The Effect of Grafting Watermelon onto Some Cucurbit Rootstocks on Vegetative growth Traits Using Zeolite under Water Stress Conditions

Pengaruh Pencangkokan Semangka pada Beberapa Batang Bawah Mentimun terhadap Sifat Pertumbuhan Vegetatif Menggunakan Zeolit pada Kondisi Cekaman Air

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Abstract. General Background: *Watermelon production in arid regions faces challenges due to water scarcity and soil fertility issues, prompting the need for agronomic strategies that improve resilience and productivity.* ***Specific Background:*** *Techniques like grafting watermelon onto cucurbit rootstocks and applying zeolite as a soil amendment have shown potential in mitigating water stress and enhancing growth. However, comprehensive studies on the combined effects of these practices under varying water regimes remain limited.* ***Knowledge Gap:*** *The interplay between grafting types, zeolite concentrations, and irrigation levels on watermelon vegetative growth and yield characteristics under water stress has yet to be fully explored.* ***Aims:*** *This study aimed to evaluate the effects of grafting watermelon onto three cucurbit rootstocks (Cucurbita pepo, pumpkin, and pumpkin seed) and applying zeolite at three concentrations (0, 20, and 40 g per plant) under two irrigation levels (full and half) to identify optimal growth conditions.* ***Results:*** *The experiment, arranged in a factorial RCBD, revealed that grafting and zeolite addition significantly improved vegetative traits like leaf number, branch length, and branch count, especially under water stress. The best performance was observed with pumpkin grafting and 40 g of zeolite under reduced irrigation, achieving significant increases in leaf length, width, and branch numbers.* ***Novelty:*** *This study uniquely combines grafting with zeolite application under water stress conditions, demonstrating that watermelon grafted onto specific rootstocks, when supplemented with zeolite, can sustain growth and yield despite reduced irrigation.* ***Implications:*** *The findings suggest that using zeolite and grafting on stress-tolerant rootstocks could enable more efficient water use in watermelon cultivation, promoting sustainable agricultural practices in water-limited regions.*

Keywords – *Watermelon grafting, Cucurbit rootstocks, Zeolite application, Water stress, Yield improvement*

Abstrak. ***Latar Belakang Umum:*** *Produksi semangka di daerah kering menghadapi tantangan karena kelangkaan air dan masalah kesuburan tanah, yang mendorong perlunya strategi agronomi yang meningkatkan ketahanan dan produktivitas.* ***Latar Belakang Khusus:*** *Teknik seperti mencangkok semangka ke batang bawah cucurbit dan menerapkan zeolit sebagai amandemen tanah telah menunjukkan potensi dalam mengurangi stres air dan meningkatkan pertumbuhan. Namun, studi komprehensif tentang efek gabungan dari praktik-praktik ini di bawah berbagai rezim air masih terbatas.* ***Kesenjangan Pengetahuan:*** *Interaksi antara jenis okulasi, konsentrasi zeolit, dan tingkat irigasi pada pertumbuhan vegetatif semangka dan karakteristik hasil di bawah stres air belum sepenuhnya dieksplorasi.* ***Tujuan:*** *Penelitian ini bertujuan untuk mengevaluasi efek mencangkok semangka ke tiga batang bawah cucurbit (Cucurbita pepo, labu, dan biji labu) dan menerapkan zeolit pada tiga konsentrasi (0, 20, dan 40 g per tanaman) di bawah dua tingkat irigasi (penuh dan setengah) untuk mengidentifikasi kondisi pertumbuhan yang optimal.* ***Hasil:*** *Percobaan yang disusun dalam Rancangan Acak Kelompok (RAL) faktorial ini mengungkapkan bahwa pencangkokan dan penambahan zeolit secara signifikan memperbaiki sifat vegetatif seperti jumlah daun, panjang cabang, dan jumlah cabang, terutama pada kondisi kekurangan air. Kinerja terbaik diamati dengan pencangkokan labu dan 40 g zeolit pada kondisi irigasi yang dikurangi, menghasilkan peningkatan yang signifikan pada panjang, lebar, dan jumlah cabang daun.* ***Hal baru:*** *Penelitian ini secara unik menggabungkan pencangkokan*

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dengan aplikasi zeolit pada kondisi kekurangan air, yang menunjukkan bahwa semangka yang dicangkokkan pada batang bawah tertentu, ketika ditambah dengan zeolit, dapat mempertahankan pertumbuhan dan hasil meskipun irigasi dikurangi. ***Implikasi:*** *Temuan ini menunjukkan bahwa penggunaan zeolit dan pencangkokan pada batang bawah yang tahan terhadap stres dapat memungkinkan penggunaan air yang lebih efisien dalam budidaya semangka, yang mendorong praktik pertanian berkelanjutan di wilayah dengan keterbatasan air.*

