

A study of grafting four watermelon(*Citrulus lanatus* L.) cultivars onto three pumpkin rootstocks and its effect on vegetative traits

دراسة تطعيم أربعة أصناف من البطيخ الأحمر (*Citrulus lanatus* L.) في ثلاثة أصول من

القرع وتأثيره في الصفات الخضرية

Ibrahim Al- Shtawi* Abboud Al-Jasim** Manhal ali***

*Professor, Department of Horticulture, Al-Furat University, Syria

**Assistant Professor, Department of Horticulture, Al-Furat University, Syria

***PhD Student, Department of Horticulture, Al-Furat University, Syria

Abstract

This research was conducted to study the effect of grafting three squash rootstocks onto four watermelon cultivars and their impact on vegetative traits. Four watermelon cultivars (Raad, Elita, Nevada, and Slyn Black) were grafted using the side grafting method onto three squash rootstocks belonging to the genus Cucurbita (Zag, Speder, and Sasha), in addition to an un-grafted control. The research was conducted in Hasaka Governorate (Hasaka City) for the 2024-2025 seasons.

The research was conducted according to a split-block design with three replicates, and the averages of each genotype of the watermelon plant were compared separately. Watermelon seeds were planted in 2024/2025, while squash seeds were planted on 2/17/2024. The side grafting process was carried out on 2/27/2024. The results showed the following: The rootstock (Zag) outperformed the rest of the rootstocks (Speder Sasha), and the control without grafting, in all Morphology traits: Plant height (cm.plant-1), number of leaves on the plant (leaf.plant-1), number of main branches (branch.plant-1), leaf area (cm².plant-1), fruit length (cm.fruit-1), fruit diameter (cm.fruit-1), number of marketable fruits (fruit.plant-1), total number of fruits (fruit.plant-1).

The results indicated no significant differences between the grafts used (Raad, Elita, Nevada, Shelian Black), and they all outperformed the control plant without grafting (Control).

Keywords: Graft, rootstock, grafting, watermelon, squash.

1. Introduction:

Watermelon (*Citrullus lanatus* L.) is considered one of the important vegetable crops belonging to the Cucurbitaceae family, which includes 90 genera and more than 750 species. It is a significant summer crop both economically and nutritionally. Its fruits contain carbohydrates, especially sugars that greatly influence fruit quality, in addition to fibers and mineral salts such as calcium and iron. It also contains the pigments lycopene and carotene (Al-Rukabi et al., 1981; Matloob et al., 1989). Every 100 grams of watermelon fruit contains 93% water, 6.4 grams of carbohydrates, 590 International Units of vitamin A, and 2,300–7,200 micrograms of lycopene, which is higher than that found in tomatoes (Wehner, 2008).

Watermelon fruits are widely consumed worldwide compared to other cucurbit species (Robenson et al., 1997).

Several American studies have indicated that watermelon is beneficial for the heart, not only improving arterial health but also acting as a nerve relaxant, reducing stress and anxiety, alleviating stomach spasms, and preventing intestinal sluggishness (Anonymous, 2005).

Watermelon is low in calories, approximately 30 calories per 100 grams, making it a popular choice for people seeking to maintain their weight. This is attributed to its high water content, which promotes satiety and hydrates the body. Lycopene, a powerful antioxidant present in watermelon, plays a vital role in preventing certain chronic diseases such as cardiovascular diseases and cancers, mainly due to its antioxidant effect on cells (Edwards et al., 2003). Furthermore, some studies suggest that lycopene may help reduce skin inflammation and improve skin health, especially when exposed to sunlight (Rao & Agarwal, 2000).

Watermelon fruits are considered soothing and refreshing in hot climates and reduce thirst due to their high water content. They also act as a stimulant, moisturizer, digestive aid, and mild laxative. Moreover, they help purify the blood and dissolve kidney stones. The seeds have medical importance as they contain essential oils and amino acids and are used externally to treat eczema (Haraz, 2012).

Studies conducted on various watermelon cultivars revealed that they contain considerable amounts of fats and proteins rich in amino acids (Ma et al., 1990).

Watermelon varieties differ in fruit shape, external and internal color, rind thickness, maturity time, and cultivar characteristics. They also vary in their adaptability to the environmental conditions of the production area (Hassan, 2001).

Watermelon cultivation has been widespread since ancient times, with Africa considered its original habitat where it grew wild (Ware and McCollum, 1968).

Watermelon is a high-yield crop in the markets, providing substantial financial returns for farmers due to high demand during summer, both locally and for export. It is suitable for cultivation in hot, dry climates, such as in some Arab countries, making it a strategic crop.

The development of new cultivars with improved flavor and enhanced transport and storage tolerance has expanded its cultivation and export (Nerson, 2002).

Vegetable propagation by grafting is a horticultural practice used since ancient times in East Asia and later introduced to Europe, North America, and various countries worldwide. This technique relies on natural plant parts, making it a form of clean agriculture, which has led to its wide adoption in extensive fields across many countries for various crops (Kubota et al., 2008). Grafting can improve resistance to soil-borne pathogens, significantly enhance water and nutrient uptake efficiency, increase yield quantity and quality, and prolong the production season (Hang et al., 2005). This technique is applied to various vegetables such as red and yellow watermelon, cucumber, and solanaceous crops by grafting onto rootstocks of different species and genera, due to its significant effects on vegetative growth, productivity, and the plants' ability to absorb essential nutrients (Davis et al., 2008). Grafting in watermelon plants has been widely implemented worldwide mainly to avoid fungal diseases. Available studies have shown a strong positive response in vegetative growth indicators, quantitative yield traits, and fruit quality.

