was recorded under treatment A4, reaching 25.35 branches seedling^{-1}, compared with the lowest mean value observed under treatment A1, which recorded 21.88 branches seedling^{-1}.

Regarding the second factor, the application of Nano-fertilizer and putrescine also showed a significant effect on this trait. The maximum mean number of branches was obtained under treatment B3, reaching 24.62 branches seedling^{-1}, whereas the lowest value was recorded under treatment B1 at 22.37 branches seedling^{-1}.

Furthermore, the interaction between the studied factors significantly influenced the mean number of branches. The highest value was achieved under the combined treatment A4B3, reaching 26.64 branches seedling^{-1}, compared with the lowest mean recorded under treatment A1B1, which was 19.94 branches seedling^{-1}.

Table (4). Effect of Nano-fertilizer, putrescine, and plant growth regulators on the mean number of branches (branch seedling^{-1}).

B				Factor
average	**B3**	**B2**	**B1**	**A**
21.88	23.28	22.44	19.94	**A1**
22.66	23.48	23.35	21.15	**A2**
24.82	25.09	25.31	24.08	**A3**
25.35	26.64	25.11	24.32	**A4**
	24.62	24.05	22.37	Avereage
interaction	**B**		**A**	**L.S.D**
2.680	2.161		5.021	**0.05**

A:Plant Growth Regulators **B: Nano Fertilizer**

ISSN 2072-3857

The observed increase in seedling height following treatment with plant growth regulators may be attributed to their role in stimulating the synthesis of proteins and enzymes involved in cell division and cell enlargement. This, in turn, leads to an increase in osmotic pressure within cells, enhancing the absorption of water and nutrients, which is positively reflected in vegetative growth parameters, including seedling height [13] .

[8] .reported that foliar application of the growth regulator Paisen—a synthetic cytokinin—on fig trees cv. Aswad Diyala resulted in significant increases in vegetative growth indicators, as well as leaf total chlorophyll, carbohydrate content, and nitrogen percentage.

The Increase in leaf number and leaf area may also be attributed to the role of plant growth regulators in promoting cell division and differentiation of callus tissues, leading to the formation of a strong graft union. Moreover, their role in vascular tissue differentiation at the grafting zone facilitates the translocation of water and nutrients [20].

The Increase in the number of branches may be explained by the stimulatory effect of growth regulators on the formation and development of woody tissues in buds and stems, thereby enhancing nutrient transport. This process promotes the emergence of lateral buds, in addition to increasing the expansion of conductive tissues (xylem and phloem) [3,7].

The enhancement In seedling height resulting from Nano-fertilizer and putrescine application may be attributed to their role in supplying essential macro-nutrients required for photosynthesis, respiration, and various metabolic processes. These processes play a crucial role in cell division and elongation, which positively influences vegetative growth traits[1]. Nitrogen, in particular, stimulates meristematic activity, increasing cell division and elongation. Phosphorus plays a fundamental role in vegetative growth, while both phosphorus and potassium enhance photosynthetic efficiency. They are also involved in membrane formation and energy compound synthesis. Additionally, potassium activates numerous enzymes responsible for cell division and expansion, leading to increased leaf number and leaf area [27,13].

The increase in branch number may further be attributed to the role of nitrogen in protoplasmic processes, enzymatic reactions, and photosynthesis, which collectively enhance vegetative growth, including branch formation. These findings are consistent with those reported by [19].

3_2 Chemical Traits

ISSN 2072-3857

3_2_1 Total Leaf Chlorophyll Content (SPAD Units)

The results presented in Table (5) indicate that the application of plant growth regulators to grafted apricot seedlings had a significant effect on total leaf chlorophyll content. The highest mean value was recorded under treatment A4, reaching 58.32 SPAD units, whereas the lowest chlorophyll content was observed under treatment A1, which recorded 51.91 SPAD units.

The results further showed that nano-fertilizer and putrescine treatments also exerted a significant effect on this trait. The highest chlorophyll content was recorded under treatment B2, reaching 60.38 SPAD units, compared with the lowest value observed under treatment B1, which was 51.13 SPAD units.