Kata Kunci – *Pencangkokan semangka, Batang bawah labu, Aplikasi zeolit, Stres air, Peningkatan hasil*

I. INTRODUCTION

Watermelon is a vegetable crop belonging to the Cucurbitaceae family, which is important from an economic and nutritional point of view, as its fruits contain carbohydrates, especially sugars, which have a significant impact on the quality of the fruits, in addition to fibers and mineral salts such as calcium and iron. It also contains the pigments lycopene and carotene [9]. Every 100 g of watermelon fruits contain 93% water, 6.4 g carbohydrates, 590 IU of vitamin A, and 7200-2300 lycopene, which is higher than that found in tomatoes [14]. Therefore, the main means to overcome the problems of soil degradation and soil-borne diseases is to graft desired shoots onto resistant rootstocks [11] .

The Central Statistical Organization of the Ministry of Planning issues its annual report on estimates of secondary crops and vegetables production by governorate for the year 2022, as the production of table sorghum reached (440) thousand tons, an increase of 16.4% over the production of 2021, which was estimated at 378 thousand tons, and it comes in second place for secondary crops after jet in Iraq. The cultivated and productive area of sorghum is 94,932 dunums, and the average productivity of the cultivated and produced area is 4636.5 kg dunum-1, and the production is 440,149 tons. Recently, many techniques have been widely used to enhance drought tolerance and nutrient absorption, and grafting preserves plants using the scion and rootstock from water shortages and water stress [13]. As for Iraq, the grafting technique did not take its sufficient share of agricultural applications in vegetable crops due to its exposure to many problems such as the decline in the cultivated area and low productivity per unit area [1]. Soils, especially sandy and sedimentary soils in Iraq, suffer from weak physical properties, which leads to a decrease in crop productivity due to the deterioration of soil fertility. Recently, the use of minerals for agricultural purposes has increased widely, as the mineral zeolite has helped preserve nutrients in the soil and provide a high moisture content in the soil. The mineral zeolite is characterized by a high ability to retain nutrients and water, as it provides plants with nutrients gradually. This mineral contributes to raising the readiness of essential nutrients in crop growth [2] and [8].

Zeolite was used to reduce nitrogen volatility and increase the soil's ability to retain ready water. Agricultural producers need to adopt agricultural technologies that increase both the productivity of limited water resources and crop productivity due to water crisis. Both scarcity and waste bring problems of soil erosion, increased soil salinity [3].

This study aims to:

1. To know the compatibility of grafting squash on squash and pumpkin rootstocks as well as imported seed squash and the effect of this process on the vegetative characteristics of squash.
2. To study the effect of zeolite mineral, water stress, and their interaction in improving some water characteristics of squash crop leaves, soil fertility characteristics, and their effect on the growth of Watermelon plants in the soil.

II. METHODS

The field experiment was carried out in one of the farms of Diyala Governorate, Al-Khalis District - Al-Azim Sub-district for the agricultural season 2022. To study the effect of grafting the watermelon of some gourds on growth characteristics and yield using zeolite under water stress conditions, where the grafting of the Japanese variety (Yaqut) was used on the watermelon of three types of gourds (honey pumpkin, seed pumpkin, zucchini pumpkin) in addition to the comparison variety of the rootstock as the first factor and the second factor is adding zeolite to the soil near the plant at a depth of 10 cm at three levels (0, 20, 40) g seedling-1 and two levels of water stress (full irrigation 100% and 50% of full irrigation). The field soil was analyzed by taking samples from several areas of the field before planting and at a depth of 0-30 cm Physical and chemical analyses were conducted in the laboratory of the Department of Soil Sciences and Water Resources (Table 1), where the first experiment was planting in plastic dishes. After the plants reached the required level for grafting, the squash was grafted as a graft on three cucurbit plants (zucchini squash, honey squash, seed squash for grafting), then the seedlings were planted in the permanent field after the plant reached the fusion.

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Table 1. Some physical and chemical properties of the soil of the experimental field before planting.

Attribute	Value	Unit of Measurement
$pH_{1:1}$	7.32	—
$EC_{1:1}$	2.7	dSm^{-1}
N	13.4	ppm
K	157.21	ppm
Clay	124	$g\ kg^{-1}$
Silt	192.5	$g\ kg^{-1}$
Sand	691.5	$g\ kg^{-1}$
Field capacity	%	%23
Soil texture	Loamy sand	

Experimental treatments

Three factors were used in the experiment:

The first factor was grafting the scion onto the rootstocks, there were four treatments:

1. The Watermelon plant without grafting (V1) (control treatment), 1000 seeds of the Yaqoot F1 variety of Japanese origin and 90% purity were planted.
2. Grafting the Watermelon onto zucchini (V2), 200 seeds of the Noor hybrid variety were planted, imported to Iraq by the Lebanese company Bluefield of Dutch origin and 99% purity.
3. Grafting the Watermelon onto honey gourd (V3), 200 seeds of honey gourd were planted, and they were local seeds.
4. Grafting the Watermelon onto imported seeded gourd (V4), 200 seeds of the (Nun 9075 RT F1) variety of Chinese origin were planted and the purity was 99%.