2.Objectives and Significance of the Study:

.21. Significance of the Study:

This deterioration is attributed to several reasons, including water scarcity, soil salinity, reduction of arable land, and the spread of soil-borne pathogens such as *Fusarium* and *Verticillium* fungi. Watermelon plants suffer from weak resistance to these pathogens, for instance they attack the roots during fruit formation, increasing economic losses. This necessitates finding solutions to these problems, with environmentally friendly approaches being the best option, such as grafting watermelon plants onto squash rootstocks. This is because pumpkin and squash roots have tolerated soil-borne pathogens, especially *Fusarium*, *Verticillium*, *Phytophthora*, and root-knot nematodes, which are primary diseases affecting watermelon crops (Davis et al., 2008).

On the other hand, FAO statistics (2012) confirmed an increase in the cultivated area and total production of squash, which may indicate to squash's ability to withstand obstacles that watermelon plants cannot endure. Therefore, using these plants as rootstocks in grafting will optimize irrigation water use and reduce the use of chemical fertilizers and fungicides that cause many health, environmental problems, and reduce economic costs.

Given the nutritional importance of watermelon as a crop, its nutritional value, and its widespread cultivation in large areas of Syria, along with the spread of many diseases—especially soil-borne fungal diseases in eastern regions where watermelon is grown—and the ineffectiveness of many pesticides on soil diseases, recent agricultural research has focused on developing tolerant varieties that maintain an adequate income level for producers. This has led to the adoption of vegetable grafting techniques onto resistant rootstocks to overcome these problems.

2.2. Objectives of the Study:

Study of the effect of origin on the morphological traits of the fruit (plant height, number of leaves, number of main branches, leaf area, fruit length, fruit diameter, number of marketable fruits, total number of fruits).

3. Materials and Methods:

3.1. Study Area:

The study was conducted in Al-Hasakah Governorate on a plot of land supplied with well water suitable for agriculture, located at latitude 36.5°N and longitude 40.75°E, at an elevation of 305 meters above sea level, with an average annual rainfall of 275 mm.

3.2. Environmental Characteristics of the Research Site:

3.2.1. Climate: Table (1) shows the average temperatures and rainfall amounts during the growing seasons in the field for the years 2024-2025.

| Month | First Season 2024 | | | Second Season 2025 | | |
|-------|-----------------------------|-----------------------------|------------------------------------|-----------------------------|-----------------------------|------------------------------------|
| | Average Minimum Temperature | Average Minimum Temperature | Monthly Rainfall Amount (mm/month) | Average Minimum Temperature | Average Minimum Temperature | Monthly Rainfall Amount (mm/month) |
| Feb | 4 | 13 | 40 | 5 | 13 | 50 |
| Mar | 7 | 18 | 30 | 7 | 17 | 40 |
| Apr | 11 | 23 | 48 | 11 | 23 | 30 |
| May | 16 | 30 | 18 | 15 | 29 | 15 |
| Jun | 21 | 37 | 0 | 20 | 35 | 2.5 |
| Jul | 24 | 40 | 0 | 23 | 39 | 0 |

Source: (Al-Hasakah Meteorological Station 2024-2025)

The climatic data for temperatures are suitable for watermelon cultivation, but the rainfall amount is insufficient, so irrigation was applied using drip irrigation as needed according to temperature increases.

3.2.2. Soil: Mechanical and chemical Results, with results recorded in Table (2):

| Characteristics | pH | E.C | Physical properties% | | | Chemical properties ppm | | | g/100g soil | |
|-----------------|-----|------|----------------------|------|------|-------------------------|-------------------------------|-----|-------------------|----------------|
| | | | Sand | Silt | Clay | N | P ₂ O ₅ | K | CaCO ₃ | Organic matter |
| First Season | 7.8 | 2.29 | 44 | 20 | 36 | 10.5 | 7.8 | 320 | 32 | 0.33 |
| Second Season | 7.4 | 2.41 | 41 | 22 | 34 | 9.5 | 7.1 | 295 | 29 | 0.38 |

It was confirmed that from Table (2) that the soil texture is sandy-clay according to the soil texture triangle, with clay content ranging between 34-36%, silt between 20-22%, and sand between 41-44%. The soil pH ranged between 7.4 and 7.8 for the two seasons. Chemical analysis showed total nitrogen ranging from 9.5 to 10.5 ppm, phosphorus (P₂O₅) between 7.1 and 7.8 ppm, and potassium between 295 and 320 ppm for the two agricultural seasons.

3.3. Experimental Material

3.3.1. Grafts

3.3.1.1. Origin and Characteristics of 'Raad' Red Watermelon:

Different of Syrian origin, developed and produced in Syria to suit the region's climate and soil conditions. This variety is distinguished by its high quality and its ability to adapt to Climate changes environments, making it well-suited for cultivation in the Middle East and North Africa.

3.3.1.2. Origin and Characteristics of 'Elita' Red Watermelon:

Different of Dutch origin, developed in the Netherlands using modern breeding techniques to enhance its qualities in terms of taste, size, and resilience.