Moreover, the interaction between the studied factors significantly affected the relative chlorophyll content in leaves. The combined treatment A4B2 produced the highest chlorophyll value, reaching 67.78 SPAD units, whereas the lowest value was recorded under treatment A1B1, which reached 47.07 SPAD units.

Table (5). Effect of Nano-fertilizer, putrescine, and plant growth regulators on total leaf chlorophyll content (SPAD units).

B				Factor
average	**B3**	**B2**	**B1**	**A**
51.91	51.75	56.93	47.07	**A1**
54.35	50.71	59.84	52.51	**A2**
53.43	52.48	56.99	50.83	**A3**
58.32	53.07	67.78	54.11	**A4**
	52.00	**60.38**	**51.13**	Average
A 6.049	**B** 5.850	**interaction** 11.549		**L.S.D 0.05**

A:Plant Growth Regulators

B: Nano Fertilizer

ISSN 2072-3857

Total Carbohydrates Percentage (%)

The results presented in Table (6) indicate that the application of plant growth regulators to grafted apricot seedlings did not produce a significant effect on the total carbohydrate percentage in the leaves.

However, the results shown in the same table reveal that Nano-fertilizer and putrescine treatments had a significant effect on this trait. The highest carbohydrate percentage was recorded under treatment B2, reaching 15.20%, compared with the lowest value observed under treatment B1, which was 12.66%.

Regarding the interaction between the studied factors, a significant effect was observed. The highest interaction value was obtained under treatment A3B2, reaching 15.80%, whereas the lowest value was recorded under treatment A1B1, which reached 11.02%.

Table (6). Effect of Nano-fertilizer, putrescine, and plant growth regulators on total carbohydrate percentage in leaves (%).

B				Factor A
average	**B3**	**B2**	**B1**	
12.61	12.67	14.18	11.02	**A1**
13.75	13.67	15.15	12.44	**A2**
14.37	14.00	15.80	13.33	**A3**
14.38	13.59	15.67	13.88	**A4**
	13.48	15.20	12.66	Avereage
A	**B**	**interaction**		**L.S.D**
NS	2.019	4.037		**0.05**

A:Plant Growth Regulators

B: Nano Fertilizer

ISSN 2072-3857

3_2_3 Nitrogen Percentage in Leaves (%)

The results presented in Table (7) indicate that the application of plant growth regulators to grafted apricot seedlings did not produce a significant effect on leaf nitrogen percentage.

In contrast, Nano-fertilizer and putrescine treatments showed a significant effect on this trait. Treatment B2 recorded the highest nitrogen percentage, reaching 2.64%, compared with the lowest value observed under treatment B1, which was 2.00%.

Regarding the interaction between the studied factors, a significant effect was observed. The highest nitrogen percentage was obtained under the combined treatment A4B2, reaching 2.99%, whereas the lowest value was recorded under treatment A1B1, which reached 1.78%.

Table (7). Effect of Nano-fertilizer, putrescine, and plant growth regulators on nitrogen percentage in leaves (%).

B				Factor
average	**B3**	**B2**	**B1**	**A**
1.99	1.94	2.27	1.78	**A1**
2.31	2.14	2.71	2.10	**A2**
2.19	2.05	2.59	1.93	**A3**
2.46	2.19	2.99	2.22	**A4**
	2.08	**2.64**	**2.00**	average
A	**B**		**interaction**	**L.S.D**
NS	0.574		1.109	**0.05**

A: Plant Growth Regulators

B: Nano Fertilizer

ISSN 2072-3857

3_2_4 Leaf Iron Content (mg kg^{-1} Dry Weight)

The results presented in Table (8) indicate that the application of plant growth regulators to grafted apricot seedlings had a significant effect on leaf iron content. The highest mean iron content was recorded under treatment A4, reaching 57.46 mg kg^{-1} dry weight, compared with the lowest value observed under treatment A1, which recorded 53.24 mg kg^{-1} dry weight.

Similarly, Nano-fertilizer and putrescine treatments showed a significant effect on this trait. The highest iron content was obtained under treatment B2, reaching 60.48 mg kg^{-1} dry weight, whereas the lowest value was recorded under treatment B1 at 50.19 mg kg^{-1} dry weight.