The second factor was adding zeolite, which was added at three levels:

1. without adding (0): Control treatment
2. Adding 20 g seedling-1 was added to the soil near the plant at a depth of 10 cm.
3. Adding 40 g plant-1 was added to the soil near the plant at a depth of 10 cm.

The third factor was water stress and it was at two levels:

1. The first level of irrigation is 100%, which is the full irrigation that was calculated based on fixing the time in each irrigation.
2. The second level of irrigation is 50% of the first level and is estimated at half the time needed by the first level.

Experimental design, statistical analysis and field cultivation

A factorial experiment was carried out according to the Split–Split Plot Design with three replicates to study the effect of grafting on the watermelon of some gourds in terms of growth characteristics and yield using zeolite under water stress conditions. The first factor was placed in the main plots or panels, the zeolite treatments in the secondary plots or panels, and the water stress treatments in the sub-plots or panels, to produce 24 experimental units in each sector, and the number of replicates was three, so the number of experimental units in the experiment was 72 experimental units. The seedlings were planted in the field at a distance of 50 cm between one seedling and another in lines, and distance between one line and another was 4 m, where irrigation was done by drip irrigation, and each experimental unit included 10 plants, and agricultural service operations were carried out for the seedlings, including weeding, hoeing, irrigation, fertilization, and pest control. The significance of the differences between the averages was tested according to Duncan's Multiple Range Test at a probability level of 0.05.

The apical grafting process was carried out by taking the two seedlings of the watermelon (scion) and the squash (stock) and cutting the scion stem, i.e. by cutting the growing tip of the scion with the two upper leaves and placing the cut stem of the scion with the stem of the squash after cutting the growing tip of the squash, i.e. when cutting and removing the vegetative growth of the stock and pinching the grafting area with a plastic clip, especially the grafted seedlings were taken and placed in a dark plastic basin under controlled conditions of temperature and humidity as mentioned above and the seedlings were irrigated by dipping the root area from below with water containing fungicides to prevent fungal growth. After a week, the seedlings were transferred to a low tunnel with an artificial heating source and a thermometer to monitor the temperatures. After the successful fusion and good growth of the squash scions, the seedlings ready for planting were taken and the grafting clips were removed two weeks after planting the seedlings in the field.

Studied Traits

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Vegetative Characteristics

1. Number of leaves (leaf of plant-1): 5 plants were taken randomly in the experimental unit and the number of leaves of each plant was calculated by counting all the leaves of the plant except the very small ones.
2. Length of leaves (cm): 5 plants were taken randomly in the experimental unit and 5 leaves from each plant and the length of the leaf (cm) was measured using a plastic ruler to measure the length of the leaf and the average was extracted.
3. Width of leaves (cm): The same leaves in which the length of the leaf was measured were taken and their width was measured in the same way.
4. Length of the main branch m: 5 plants were taken randomly in the experimental unit and the length of the main branch was measured using a plastic ruler.
5. Number of main branches: 5 plants were taken randomly in the experimental unit and the number of main branches of the main branch of each plant was calculated by counting all the main branches except the very small ones.
6. Number of secondary branches: 5 plants were randomly taken in the experimental unit and the number of secondary branches of the main branch of each plant was calculated by counting all secondary branches except the very small ones.

III. RESULT AND DISCUSSION

Effect of grafting, zeolite and water stress on vegetative growth characteristics

1. Average number of leaves of the watermelon (leaf plant-1)

   The results of Table 2 show a significant effect on the number of leaves for the watermelon plants. As for grafting, the honey gourd treatment plants excelled by giving the highest value in the number of leaves, as it reached 336.4375 leaves per plant-1, compared to the rest of the treatments, and the lowest in the comparison treatment, as it reached 179.5882 leaves per plant-1. A significant effect is also evident in the superiority of the plants treated with zeolite by adding 40 gm by giving the highest value in the number of leaves, as it reached 302.4783 leaves per plant-1, compared to the plants of the comparison treatment, which gave the lowest value in the number of leaves for the watermelon plant, as it reached 240.7727 leaves per plant-1. The superiority of the plants treated with 100% full irrigation was recorded by giving the highest value in number of leaves, as it reached 281.0830 leaves per plant-1, compared to the plants treated with half full irrigation, which gave lowest value in the number of leaves, as it reached 263.2778 leaves per plant-1.