3.3.1.3. Origin and Characteristics of 'Nevada' Red Watermelon:

An American variety, developed in the United States to meet market demands for taste, s
w

3.3.1.4. Origin and Characteristics of 'Shelian Black' Red Watermelon:

A Chinese variety, developed in China using specialized breeding techniques to enhance its shape, color, and taste.

3.3.2. Rootstocks

3.3.2.1. Origin and Characteristics of Rootstock 'Zag:'

Of Japanese origin, developed in Japan to be used as a rootstock for grafting watermelon and melon crops. This rootstock is notable for its high resistance to diseases and harsh environmental conditions, making it a popular choice among farmers seeking to improve watermelon quality and increase yield.

3.3.2.2. Origin and Characteristics of Rootstock 'Speder:'

The 'Speder' squash rootstock is of Dutch origin, developed in the Netherlands for use in grafting watermelon and melon crops.

3.3.2.3. Origin and Characteristics of Rootstock 'Sasha:'

The 'Sasha' squash rootstock is also of Dutch origin, developed in the Netherlands for use in grafting watermelon and melon crops.

3.4. Experimental Layout: Land Dimensions:

c
o
n
s
u
m

| | | | |
|------------------------------------|-------|-------|-------|
| AD1R1 | BD1R1 | CD1R1 | D1R1 |
| AD2R1 | BD2R1 | CD2R1 | D2R1 |
| AD3R1 | BD3R1 | CD3R1 | D3R1 |
| AD4R1 | BD4R1 | CD4R1 | D4R1 |
| Service corridor between repeaters | | | |
| D2R2 | AD2R2 | BD2R2 | CD2R2 |
| D1R2 | AD1R2 | BD1R2 | CD1R2 |
| D4R2 | AD4R2 | BD3R2 | CD4R2 |
| D3R2 | AD3R2 | BD4R2 | CD3R2 |
| Service corridor between repeaters | | | |
| CD4R3 | D4R3 | AD4R3 | BD4R3 |
| CD2R3 | D2R3 | AD2R3 | BD2R3 |
| CD1R3 | D1R3 | AD1R3 | BD1R3 |
| CD3R3 | D3R3 | AD3R3 | BD3R3 |

Length of cultivated land: The distance between plants is 1 meter, and service paths are 2 meters wide, resulting in a total length of 128 meters.

Width of cultivated land: The width includes 1.5 meters from the base, and the distance between the edge of one bed and the next is 1 meter, so the width equals 13 meters.

Thus, the total cultivated area is: 1664 m².

3.5. Land Preparation for Cultivation:

The designated plot was first cleared of previous crop residues. A primary tillage was performed to a depth of 35 cm. Then, 25 tons/hectare of decomposed organic manure (cow dung) was added. In addition, chemical fertilizers were applied based on soil analysis results and the fertilizer recommendation by the Ministry of Agriculture and Agrarian Reform, as follows: Potassium sulfate (50%) at a rate of 30 kg/ha. Triple superphosphate (46%) at a rate of 20 kg/ha, applied entirely after deep tillage and before land leveling and bed formation. Nitrogen, in the form of urea (46%), was applied at a rate of 25 kg/ha, divided into three doses: 30% during land preparation, 30% three weeks after planting, and the remaining amount at the beginning of fruit formation.

3.6. Research Methodology:

The experiment was carried out in a greenhouse specialized for producing grafted seedlings. Styrofoam trays with 50 cells were used. Sterilized peat moss was added to the trays as the growing medium. Red watermelon and pumpkin seed were sown on 25 March, April 2024, respectively, various care operations were conducted. Once the seedlings developed four true leaves, tongue grafting was performed. This involved making a slanted incision on both scion and rootstock using a sterilized blade, then joining them together using plastic clips.

The grafted seedlings were then transferred to empty trays, planted alternately to accommodate the larger leaf area of the scion. Routine care continued. Once grafting was successful: The root system of the scion below the grafting point was removed, leaving the foliage. The shoot system of the rootstock above the grafting point was removed.

When the seedlings reached a suitable size for transplantation, they were moved to open field conditions and transplanted on May 1, 2024. The field was well-prepared, leveled, and arranged into beds: Bed base width: 1.5 meters Top width: 1 meter

Grafted and control watermelon plants were planted at 1-meter spacing within rows, and 2-meter spacing between rows, with 3-meter-wide service paths between replicates. Drip irrigation lines were installed accordingly. The plants were monitored until full maturity, and data were collected thereafter.

3.7. Studied Parameters:

1.3.7. Plant height (cm.plant-1):

The height of the plant stem was measured periodically during its various growth stages. The young plant was only a few centimeters tall, and its height increased until the length of the creeping stems reached several meters when fully grown. The measurement was taken from the base of the plant to the tip of the tallest stem. According to research, the height of the watermelon plant can reach about 3-4 meters when fully grown, and in some cases, it can reach 5 meters depending on the variety and growing conditions (Johnson et al., 2010).

2.3.7. Number of leaves (leaf. Plant-1):

A group of homogeneous plants was chosen based on age and health condition. Ten plants were selected to increase the accuracy of the measurement, and the leaves on each plant in the sample were counted manually, excluding dead or damaged leaves. The average number of leaves was then calculated by dividing the total number of leaves by the number of plants measured using the following formula: Average number of leaves = Total number of leaves / Number of plants. The measurements were repeated at different times during the growth stages to obtain more comprehensive data (Crawford, 2015).

