An-Najah National University

Faculty of Graduated Studies

Performance of Watermelon Grafted onto Different Rootstocks

By

Hashem Derdah Ahmed Ali

Supervisor
Dr. Hassan Abu Qaoud

This Thesis is Submitted in Partial Fulfillment of Requirements for the Degree of Master of Plant Production, Faculty of Graduated Studies, An-Najah National University, Nablus, Palestine.

2012

Performance of Watermelon

Grafted onto Different Rootstocks.

By

Hashem Derdah Ahmed Ali

This thesis was defended successfully on10/4/2012 and approved by:

Committee Members		**Signature**
1- Dr. Hassan Abu Qaoud	**(Supervisor)**	**……………….**
2- Dr. Munqez Shtaya	**(Internal Examiner)**	**……………….**
3- Dr. Abdallah All Omari	**(External Examiner)**	**……………….**

Dedication

I would like to dedicate this page to the committed teachers and good friends that have inspire me during my early years and throughout my life to seek for learning and greater education. To my parents who have given their love, encouragement, and sacrificed time and pleasure to teach me the great value of persistence in hard worthwhile work and study. To my Father who has given me the intelligence, faith, strength and support necessary to succeed. To the professors that have encouraged me along the way and have helped make this dream a reality. I have learned that achieving requires first the desire and then faith to move ahead with vision, dedication, and determination. One must have self confidence, be open-minded, willing to work and endure until the end.

ACKNOWLEDGMENTS

I would like to acknowledge my deepest appreciation into my mother and father, my wife, my kids and everybody for their unwavering support, whom helped me to achieve this work. Especially my advisor Dr. Hassan Abu Qaoud for his supervision, guidance, encouragement, and support throughout the course of this study and for reviewing this theses. The accomplished theses that have taught me along this difficult but rewarding path that have been ever so willing to assist me in the pursuit and fulfillment of this research project. I also thank the Juneidi nursery that contributed to the search and facilities for making this work successful. I also express my appreciation to Dr. Hassan Abu Qaoud for constructive criticism and support in refining the quality of this thesis. And I would like to, specially mention Anwar Foquah is a farmer, cooperation in the field and follow up the work for the success and submit it into existence.

I would like to acknowledge and express my sincere gratitude to the Ministry of Agriculture (MoA), which gave me enough time for the Advancement of Science to serve the dear compatriots national.

I can witness the good in this extraordinary society who continues to reach out to the agricultural community that is so deeply rooted in the North-Aghor of the west bank (Palestine) and its' history.

الإقرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان :

Performance of Watermelon

Grafted onto Different Rootstocks.

أقر بأن ما اشتملت عليه هذه الرسالة إنما هي نتاج جهدي الخاص، باستثناء ما تمت الإشارة إليه حيثما ورد، وأن هذه الرسالة ككل، أو أي جزء منها لم يقدم لنيل أية درجة أو لقب علمي أو بحثي لدى أية مؤسسة تعليمية أو بحثية أخرى .

Declaration

The work provided in this thesis , unless otherwise referenced , is the researcher's own work , and has not been submitted elsewhere for any other degree or qualification.

Student's Name :	**اسم الطالب :**
Signature :	**التوقيع:**
Date:	**التاريخ:**

Table of Contents

List of Table

List of Figure

Performance of Watermelon Grafted onto Different Rootstocks

By
Hashem Derdah Ahmed Ali
Supervisor
Dr. Hassan Abu Qaoud

Abstract

The influence of using different rootstocks on the success of grafting, plant growth, fruit yield and fruit quality of two watermelon cultivars (Crimson Sweet and Jaddoai) was studied. The experiment was conducted in open field (Low tunnel) in Bardalla (Palestinian Northern - Ghor region). The rootstocks used were 'Pumpkin *(Cucurbita moschata)*, Gladioter watermelon*(Citrullus lanatus var. Gladioter)*, Al-kamari squash *(Cucurbita pepo var. melopepo)*, and Ein-senna squash*(Cucurbita maxima)* '. One cotyledon (splice/slant-cut) grafting method was used. In addition to, the above combinations both self grafted and non-grafted of the two cultivars were involved. The seedlings were then hand planted in the field. The combination treatments were arranged as a factorial treatment in a completely randomized design.

The results revealed a high percentage ranged from 90-100% of successful grafting combination for both cultivar scions and rootstocks.