   The results of Table 2 show that two-way interactions between grafting and zeolite had a significant effect, as plants of the grafting treatment of honey gourd with the addition of 40 g plant-1 of zeolite gave the highest value in the number of leaves, reaching 380.6000 leaves, and lowest value in the number of leaves, 168.2000 leaves plant-1 in comparison treatment. The results of Table 2 also show a significant effect of the three interactions between grafting, zeolite, and water consumption in the number of leaves, as the highest value was recorded for the plants of the grafting treatment of honey gourd with addition of 40 g plant-1 of zeolite and half irrigation, reaching 381.0000 leaves plant-1, compared to the rest of the treatments and the comparison treatment, and the lowest value in the number of leaves in the comparison treatment and without adding zeolite and half full irrigation was 155.3333 leaves plant-1.

Table 2 Effect of grafting, zeolite, water stress and their interaction on number of leaves (leaf plant-1)

Water stress	Zeolite	Grafting				Water stress and zeolite interaction	Water stress average	Zeolite average
		compare watermelon	zucchini	Honey	Seedy			
% 100	0	187.5000i	288.3333def	328.5000cb	226.6667h	257.7000d		
	20	187.3333i	313.0000cd	356.6667ab	244.6667gh	275.4167c		
	40	193.6667i	383.3333a	380.3333a	298.6667de	314.0000a		
% 50	0	155.3333j	275.3333ef	243.3333gh	232.6667h	226.6667b		

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	20	167.0000ij	316.6667cd	341.0000bc	246.6667gh	267.8333bc		
	40	189.3333i	355.6667a	381.0000a	264.0000fg	289.9091b		
	Interaction of Water Stress and Grafting							
Water stress	%100	189.7500d	328.2222b	168.2000a	256.6667c		281.083A	
	% 50	170.5556e	315.8889b	314.3750b	247.7778c		263.2778 B	
Interaction of Zeolite and Grafting								
Zeolite	0	168.2000g	281.8333d	277.4000d	229.6667e			240.7727 C
	20	177.1667fg	314.8333c	348.8333b	245.6667e			271.6250 B
	40	191.5000f	369.5000a	380.6000a	281.3333d			302.4783 A
Grafting average		179.5882 D	322.0556B	336.4375 A	252.2222C			

*Means with different letters are significantly different at 0.05 probability level.

2. Average leaf length of the watermelon plant (cm):
The results of Table 3 show a significant effect on the length of the leaves of the watermelon plants. As for grafting, the honey grafting treatment plants excelled by giving the highest value in the length of the leaves, which reached 20.1250 cm, compared to the rest of the treatments, and the lowest in the comparison treatment, which reached 15.6471 cm. A significant effect is also evident in the superiority of the plants treated with zeolite by adding 40 g plant-1 by giving the highest value in the length of the leaves, which reached 21.0000 cm, compared to the plants of the comparison treatment, which gave the lowest value in the length of the leaves of the watermelon plant, which reached 15.8636 cm. The superiority of the plants treated with 100% full irrigation was recorded by giving the highest value in the length of the leaves, which reached 19.0556 cm, compared to the plants treated with half full irrigation, which gave the lowest value in the length of the leaves, which reached 18.0556 cm. It is also clear from the results of Table 3 that the bilateral interactions between grafting and zeolite had a significant effect, as the plants treated with zeolite by adding 40 g plant-1 and grafting honey gourd gave the highest value in leaf length, reaching 24.8000 cm, and the lowest value in leaf length in the comparison treatment of squash and adding 40 g zeolite, reaching 15.1667 cm.
The results of Table 3 show a significant effect of the three interactions between grafting, zeolite and water stress on leaf length, as the highest value was recorded for the plants of the grafting treatment of honey gourd and the addition of zeolite 40 g plant-1 and half full irrigation, as it reached 25.5000 cm, compared to the rest of the treatments and the comparison treatment of grafting and the addition of zeolite 40 g plant-1 and half full irrigation, and the lowest value in leaf length was 13.3333 cm per leaf.