3.3.7. Number of main branches (Plant branch-1):

(10) watermelon plants were selected from the field to ensure good representation and to obtain an accurate average, then the main branches of each plant were counted. The main branch is considered to be the one that grows directly from the main stem of the plant. The branches from all samples were collected and divided by the number of plants that were counted. The observations and data were documented in a table to facilitate later analysis. (kader et al, 2011).

4.3.7. Leaf area (cm².plant-1):

The leaf area can be calculated as follows: Leaf area = dry weight of the leaf × 130A constant factor for calculating the leaf area of the watermelon: 130 cm² .gram-1.

5.3.7. Length of the fruit (cm.Fruit-1):

Place the watermelon on a flat surface, use a measuring tape to measure the length of the watermelon from the bottom end to the top end, ensuring that the tape is closely aligned with the surface of the watermelon and the measurement is done straight. The measurement is recorded in centimeters. The circumference of the watermelon was also measured to determine the volume, where the measuring tape was used to measure the circumference around the widest point of the watermelon. (United States Department of Agriculture USDA).

6.3.7. Fruit diameter (cm. Fruit-1):

A measuring tape (meter) was used to measure the width of the watermelon from the wider side in centimeters, ensuring that the tape passes through the center. Then, use the following formula to calculate the diameter: $\text{Diameter} = \text{Circumference} / \pi$. A constant value approximately equal to 3.14 (USDA).

7.3.7. The number of marketable fruits (fruit.plant-1):

The number of marketable red watermelon fruits per plant was counted manually, excluding infected, small, and deformed fruits (Hochmuth et al, 2007).

8.3.7. Total fruit number (fruit.plant-1):

The total number of fruits was calculated from the following formula: $\text{Total number of fruits} = \text{Number of flowers} / \text{Fertilization rate}$ (Khan et al, 2016).

3.8..Experimental Design:

Main plots (rootstocks): T1: Zag, T2: Speder, T3: Sasha, T4: Control (ungrafted)

Sub-plots (scions): L1: Raad variety, L2: Elita variety, L3: Nevada variety, L4: Chilian Black variety.

| repeaters | Split plots | T ₁ | T ₂ | T ₃ | T ₄ |
|-----------|----------------|--|--|--|--|
| R1 | L ₁ | L ₁ T ₁ R ₁ | L ₁ T ₂ R ₁ | L ₁ T ₃ R ₁ | L ₁ T ₄ R ₁ |
| | L ₂ | L ₂ T ₁ R ₁ | L ₂ T ₂ R ₁ | L ₂ T ₃ R ₁ | L ₂ T ₄ R ₁ |
| | L ₃ | L ₃ T ₁ R ₁ | L ₃ T ₂ R ₁ | L ₃ T ₃ R ₁ | L ₃ T ₄ R ₁ |
| | L ₄ | L ₄ T ₁ R ₁ | L ₄ T ₂ R ₁ | L ₄ T ₃ R ₁ | L ₄ T ₄ R ₁ |
| R2 | L ₁ | L ₁ T ₁ R ₂ | L ₁ T ₂ R ₂ | L ₁ T ₃ R ₂ | L ₁ T ₄ R ₂ |
| | L ₂ | L ₂ T ₁ R ₂ | L ₂ T ₂ R ₂ | L ₂ T ₃ R ₂ | L ₂ T ₄ R ₂ |
| | L ₃ | L ₃ T ₁ R ₂ | L ₃ T ₂ R ₂ | L ₃ T ₃ R ₂ | L ₃ T ₄ R ₂ |
| | L ₄ | L ₄ T ₁ R ₂ | L ₄ T ₂ R ₂ | L ₄ T ₃ R ₂ | L ₄ T ₄ R ₂ |
| R3 | L ₁ | L ₁ T ₁ R ₃ | L ₁ T ₂ R ₃ | L ₁ T ₃ R ₃ | L ₁ T ₄ R ₃ |
| | L ₂ | L ₂ T ₁ R ₃ | L ₂ T ₂ R ₃ | L ₂ T ₃ R ₃ | L ₂ T ₄ R ₃ |
| | L ₃ | L ₃ T ₁ R ₃ | L ₃ T ₂ R ₃ | L ₃ T ₃ R ₃ | L ₃ T ₄ R ₃ |
| | L ₄ | L ₄ T ₁ R ₃ | L ₄ T ₂ R ₃ | L ₄ T ₃ R ₃ | L ₄ T ₄ R ₃ |

Figure(1) Experimental diagram

4. Results and Discussion:

4.1. The effect of watermelon inoculation on squash in plant height (cm.plant-1) for the agricultural seasons 2024-2025:

Table. (3) Average plant height (cm.plant-1) for the agricultural seasons 2024-2025.

| Plant height (cm.plant-1) | | | | | |
|---------------------------|-------------|-----------|----------|------------|--------|
| Split plots | T1= Zag | T2=Speder | T3=Sasha | T4=Control | Mean |
| L1= Raad | 169 | 144 | 130 | 118 | 140.25 |
| L2= Elyta | 174 | 148 | 142 | 124 | 147.00 |
| L3= Nevada | 175 | 149 | 143 | 129 | 148.92 |
| L4= Shilian Black | 182 | 149 | 146 | 136 | 153.17 |
| Mean | 175.08 | 147.42 | 140.17 | 126.67 | |
| LSD0.05 | rootstock | 1.888 | | | |
| | Graft | 2.180 | | | |
| | interaction | 3.776 | | | |

Table (3)The results shows illustrates the superiority of the first treatment (T1=Zag) over the other treatments in terms of average plant height (cm. plant-1) with an average plant height of (170.08 cm. plant-1), while the lowest average plant height was recorded for the treatment (T4=Control) at an average of (125.50 cm. plant-1).