Furthermore, the interaction between the studied factors significantly influenced leaf iron content. The maximum value was achieved under the combined treatment A3B2, reaching 61.47 mg kg^{-1} dry weight, compared with the minimum value recorded under treatment A1B1, which was 47.87 mg kg^{-1} dry weight.

Table (8). Effect of Nano-fertilizer, putrescine, and plant growth regulators on leaf iron content (mg kg^{-1} dry weight).

B				Factor A
average	**B3**	**B2**	**B1**	
53.24	51.31	60.55	47.87	**A1**
54.14	52.09	59.73	50.97	**A2**
54.40	51.42	61.47	50.33	**A3**
57.46	60.24	60.54	51.60	**A4**
	53.76	60.48	50.19	avereage
Interaction 4.622	**B** 2.241		**A** 2.658	**L.S.D 0.05**

A:Plant Growth Regulators **B: Nano Fertilizer**

ISSN 2072-3857

The increase in chlorophyll content may be attributed to the role of plant growth regulators in improving vegetative growth characteristics and enhancing nutrient uptake. In addition, they stimulate vital physiological processes within the plant, particularly during early leaf development. Their influence on the distribution of hemicellulosic fibers within cell walls facilitates cell expansion and elongation, which consequently increases leaf area, delays senescence, and enhances root capacity to absorb greater quantities of water. This, in turn, raises the concentration of essential nutrients involved in the synthesis of total chlorophyll [15,7].

The observed Increase in total leaf chlorophyll content following foliar application of the nutrient solution and putrescine may also be explained by the interactive effects of the supplied nutrients in chlorophyll biosynthesis. Some of these elements are structural components of the chlorophyll molecule itself, particularly nitrogen and magnesium [23,16].

The increase in carbohydrate percentage may be attributed to the role of mineral nutrients in food synthesis. Potassium, for example, plays a major role in enhancing carbohydrate accumulation. The superiority of Nano-fertilizer–treated seedlings in carbohydrate content could be related to the enhanced synthesis of assimilates and improved vegetative growth performance, which is positively reflected in carbohydrate accumulation [25,12].

The results further indicated that foliar application of Nano NPK fertilizer significantly affected nutrient concentrations in leaves. The increased nutrient levels in Nano-fertilizer–treated seedlings may be attributed to the direct absorption of nutrients through leaf tissues, leading to higher internal concentrations. Moreover, the positive effect of Nano-fertilizer in promoting a strong vegetative and root system enhances root efficiency in absorbing additional nutrients, thereby increasing their accumulation within plant tissues [22].

4 References

[1] Awad ,S .M. and A .R .Atawia .(1995). Effect of foliar sprays with so micronutrientson "Le-Conte" peartrees. 1-Treegrowth, lowering & leaf mineral contents .Annals of Agricultural Science , Ain Shams Univ . 40 (1) : 359-367 .

[2] Ali Nour Al-Din Shawqi, N. A. D. S.,&Al- Joudhari Hayawi Y., H. Y. (2017). Applications of nanotechnology of micronutrients in

agricultural production. Iraqi Journal of Agricultural Sciences, 48(4), 984–990

[3] Al-Asadi Maher Hamid Salman, M. H. S.,&Al-Khaikani Ali Jasim, A. J. (2019). Plant Growth Regulators. Al-Qasim Green University, Ministry of Higher Education and Scientific Research, Iraq.

[4] Al-Bitar Alaa Dawood, A. D. (2015). Fruit Trees: Cultivation, Management and Production. Deanship of Scientific Research and Graduate Studies, Al-Quds Open University, Ramallah, Palestine.

[5] Al-Essa Imad, I.,&Batha Mohammed, M. (2012). Production of Deciduous Fruit Trees (1st ed.). University of Damascus Publications, Syria.

[6] Al-Sahaf Fadhil Hussein, F. H. (1989). Plant Nutrition. Higher Education Press, Mosul; House of Wisdom for Publishing, Translation and Distribution, University of Baghdad, Ministry of Higher Education and Scientific Research, Iraq.