Table 3 Effect of grafting, zeolite, water stress and interaction on leaf length (cm)

Water stress	Zeolite	Grafting				Water stress and zeolite interaction	Water stress average	Zeolite average
		compare watermelon	zucchini	Honey	Seedy			
100 %	0	14.0000hi	14.6667ghi	15.5000fghi	15.3333fghi	14.9000 c		
	20	16.6667defghi	21.0000abcdefg	20.3333abcdefgh	21.3333abcdef	19.8333 ab		
	40	17.0000defghi	24.6667ab	24.3333abc	22.6667abcd	22.1667 a		
% 50	0	16.3333defghi	17.0000defghi	16.6667defghi	16.6667defghi	16.6667 c		

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	20	16.0000efghi	18.3333cdefghi	18.6667bcdefghi	17.6667defghi	17.6667bc		
	40	13.3333i	22.3333abcde	25.5000a	19.6667abcdefghi	19.7273ab		
	Interaction of Water Stress and Grafting							
Water stress	100 %	16.1250bc	20.1111a	20.6250a	19.7778a		19.0556A	
	% 50	15.2222c	19.2222ab	19.6250a	18.0000abc		18.0556A	
Interaction of Zeolite and Grafting								
Zeolite	0	15.4000cd	15.8333cd	16.2000cd	16.2000cd			15.8636C
	20	16.3333cd	19.6667bc	19.5000bcd	19.5000bcd			18.7500B
	40	15.1667d	23.5000ab	24.8000a	21.1667ab			21.0000A
Grafting average		15.6471B	19.6667A	20.1250A	18.8889A			

*Means with different letters are significantly different at 0.05 probability level.

3. Average leaf width of a watermelon plant (cm)

The results of Table 4 show a significant effect on the leaf width of the watermelon plants. As for grafting, the watermelon grafting treatment plants outperformed the honey gourd by giving the highest value in leaf width, which reached 14.5625 cm per leaf, compared to the rest of the treatments, and the lowest in the comparison treatment, which reached 10.3529 cm per leaf. A significant effect is also evident in the superiority of the plants treated with zeolite by adding 40 g plant-1 giving the highest value in leaf width, which reached 15.3043 leaves, compared to the plants of the comparison treatment, which gave the lowest value in leaf width for the watermelon plant, which reached 10.3636 cm per leaf. The superiority of the plants treated with 100% full irrigation was recorded by giving the highest value in leaf width, which reached 13.2778 cm per leaf, compared to the plants treated with half-full irrigation, which gave the lowest value in leaf width, which reached 12.7778 cm per leaf.

The results of Table 4 also show that the bilateral interactions between grafting and zeolite have a significant effect, as the plants of the grafting treatment on honey gourd and the addition of 40 gm of zeolite gave the highest value in leaf width, reaching 19.2000 cm per leaf, and the lowest value in leaf width was 10.0000 cm in the comparison treatment of grafting and the addition of 40 gm plant-1 of zeolite. The results of Table 4 also show that there is a significant effect of the triple interactions between grafting, zeolite and water stress on leaf width, as the highest value was recorded for the plants of the grafting treatment on honey gourd and the addition of 40 gm plant-1 of zeolite and half full irrigation, reaching 21.0000 cm per leaf, compared to the rest of the treatments and the comparison treatment of grafting and the addition of 40 gm plant-1 of zeolite and half full irrigation, and the lowest value in leaf width was 12.7778 cm per leaf.

Table 4 Effect of grafting, zeolite, water stress and their interaction on leaf width (cm)

Water stress	Zeolite	Grafting				Water stress and zeolite interaction	Water stress average	Zeolite average
		compare watermelon	zucchini	Honey	Seedy			
% 100	0	8.5000	9.3333e	9.5000de	9.6667de	9.3000d		
	20	11.0000cde	15.6667abcd	14.6667bcde	15.6667abcd	14.2500ab		
	40	11.3333cde	18.0000ab	18.0000ab	16.6667abc	16.0000a		
% 50	0	11.0000cde	11.6667cde	11.3333cde	11.0000cde	11.2500cd		

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	20	11.0000cde	12.6667bcde	13.3333bcde	12.6667bcde	12.4167bc		
	40	8.6667e	16.3333abc	21.0000a	14.3333bcde	14.5455ab		
	Interaction of Water Stress and Grafting							
Water stress	%100	10.5000bc	14.3333a	14.6250a	14.0000a		13.2778 A	
	% 50	10.2222c	13.5556ab	14.5000a	12.6667abc		12.7778 A	
Interaction of Zeolite and Grafting								
Zeolite	0	10.0000c	10.5000c	10.6000c	10.3333c			10.3636 C
	20	11.0000c	14.1667bc	14.0000bc	14.1667bc			13.3333 B
	40	10.0000c	17.1667ab	19.2000a	15.5000ab			15.3043 A
Grafting average		10.3529B	13.9444A	14.5625A	13.3333A			

*Means with different letters are significantly different at 0.05 probability level.