The table (3) also shows the superiority of the second treatment (L4=Shalian Black) over the remaining treatments with an average plant height of (156.58 cm. plant-1), while the lowest average plant height was recorded for the treatment (L1=Raad) at an average plant height of (146.50 cm. plant-1).

It was evident from the table that the first treatment (T1=Zag) is superior when interacting with the second treatment (L4=Shalian Black), recording a plant height of (177 cm. plant-1), whereas the lowest plant height for the interaction was recorded for the first treatment (T4=Control) with the second treatment (L1=Raad), at a plant height of (118 cm. plant-1).

4.2. The effect of watermelon vaccination on squash in the number of leaves (leaf.plant-1) for the agricultural seasons 2024-2025:

Table. (4) Average number of leaves (leaf.plant-1) for the 2024-2025 agricultural seasons

| Number of leaves (Leaf. Plant-1) | | | | | |
|----------------------------------|-------------|-----------|----------|------------|-------|
| Split plots | T1= Zag | T2=Speder | T3=Sasha | T4=Control | Mean |
| L1= Raad | 34 | 30 | 33 | 20 | 29.25 |
| L2= Elyta | 35 | 33 | 32 | 22 | 30.33 |
| L3= Nevada | 38 | 33 | 32 | 18 | 30.42 |
| L4= Shilian Black | 43 | 35 | 35 | 17 | 32.42 |
| Mean | 37.42 | 32.58 | 33.00 | 19.42 | |
| LSD0.05 | rootstock | 1.731 | | | |
| | Graft | 1.998 | | | |
| | interaction | 3.461 | | | |

Table (4)The results shows the superiority of the first factor (T1=Zag) over the other treatments in terms of the average number of leaves (leaves.plant-1), where it recorded an average of (42.83 leaves.plant-1), while the treatment (T4=Control) recorded the lowest average number of leaves at (19.42 leaves.plant-1).

Table (4) also indicates the superiority of the second factor (L2=Elita) over the other treatments with an average number of leaves (35.42 leaves.plant-1), while the treatment (L1= Raad) recorded the lowest average number of leaves at (31.42 leaves.plant-1).

It is evident from the table that the first factor (T1=Zag) was superior when interacting with the second factor (L3=Nevada), recording a number of leaves (44 leaves.plant-1), while the lowest number of leaves was recorded in the interaction of the first factor (T4=Control) with the second factor (L1= Raad), recording (20 leaves.plant-1).

4.3. The effect of watermelon vaccination on the squash in the number of main branches (branch. plant-1) for the agricultural seasons 2024-2025:

Table. (5) Average number of main branches (branch. plant-1) for the agricultural seasons 2024-2025

| Number of main branches (Branch. Plant-1) | | | | | |
|---|-------------|-----------|----------|------------|------|
| Split plots | T1= Zag | T2=Speder | T3=Sasha | T4=Control | Mean |
| L1= Raad | 6 | 4 | 3 | 3 | 3.92 |
| L2= Elyta | 5 | 3 | 3 | 3 | 3.75 |
| L3= Nevada | 5 | 3 | 4 | 3 | 3.67 |
| L4= Shilian Black | 6 | 5 | 5 | 3 | 4.58 |
| Mean | 5.42 | 3.92 | 3.75 | 2.83 | |
| LSD0.05 | Rootstock | 0.493 | | | |
| | Graft | 0.569 | | | |
| | interaction | 0.986 | | | |

Table (5)The results shows the superiority of the first factor (T1=Zag) over the other treatments in the average number of main branches (branch. plant-1), recording an average of (5.42 branch. plant-1), while the lowest average number of main branches was recorded for the treatment (T4=Control) with an average of (2.83 branch. plant-1).

The table (5) also indicates the superiority of the second factor (L4=Shillan Black) over the other treatments with an average number of main branches (4.58 branch. plant-1), while the lowest average for the treatment (L3=Nevada) was (3.67 branch. plant-1).

It is clear from the table that the first factor (T1=Zag) is superior when interacting with the second factor (L4=Shillan Black), recording a number of main branches (6 branch. plant-1), while the lowest number of branches in the interaction of the first factor (T4=Control) with the second factor (L2=Elita) recorded a plant height of (3 branch. plant-1).