[7] Al-Khafaji M A. (2014). Plant growth regulators and their applications and horticultural uses, College of Agriculture, University of Baghdad, Ministry of Higher Education and Scientific Research.

[8] Al-Jubouri.H.K. (2021). Effect of Paisen, Populuseuphratica Bud Extract and Copper Sulfate on Some Traits of Vegetative Growth and Yield of Aswad Diyala Cultivars IOP Conf. Series: Earth and Environmental Science

[9] Central Statistical Organization Iraq (2021). Ministry of Planning, Directorate of Agricultural Statistics. Baghdad, Iraq.

[10] Chou, G.J.1966. Anew method of measuring the leaf area of Citrus. Acta.Hort.sci. 5,7-20.

[11] Chapman, H. D and P. F. Pratt. 1961. Method of Analysis for Soils.

[12] Davies, P. J. 2010. The plant hormones: their nature, occurrence, and functions. In: Plant Hormones (pp. 1-15). Springer, Dordrecht

[13] Gharousha Kamel Hassan Mohammed, K. H. M. (2020). Plant Growth Regulators and Plant Physiology. University of Mentouri, Ministry of Higher Education and Scientific Research, People's Democratic Republic of Algeria.

[14] George, M.(2019).Fruit Sciences & Postharvest Group, Agricultural Sciences, Biotechnology and Food Science (ABF) at the Cyprus University of Technology (CUT), based in Lemesos, Anexartisias 57, Pareas Building PO Box 50329, 3603 Lemesos Cyprus

ISSN 2072-3857

[15] Hopkins W. G., & Hüner N. P. A. (2004). Introduction to Plant Physiology . (3ed). John Wiley and Sons, Inc.

[16] Hanifah W, Purnomo CW, Purwono SU.2019. Slow release NPK

fertilizer preparation from natural resources. In: Materials

Science Forum. 948, pp. 43-48.

[17] Josyln, M.A. 1970. Method in Food Analysis, Physical, Chemical and Instrumental Methods of Analysis. 2nd ed. Academic Press,New York and London.

[18] Janmohammadi, M., Navid, A., Segherloo, A. E.,&Sabaghnia, N.

.2016. impact of nano-chelated micronutrients and biological fertilizers on growth performance and grain yield of maize under deficit irrigation condition. Biologija, 62(2).

[19] Nour Al-Din Shawqi Ali, S. A. (2012). Guide to Plant Nutrition. University of Baghdad, Ministry of Higher Education and Scientific Research, Iraq. [20] Radi Mostafa

Mohamed, M. M.,&Abdel-Megid Safia Mahmoud, S. M. (2021). Plant Growth Regulators. Fayoum University, Arab Republic of Egypt.

[21] Singh, M. D.; G. Chirag; P. O. Prakash; M. H. Mohan; Prakasha, G. and Vishwajith.2017. Nano fertilizers is a new way to increase nutrients use efficiency in crop production. International Journal of Agriculture Sciences, 9(7): 3831-3833.

[22] Sekhon , B.S. 2014 Nanotechnology in agri –food production : an overview . Nanotechnology,Science and Applications, 7:31-53 and development (No. Ed. 6). Sinauer Associates Incorporated

[23] Taiz, L.; Zeiger, E.; Møller, I. M. and Murphy, A. 2015. Plant physiology

[24] Velikova, V., I. Yordannw and A. Edreva (2000). Oxidative stress

and some axodant system in acid rain-treated bean plants. Protective role of exogenous polyamine. Plant Sci., 115: 59-66.

[25] Xia, Z., He, Y., Yu, L., Miao, J., Korpelainen, H. and Li, C. 2020. Root traits and rhizosphere processes reflect differential phosphorus acquisition strategies in contrasting

Populus clones. Forest Ecology and Management, 457, 117-140.

[26] Yash Kalra,1997. Reference Method for Plant Analysis, 1st Edition.

ISSN 2072-3857

[27] Yaqoub Mohammed Mohammed, M. M.,&Abu Gharssa Salah Al-Din Mustafa, S. A. M. (2022). Fundamentals of Plant Nutrition (1st ed.). Omar Al-Mukhtar University, Libya.

ISSN 2072-3857