4. Average length of the main branch of the watermelon plant (cm)

The results of Table 5 show that there is a significant effect on the length of the main branch of the watermelon plants. As for grafting, the watermelon grafting treatment plants outperformed the seeded squash by giving the highest value in the length of the main branch, which reached 4228.8889 cm, compared to the rest of the treatments, and the lowest in the comparison treatment, which reached 2807.6471 cm. A significant effect is also evident in the superiority of the plants treated with zeolite by adding 40 g plant-1 of zeolite by giving the highest value in the length of the main branch, which reached 4168.2609 cm, compared to the plants of the comparison treatment, which gave the lowest value in the length of the main branch of the watermelon plant, which reached 3160.4545 cm. The superiority of the plants treated with 100% full irrigation was recorded by giving the highest value in the length of main branch, which reached 3773.8889 cm, compared to plants treated with half water consumption, which gave lowest value in length of the main branch.

The results of Table 5 also show that there is a significant effect of the two-way interactions between grafting and zeolite, as the plants of the grafting treatment on seeded watermelon and the addition of 40 g plant-1 of zeolite gave the highest value in the length of the main branch, reaching 4876.6667 cm, and the lowest value in the length of the main branch, 2442.0000 cm in the comparison treatment. The results of Table 5 also show that there is a significant effect of the three-way interactions between grafting, zeolite and water stress on the length of the main branch, as the highest value was recorded for the plants of the grafting treatment on seeded squash and the addition of 40 g plant-1 of zeolite and full irrigation, reaching 5073.3333 cm, compared to the rest of the treatments and the comparison treatment and full irrigation, and lowest value in the length of main branch was 2400.0000 cm for the plants.

Table 5 Effect of grafting, zeolite, water stress and their interaction on Main branch length (cm)

Water stress	Zeolite	Grafting				Water stress and zeolite interaction	Water stress average	Zeolite average
		compare watermelon	zucchini	Honey	Seedy			
100 %	0	2400.0000 n	2966.6667lm	3025.0000lm	3500.0000ijk	3025.0000e		
	20	3263.3333 jkl	3986.6667defgh	4183.3333 def	4406.6667bcd	3960.0000b		
	40	3173.3333 kl	4373.3333bcde	4760.0000ab	5073.3333a	4345.0000a		
% 50	0	2470.0000 n	3416.6667jkl	3550.0000 hijk	3656.6667ghij	3273.3333d		

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	20	2690.0000 mn	3920.0000efghi	3883.3333fghi	4056.6667defg	3637.5000c		
	40	2713.3333 mn	4246.6667cdef	4405.0000 bcd	4680.0000abc	3975.4545b		
	Interaction of Water Stress and Grafting							
Water stress	100 %	3013.7500 d	3775.5556c	4110.0000ab	4326.6667a		3773.8889A	
	% 50	2624.4444 e	3861.1111c	3888.7500 bc	4131.1111ab		3643.3333A	
Interaction of Zeolite and Grafting								
Zeolite	0	2442.0000 g	3191.6667ef	3340.0000 de	3578.3333d			3160.4545C
	20	2976.6667 f	3953.3333c	4033.3333 bc	4231.6667bc			3798.7500B
	40	2976.6667 f	4310.0000b	4618.0000a	4876.6667a			4168.2609A
Grafting average		2807.6471 D	3818.3333C	3999.3750 B	4228.8889 A			

*Means with different letters are significantly different at 0.05 probability level.

5. Average number of main branches of a watermelon plant (branch plant-1)

The results of Table 6 show a significant effect on the number of main branches of the watermelon plants. As for grafting, the watermelon grafting treatment plants outperformed the honey gourd by giving the highest value in the number of main branches, which reached 15.4375 branches, compared to the rest of the treatments, and the lowest in the comparison treatment, which reached 13.5294 branches plant-1. A significant effect is also evident in the superiority of the treatment plants by adding 40 g plant-1 of zeolite by giving the highest value in the number of main branches, which reached 16.4348 branches plant-1, compared to the comparison treatment plants, which gave the lowest value in the number of main branches of the watermelon plant. The superiority of the plants treated with halffull irrigation 100% was recorded by giving the highest value in the number of main branches, which reached 15.0278 branches plant-1, compared to the plants treated with full irrigation, which gave the lowest value in the number of main branches.

The results of Table 6 also show that the two-way interactions between grafting and zeolite have a significant effect, as the plants of the grafting treatment on honey gourd and the addition of 40 g plant-1 of zeolite gave the highest value in the number of main branches, reaching 16.8000 branches plant-1 and the lowest value in the number of main branches, 10.0000 branches plant-1 in the grafting treatment of zucchini squash and without adding zeolite. The results of Table 6 also show that there is a significant effect of the three interactions between grafting, zeolite and water stress on the number of main branches, as the highest value was recorded for the plants of the grafting treatment on zucchini squash and the addition of 40 g plant-1 of zeolite and full irrigation, reaching 17.6667 branches plant-1, compared to the rest of treatments and the comparison treatment of grafting, zeolite and full irrigation, and the lowest value in the number of main branches was 7.5000 branches plant-1.