4.4. Effect of watermelon vaccination on squash in leaf area (m².plant-1) for the 2024-2025 agricultural seasons:

Table. (6) Average paper area (m². plant-1) for the agricultural seasons 2024-2025

| Paper area (m ² .plant-1) | | | | | |
|--------------------------------------|-------------|-----------|----------|------------|--------|
| Split plots | T1= Zag | T2=Speder | T3=Sasha | T4=Control | Mean |
| L1= Raad | 255.33 | 244.67 | 244.67 | 193.00 | 234.42 |
| L2= Elyta | 264.00 | 244.00 | 229.00 | 174.67 | 227.92 |
| L3= Nevada | 261.67 | 241.67 | 226.67 | 171.67 | 225.42 |
| L4= Shilian Black | 282.33 | 262.33 | 247.33 | 194.33 | 246.58 |
| Mean | 265.83 | 248.17 | 236.92 | 183.42 | |
| LSD0.05 | Rootstock | 0.030 | | | |
| | Graft | 0.035 | | | |
| | Interaction | 0.061 | | | |

Table (6)The results shows the superiority of the first factor (T1=Zag) over the other treatments in terms of average leaf area (m².plant-1), with an average leaf area of (265.83 m².plant-1), while the lowest average leaf area was recorded for the treatment (T4=Control) with an average of (183.42 m².plant-1).

The table(6) also indicates the superiority of the second factor (L4=Shilean Black) over the other treatments, with an average of (246.58 m².plant-1), while the lowest average leaf area was recorded for the treatment (L3=Nevada) with an average of (225.42 m².plant-1). It is clear from the table that the first factor (T1=Zag) showed superiority when interacting with the second factor (L4=Shilean Black), recording a leaf area of (282.33 m².plant-1), while the lowest leaf area was recorded in the interaction of the first factor (T4=Control) with the second factor (L3=Nevada) recording a leaf area of (171.67 m².plant-1).

4.5. The effect of watermelon vaccination on squash in fruit length (cm .fruit-1) for the agricultural seasons 2024-2025:

Table. (7) Average fruit length (cm. fruit-1) for the agricultural seasons 2024-2025.

| Fruit length (cm. fruit-1) | | | | | |
|----------------------------|-------------|-----------|----------|------------|-------|
| Split plots | T1= Zag | T2=Speder | T3=Sasha | T4=Control | Mean |
| L1= Raad | 34.67 | 26.67 | 24.00 | 21.33 | 26.67 |
| L2= Elyta | 34.00 | 24.33 | 24.00 | 15.67 | 24.50 |
| L3= Nevada | 34.00 | 25.00 | 25.33 | 17.00 | 25.33 |
| L4= Shilian Black | 43.33 | 30.67 | 29.00 | 21.00 | 31.00 |
| Mean | 36.50 | 26.67 | 25.58 | 18.75 | |
| LSD0.05 | Rootstock | 1.420 | | | |
| | Graft | 1.640 | | | |
| | interaction | 2.840 | | | |

Table (7)The results shows the superiority of the first factor (T1=Zag) over the other treatments in average fruit length, with an average fruit length of (36.50 cm. fruit-1), while the lowest average fruit length was recorded for the treatment (T4=Control) at an average of (18.75 cm. fruit-1).

The table (7) also indicates the superiority of the second factor (L4=Shallyan Black) over the other treatments with an average of (31.00 cm. fruit-1), while the lowest average fruit length was recorded for the treatment (L2=Elyta) with an average of (24.50 cm. fruit-1).

It is clear from the table that the first factor (T1=Zag) shows greater height when interacting with the second factor (L4=Shallyan Black), recording a fruit length of (43.33 cm. fruit-1), while the lowest fruit length was observed in the interaction of the first factor (T4=Control) with the second factor (L2=Elyta), recording a fruit length of (15.67 cm. fruit-1).

4.6. The effect of watermelon vaccination on the fruit diameter (cm.fruit-1) for the agricultural seasons 2024-2025:

Table .(8) Average Fruit Diameter (cm. fruit-1) for the agricultural seasons 2024-2025.

| The fruit's diameter (cm. Fruit-1) | | | | | |
|------------------------------------|-------------|-----------|----------|------------|-------|
| Split plots | T1= Zag | T2=Speder | T3=Sasha | T4=Control | Mean |
| L ₁ = Raad | 23.67 | 21.00 | 20.33 | 16.33 | 20.33 |
| L ₂ = Elyta | 28.33 | 20.00 | 18.67 | 13.67 | 20.17 |
| L ₃ = Nevada | 26.67 | 19.67 | 19.00 | 13.67 | 19.75 |
| L ₄ = Shillian Black | 30.00 | 25.33 | 24.00 | 17.00 | 24.08 |
| Mean | 27.17 | 21.50 | 20.50 | 15.17 | |
| LSD _{0.05} | rootstock | 1.239 | | | |
| | Graft | 1.430 | | | |
| | interaction | 2.477 | | | |

Table (8)The results shows the superiority of the first factor (T1=Zag) over the other treatments in the average fruit diameter, recording an average fruit diameter of (27.17 cm.fruit-1), while the lowest average for the fruit diameter was recorded for the treatment (T4=Control) with an average of (15.17 cm.fruit-1).

The table (8) also indicates the superiority of the second factor (L4=Shillian Black) over the other treatments with an average of (24.08 cm .fruit-1), while the lowest average for the fruit diameter was recorded for the treatment (L3=Elita) with an average of (19.75 cm.fruit-1).

It is clear from the table that the first factor (T1=Zag) surpassed when interacting with the second factor (L4=Shillian Black), recording a fruit diameter of (30.00 cm .fruit-1), while the smallest fruit diameter occurred in the interaction of the first factor (T4=Control) with the second factor (L2=Elita), recording a fruit diameter of (13.67 cm .fruit-1).