The total fruit yield of grafted plants was significantly higher than that of non-grafted plants onto both rootstock cultivars. The highest total production was obtained when both Pumpkin and Gladioter rootstocks were used (15.1 and 14.2 kg/plant respectively). On the other hand, both

Ein-senna and self-grafted plants resulted in the lowest production (10.4 and 11.3kg/plant respectively).

Grafted plants in both Pumpkin and Gladioter rootstocks were more vigorous than the grafted Ein-senna rootstock ones. Plants grafted onto ‘Pumpkin’ and ‘Gladioter’ produced 8.363 kg/plant and 8.050 kg/plant more vegetative fresh weight than the grafted Ein-senna rootstock and self-grafted (4.263 kg/plant and5.293 kg/plant), respectively, whereas non-grafted (control) plants had a lower vegetative fresh weight in both treatments. Both control and self-rooted plants showed earliness in their production. Grafting improved stem length, number of lateral branches per plant, number of leaves per branch, root length and vegetative fresh and dry weights of stem, leaves and root. Ein-senna was significantly poor for biomass characteristics than the other rootstocks. An increase in brix% in the rind of the fruit was obtained in all grafting combination excepted with Ein-senna rootstock (4.5%), the higher brix value was obtained inside the fruit when Gladioter was used as rootstock(12.5%).

Chapter One

Introduction

1.Introduction

Watermelon *Citrullus lanatus* has been widely cultivated all over the world. It's fruit has been accepted as a delicious fruit. It is a source of liquid containing over 90% water and 10 to 12% total solids including vitamin A, C, B6 and potassium (USDA, 2001). Watermelon Fruits were basic food for people and animals in different countries. Recently, watermelon fruits have become recognized more for their nutritional qualities, it has been reported that the red pigment of watermelon, lycopene, has inhibiting qualities to some forms of cancer (USDA, 2007).

Watermelon constituted 0.12% of total cultivated area of the Palestinian Territories. During the last 30 years, the total area cultivated with watermelon in the West Bank had been reduced from more than 20000 to less than 2000 dunums (PCBS. 2005-2006). Among the main reasons for such reduction was the infection with soil borne diseases. These diseases cause a decrease in yield and quality. There are different ways to prevent soil-borne diseases such as crop rotation, breeding programs, soil fumigant (methyl bromide) (Yetisir and Sari, 2004; Rivero et al., 2003). However, because of the great hazards of such chemicals, Methyl bromide has been banded, other chemicals are not efficient and have negative impact on health and environment.

Another control strategy is using of resistant varieties. It is effective on reducing yield loss, minimizing pesticide use and eliminating ruin problem, even some fruit characteristics may not meet the grower demands. To overcome such problems, the use of seedlings grafted on *Cucurbita* and *Lagenaria* rootstocks, which have an acquired resistance to soil borne diseases, was suggested by several researchers as an environmentally safe alternative to methyl bromide (Miguel *et al.*, 2004; Boughalleb *et al.*, 2008). It was reported that the resistance of grafted plants to *Fusarium* wilt is related to rootstock's resistance (Heo, 1991). Other alternatives including; solarization, biofumigation, grafting, chemicals, steaming, compost application and soilless culture. Among these alternatives, researches were mostly focused on solarization and grafting, and their combination for efficient control and good yield (Yilmaz et al., 2007).

Although alternative pesticides and other physical treatments are being tested and developed, grafting with resistant rootstocks offers one of the best methods to avoid soil-borne diseases. Thus, using grafted rootstocks seems to be an effective solution.

Grafting vegetables is becoming popular; not only to control soil-borne diseases, but also to create a higher tolerance to abiotic soil stresses (Rivero *et al*., 2003). One reason may be that methyl bromide continues to receive critical use exemptions for cucurbit and solanceous crops (King *et al*., 2008). In addition to avoid soil-borne diseases, watermelon grafting onto cucurbit rootstocks is another agronomic interest for plant vigour and production (Aounallah et al., 2002 and Tarchoun et al., 2005). As well as, grafting may enhance tolerance to abiotic stresses, increase yield, and result in more efficient water and nutrient use; extend harvest periods, and improve fruit yield and quality (Oda, 2002a;b; Lee and Oda, 2003; Rivero *et al*., 2003, Hang *et al*., 2005).