Table 6 Effect of grafting, zeolite, water stress and their interaction on number of main branches (branch plant-1)

Water stress	Zeolite	Grafting				Water stress and zeolite interaction	Water stress average	Zeolite average
		compare watermelon	zucchini	Honey	Seedy			
% 100	0	7.5000f	7.6667f	16.6667ab	9.6667f	9.4000d		
	20	12.6667de	15.0000abcde	15.6667abcd	13.5000bcde	14.2500b		
	40	15.0000abcde	17.6667a	16.6667ab	16.3333abc	16.4167a		
% 50	0	12.6667de	12.3333e	13.3333cde	12.6667de	12.7500c		

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	20	15.3333abcde	16.3333abc	16.3333abc	14.6667abcde	15.6667a		
	40	16.0000abc	17.3333a	17.0000a	15.6667abcd	16.4545a		
	Interaction of Water Stress and Grafting							
Water stress	%100	12.2500c	13.4444bc	15.5000a	13.2222bc		13.3889 A	
	% 50	14.6667ab	15.3333a	15.3750a	14.3333ab		15.0278 B	
Interaction of Zeolite and Grafting								
Zeolite	0	10.6000d	10.0000d	13.4000c	11.1667d			11.2273 C
	20	14.0000bc	14.1667bc	16.0000ab	15.5000ab			14.9583 B
	40	15.6667ab	17.5000a	16.8000a	16.0000ab			16.4348 A
Grafting average		13.5294B	14.3889AB	15.4375A	13.7778B			

*Means with different letters are significantly different at 0.05 probability level.

6. Average number of secondary branches of a watermelon plant (branch plant -1):
The results of Table 7 show that there is a significant effect on the number of secondary branches of the watermelon plants. As for grafting, the watermelon grafting treatment plants outperformed the honey gourd by giving the highest value in the number of secondary branches, which reached 30.1875 branches/plant-1, compared to the rest of the treatments, although the lowest in the comparison treatment. A significant effect is also evident in the superiority of the plants treated with zeolite by adding 40 g/plant-1 of zeolite, giving the highest value in the number of secondary branches, which reached 32.0435 branches, compared to the plants in the comparison treatment, which gave the lowest value in the number of secondary branches of the watermelon plant. The superiority of the plants treated with 100% full irrigation was recorded by giving the highest value in the number of secondary branches, which reached 30.1667 leaves, compared to the plants treated with half-full irrigation, which gave the lowest value in the number of secondary branches.
The results of Table 7 also show that the bilateral interactions between grafting and zeolite have a significant effect, as the plants of the treatment of grafting on zucchini squash and adding 40 g plant-1 of zeolite gave the highest value in the number of secondary branches, as it reached 35.0000 branches plant-1 and the lowest value in the number of secondary branches, as it reached 23.4000 branches plant-1 in comparison treatment.
The results of Table 7 also show that there is a significant effect of triple interactions between grafting, zeolite and water stress on the number of secondary branches, as the highest value was recorded for the plants of the treatment of grafting on zucchini squash and adding 40 g plant-1 of zeolite and full irrigation, as it reached 39.3333 branches plant-1, compared to the rest of treatments and the treatment of grafting on seeded squash and the comparison of zeolite and full irrigation, and lowest value in the number of secondary branches was 21.3333 branches plant-1.

Table 7 Effect of grafting, zeolite, water stress and their interaction on Number of secondary branches (branch Plant-1)

Water stress	Zeolite	Grafting				Water stress and zeolite interaction	Water stress average	Zeolite average
		compare watermelon	zucchini	Honey	Seedy			
100 %	0	23.0000kl	25.3333hijkl	25.0000ghijkl	21.3333l	23.7000 e		
	20	26.0000fghijk	34.3333bc	32.6667bcd	34.0000bc	31.7500 b		

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	40	30.3333cdef	39.3333a	36.6667ab	33.6667bc	35.0000a		
% 50	0	23.6667jkl	26.0000fghijk	26.3333efghijk	22.6667kl	24.6667de		
	20	25.0000hijkl	24.3333hljk	28.3333defghi	28.0000efghij	26.4167d		
	40	26.0000fghijk	30.6667cde	30.0000cdefg	29.0000defgh	28.8182c		
	Interaction of Water Stress and Grafting							
Water stress	%100	26.8750cd	33.0000a	32.3750a	29.6667b		30.1667A	
	% 50	24.8889d	27.0000cd	28.0000bc	26.5556cd		26.8056B	
Interaction of Zeolite and Grafting								
Zeolite	0	23.4000fg	25.6667ef	26.0000ef	22.0000g			24.2273C
	20	25.5000ef	29.3333cd	30.5000cd	31.0000bc			29.0833B
	40	28.1667de	35.0000a	34.0000ab	31.3333bc			32.0435A
Grafting average		25.8235C	30.0000A	30.1875A	28.1111B			

*Means with different letters are significantly different at 0.05 probability level.