4.7. The effect of watermelon vaccination on squash in the number of commercial fruits (fruit.plant-1) for the agricultural seasons 2024-2025:

Table. (9) Average number of marketable fruits (fruit.plant-1) for the agricultural seasons 2024-2025

| Number of marketable fruits (fruit.plant-1) | | | | | |
|---|---------------------|------------------------|-----------------------|-------------------------|------|
| Split plots | T ₁ =Zag | T ₂ =Speder | T ₃ =Sasha | T ₄ =Control | Mean |
| L ₁ = Raad | 2.67 | 2.33 | 3.00 | 1.67 | 2.42 |
| L ₂ = Elyta | 2.67 | 2.67 | 2.33 | 1.67 | 2.33 |
| L ₃ = Nevada | 3.00 | 2.33 | 2.33 | 1.00 | 2.17 |
| L ₄ = Shilian Black | 4.00 | 2.33 | 3.67 | 2.00 | 3.00 |
| Mean | 3.08 | 2.42 | 2.83 | 1.58 | |
| LSD _{0.05} | rootstock | 0.425 | | | |
| | Graft | 0.490 | | | |
| | interaction | 0.850 | | | |

Table (9)The results shows the superiority of the first treatment (T₁=Zag) over the other treatments in the average number of marketable fruits (fruits.plant-1), recording an average of (3.08 fruits.plant-1), while the lowest average for the number of fruits was recorded for treatment (T₄=Control) with an average of (1.58 fruits.plant-1).

The table(9) also indicates the superiority of the second treatment (L₄=Shilean Black) over the other treatments with an average of (3.00 fruits.plant-1), while the lowest average for the number of fruits was recorded for treatment (L₃=Nevada) with an average of (2.17 fruits.plant-1).

It is evident from the table that the first treatment (T₁=Zag) excels when interacting with the second treatment (L₄=Shilean Black) recording a number of fruits (4.00 fruits.plant-1), while the lowest number of fruits in the interaction of the first treatment (T₄=Control) with the second treatment (L₃=Nevada) recorded a number of fruits (1.00 fruits.plant-1).

4.8. The effect of watermelon grafting on squash in the total number of fruits (fruit.plant-1) for the agricultural seasons 2024-2025:

Table. (10) Average number of total fruits (fruit.plant-1) for the agricultural seasons 2024-2025

| Number of marketable fruits (fruit.plant ⁻¹) | | | | | |
|--|---------------------|------------------------|-----------------------|-------------------------|------|
| Split plots | T ₁ =Zag | T ₂ =Speder | T ₃ =Sasha | T ₄ =Control | Mean |
| L ₁ = Raad | 4.33 | 3.00 | 4.00 | 4.33 | 3.92 |
| L ₂ = Elyta | 5.33 | 4.67 | 4.33 | 4.33 | 4.67 |
| L ₃ = Nevada | 5.33 | 4.33 | 4.00 | 3.00 | 4.17 |
| L ₄ = Shilian Black | 6.67 | 5.00 | 5.67 | 5.00 | 5.58 |
| Mean | 5.42 | 4.25 | 4.50 | 4.17 | |
| LSD _{0.05} | rootstock | 0.531 | | | |
| | Graft | 0.613 | | | |
| | interaction | 1.062 | | | |

Table (10)The results shows the superiority of the first factor (T₁=Zag) over the other treatments in the average total number of fruits (fruits.plant-1), with an average of (5.42 fruits.plant-1), while the lowest average number of fruits was recorded for the treatment (T₄=Control) with an average of (4.17 fruits.plant-1).

Table (10) also indicates the superiority of the second factor (L₄=Shillan Black) over the other treatments with an average of (5.58 fruits.plant-1), and the lowest average number of fruits recorded was for the treatment (L₁=Raad) with an average of (3.92 fruits.plant-1). It is evident from the table that the first factor (T₁=Zag) excels when interacting with the second factor (L₄=Shillan Black), recording a number of fruits (6.67 fruits.plant-1), while the lowest number of fruits in the interaction of the first factor (T₄=Control) with the second factor (L₃=Nevada) recorded a number of fruits (3.00 fruits.plant-1).

5. Conclusions and Recommendations:

5.1. Conclusions:

1. The original (Zag) excelled over the other varieties (Speder, Sasha, Control) in all morphological traits: plant height (cm.plant-1), number of leaves (leaf.plant-1), number of main branches (branch.plant-1), leaf area (cm².plant-1), fruit length (cm.fruit-1), fruit diameter (cm.fruit-1), number of marketable fruits (fruit.plant-1), total number of fruits (fruit.plant-1).
2. No differences appeared between the graft types used (Raed, Elita, Nevada, Shilian Black), and all of them surpassed the control plant without grafting.

5.2. Recommendations:

1. It is recommended to use the technique of grafting watermelon onto squash rootstocks due to its significant impact on the grafted plants in terms of improving the morphological characteristics of the scion.
2. It is advisable to use the squash rootstock Zag for its superiority over other squash rootstocks in all morphological traits.