Discussion:

The results in the previous tables showed some significant differences and other significant effects, as the grafting of the watermelon was superior to the squash and zucchini in most of the characteristics. As for the addition of zeolite 20 and 40 g plant-1, it was the highest among the other treatments. As for the full irrigation, the values of many of the studied characteristics were the highest. As for the binary interactions, the interaction of the grafting of the rose with the addition of 40 g plant-1 of zeolite for the most affected characteristic, and the interaction of the grafting of the rose with half the water consumption was the highest. As for the interaction between the additions of 40 g plant-1 of zeolite with the full water consumption, it was the highest value. As for the triple interactions, the highest values were the treatments of the grafting of the rose with the addition of 40 g plant-1 of zeolite and the full water consumption among the other treatments.

Grafting significantly affected plant growth positively when compared to nongrafted ones, as there was a significant difference between grafted plants compared to other rootstocks, and no adverse effects on fruit quality as fruit index, peel thickness, and TDS content were identified on grafted plants. These results showed that the use of grafting can be a useful alternative in watermelon production [7]. Grafted plants improve plant growth and productivity without any adverse effects on fruit quality. The positive effects of grafting can vary according to rootstock used. [6] observed that grafting Minirossa cultivar, N uptake increased by 20% compared to non-grafted plants due to the strength and spread of root system of used rootstocks, which is responsible for increasing the plant's efficiency in absorbing water and nutrients from the soil more than the roots scion plant. [10] indicated that adding zeolite to soil increases the availability of many nutrients, and thus zeolite prevents precipitation or fixation of elements because the cation exchange capacity is in an increased state. The ion exchange power of zeolite is 2 to 3 times greater than the minerals contained in the soil. [5] used zeolite to increase the soil's ability to hold water, which increased the holding of nutrients and made water more readily available for plant roots to absorb. Zeolite mixed with soil led to increased plant growth as well as increased seed productivity and dry matter of plant to improve absorption efficiency of nutrients and improve all soil properties [4]. As for water stress which results in a deficiency in the water that the plant needs in a way that affects its normal growth. Stress begins when the available water is depleted from the root zone until the water stress of the plant equals the water stress of the soil, at which point the plant cannot absorb water and reaches the point of permanent wilting. The stress resulting from drought also affects the quality of the fruits of grafted rose plants. Total dissolved solids greatly affected by grafting graft and irrigation rate, as measurable acidity is higher in grafted plants than in non-grafted plants [12].

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CONCLUSION

In light of the research results that emerged from the main stages of the experiment, can conclude the following:

1. We conclude the success of the grafting process on the studied watermelon (zucchini, local honey squash, seed squash).
2. Grafting led to an improvement in vegetative growth and grafting can effectively mitigate the negative effects of environmental stress on graft production. The tolerance of abiotic stress of grafted plants is facilitated by modifications in the deeper and wider root characteristics.
3. Zeolite is an effective and stimulating material for absorption processes, as it has a high capacity for ion exchange and high selectivity for molecules and ions, and has a high moisture retention capacity and ability to absorb, and has distinctive and unique chemical, fertility and physical properties and a high cation exchange capacity. The use of zeolite leads to water use efficiency by increasing the soil's water retention capacity and improves the readiness of soil elements.
4. Increasing the irrigation level from 50 to 100% of the crop's evaporation transpiration improved most of the vegetative growth characteristics, the percentage of flower set, the yield and its components, except for the characteristics of the percentage of dry matter in the vegetative group, early maturity, average fruit weight, most of the qualitative characteristics of the fruits, and water use efficiency, which improved with reducing the irrigation level to half. Reducing the irrigation level to half do not negatively affect the vegetative growth

RECOMMENDATION

1. The need to determine the effect of grafting on vegetative growth in order to recommend maturity indicators to improve the quality of grafted watermelon fruits. The higher cost of growing grafted squash is one of the main factors limiting adoption in areas with medium and large production. Grafted seedlings should be available at a reasonable cost to both the breeder and the farmer.
2. Recent developments in grafting squash using the apical grafting method, where the growing apices are removed, significantly reduce the time required for grafting and the use of the machine. Grafting machines require less time for grafting than required, which reduces the cost of producing grafted seedlings.
3. Adding other amounts and depths of zeolite.
4. The possibility of using water stress to improve most of the qualitative characteristics of fruits in the desired direction, such as early ripening, TSS percentage, and increasing fruit firmness. The program for determining water requirements and scheduling irrigation has an effective impact on estimating the water requirements of agricultural crops.

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