6. References:

6.1. Arabic References:

- Al-Rikabi**, Fakher Ibrahim & Abdul-Jabbar Jassim. (1981). Vegetable Production for Institute Students. Technical Institutes Foundation, Republic of Iraq.
- Harraz**, A. (2012). "A Study on the Effect of Grafting on the Growth and Productivity of Watermelon Plants." *Journal of Agricultural Sciences*, 5(2), 101–106.
- Hassan**, Ahmed Abdel-Moneim. (2001). Cucurbits: Production Technology and Advanced Agricultural Practices. Arab Publishing and Distribution House, Cairo. 97 pages.
- Crawford**, B. (2018). Vegetable Plants: Cultivation and Production. University of Plant Agriculture.

6.2. Foreign References:

- Anonymous** (2005) , National Nutrient Data Base For Standard Reference Release , USDA.
- Davis, A. R., et al. (2008). "Rootstock selection for watermelon." *HortScience*, 43(1), 29-34.
- Edwards, A. J., Vinyard, B. T., Wiley, E. R., Brown, E. D., Collins, J. K., Perkins-Veazie, P., ... & Clevidence, B. A. (2003). Consumption of watermelon juice increases plasma concentrations of lycopene and β -carotene in humans. *The Journal of Nutrition*, 133(4), 1043-1050.
- Hang, S.D., Zhao.Y.P., Wang G.Y and Song G.Y. 2005. Vegetable grafting, Beijing, China:China agriculture press.
- Hochmuth, G. J. Maynard, D. N., (2007). *Knott's Handbook for Vegetable Growers*. John Wiley & Sons.
- Johnson, D., et al. (2010). *The Cultivation of Watermelon*. Horticultural Science.
- Kader, A. A., Kader, A. (2011). "Postharvest Technology of Horticultural Crops". University of California.
- Khan, M. A., Shafique, U. (2016). "Influence of different factors on fruit setting in watermelon." *Journal of Horticulture*.
- Kubota, C. 2008: Use of grafted seedlings for vegetable production in North America, *Acta Hort. (ISHS)*, 770: 21-28.
- Ma, K, Xp. Zhang , M. Wang (1990). Nutrients in seeds of edible watermelon Cucurbit Genetics Cooperative Report 13:43-44.
- Nerson, H. (2002). Effects of plant density and seed size on yield and fruit maturity in muskmelon (*Cucumis melo* L.). *Scientia Horticulturae*, 93(1), 137-148.
- Rao, A. V., Agarwal, S. (2000). Role of antioxidant lycopene in cancer and heart disease. *Journal of the American College of Nutrition*, 19(5), 563-569.
- Robenson, R. W. and D. S. DeckerWalters. 1997. Cucurbits. CAB International, Wallingford U.K. pp. 102-106.
- Ware, G. W., McCollum, R. E. (1968). "Effect of grafting on growth and yield of watermelon." *Horticultural Science*, 3(3), 194-196.
- Waseem, M., et al. (2016). "Yield and Quality Assessment of Watermelon (*Citrullus lanatus*) as Influenced by Different Fertilization and Irrigation Regimes." *Journal of Horticultural Science & Ornamental Plants*.

دراسة تطعيم أربعة أصناف من البطيخ الأحمر (*Citrulus lanatus* L.) في ثلاثة أصول من القرع وتأثيره في الصفات الخضرية

***منهل علي **عبود الجاسم *ابراهيم الشنتوي

*أستاذ في قسم البساتين، كلية الزراعة، جامعة الفرات، سورية

**أستاذ مساعد في قسم البساتين، كلية الزراعة، جامعة الفرات، سورية

***طالب دكتوراه في قسم البساتين، كلية الزراعة، جامعة الفرات، سورية

الملخص

أجري هذا البحث بهدف دراسة تأثير تطعيم ثلاثة أصول من القرع على أربع اصناف من البطيخ الأحمر وتأثيرها في الصفات المورفولوجية. جرى التطعيم بطريقة التطعيم الجانبي لأربع اصناف من البطيخ الأحمر (رعد، ايليتا، نيفادا، شليان بلاك)، على ثلاثة أصول من القرع تتبع للجنس *Cucurbita*: (Zag, Speder, Sasha) بالإضافة إلى الشاهد بدون تطعيم (Control)، نفذ البحث في محافظة الحسكة (مدينة الحسكة) للموسمين 2024-2025. نفذ البحث وفق تصميم القطاعات المنشقة وبثلاثة مكررات وقورنت متوسطات كل تركيب وراثي من نبات البطيخ الأحمر على حدة، زرعت بذور البطيخ الأحمر في 2024\2\5 بينما زرعت بذور القرع في 2024\2\17 وأجريت عملية التطعيم الجانبي في 2024\2\27 وأظهرت النتائج ما يأتي: تفوق الأصل (Zag) على بقية الأصول (Speder, Sasha)، والشاهد بدون تطعيم، في جميع الصفات المورفولوجية: طول النبات (سم. نبات-1)، عدد الأوراق على النبات (ورقة. نبات-1)، عدد الأفرع الرئيسية (فرع. نبات-1)، المساحة الورقية (سم. نبات-1)، طول الثمرة (سم. ثمرة-1)، قطر الثمرة (سم. ثمرة-1)، عدد الثمار التسويقية (ثمرة. نبات-1)، عدد الثمار الكلية (ثمرة. نبات-1). عدم ظهور اختلافات بين الطعوم المستخدمة (رعد، ايليتا، نيفادا، شليان بلاك)، وتفوقها جميعها على النبات الشاهد بدون تطعيم (Control).

الكلمات المفتاحية: الطعم، الاصل، التطعيم، بطيخ احمر، القرع