In Palestine, watermelon grafting started in 2007 in collaboration between Minisitry of Agriculture (MOA) and Japan International Cooperation Agency (JICA) (MOA, 2008). Several local cucurbitae lines were proposed as good possible rootstocks. There are many landraces of squash, pumpkin, bottle gourd, wax gourd and *Luffa cylindrica* that can be used as rootstocks for watermelon (Yetisir, 2001). However, the compatibility of such rootstocks with watermelon as well as the effect of such rootstocks on disease resistance, production and fruit quality has not yet been studied, therefore, the primary objective of the following research is to evaluate local rootstock for watermelon. In particular to determine the effect of different rootstocks on the production and yield of two watermelon cultivars and to ascertain the effect of local rootstock on fruit quality of two watermelon cultivars.

CHAPTER TWO

LITERATURE REVIEW

2. Literature Review:

2.1. Control management of soil borne disease.

Soil borne pathogens considered as a serious problem in many cultivated area of watermelons in the world, many areas with intense watermelon production as Turkey, China, Korea, Japan, and Palestine have suffered from soil borne pathogens (Yetisir and Sari, 2003; Cohen *et al.*, 2005).

Continuous cropping is inevitable in vegetable production in indoor areas, and therefore, reduces the yield and quality of produce. Most of the damage from continuous cropping is caused by soil-borne diseases and nematodes. It was reported that soil-borne pathogens and pests such as *Verticillium*, *Fusarium* and *Meloidogyne* spp. may cause yield losses of up to 78% in production (Bletsos et al., 2003). Growers in many regions including Palestine have used fumigants such as methyl bromide, to overcome soil borne diseases. Since the ongoing limiting use of fumigants, other techniques were used, watermelons were produced on crop rotation fields once every 5-6 years (Bruton, 1998; Yetisir and Sari, 2003). However crop rotation is not feasible, in addition, inadequate rotation has perhaps contributed the greatest to increased incidence and severity of soil borne diseases. Moreover, soil sterilization can never be completed. Grafting has become an essential technique for the production of repeated crops of fruit-bearing vegetables grown in indoor areas. Nowadays, watermelon grafting has become of greater interest as an alternative to methyl bromide fumigation for disease avoidance (Cohen et al., 2005; Koren and Edelstein, 2004).

Grafting was also combined with other alternatives such as; chemicals, biofumigation, and integration of soil solarization (Morra et al., 2007). The damages brought by *Fusarium* can be reduced with the use of various techniques: grafting of watermelon onto rootstocks of the genera *Cucurbita* or *Lagenaria* (Mondal et al. 1994; Qian et al. 1995; D’amore et al. 1996), applying substrate with higher pH and Fe and Cu contents, mulching the surface of the ground with plastic foil (Sun and Huang, 1985) and by biological control with bacteria or *Aspergillus niger* (Lin et al. 1990; Mukherjee and Sen, 1998). This technique has been also applied in the production of many vegetables. An increase in the yield of tomato, pepper, eggplant, melon and cucumber protected production has been achieved when combining grafting with other protection measures over 30 years, (Yilmaz et al., 2008). Recently, vegetable production by grafting on resistant rootstocks has become a common practice to control soil-borne pathogens, especially for the cultivation of cucumber, melon, watermelon, tomato, pepper and eggplant in greenhouses in many countries. (Lee, 1994; King and Davis, 2006). Grafting vegetable crops have been used extensively in greenhouse and tunnel production as a way to decrease reliance on chemical fumigants (Oda, 1999). The primary reason for grafting of vine crops is to provide protection against soil-borne diseases

(Edelstein et al. 1999; Paplomatas et al. 2002), but some rootstocks have the added advantage of being resistant to nematodes, especially root-knot nematode *Meloidogyne* spp. Additional benefits of grafting include increased yield, increased fruit quality especially flesh firmness, and more vigorous plants that can be grown using lower plant populations (Core, 2005; Yetisir, 2003), grafting of watermelon onto other Cucurbitaceae rootstocks to provide soil-borne disease resistance has been highly successful. With this success and with more discriminating consumers of watermelon fruit comes a second challenge: to produce a high quality fruit from grafted plants that is equal to or better than that of the non-grafted plant (Lee et al., 1998 and Rivero et al., 2004).

Grafted watermelon plants onto wild watermelon rootstocks (*C. lanatus* var. *citroides*) were resistant or moderately resistant to the southern root knot nematode, *M. incognita*. **(**Thies and Levi, 2007**).**

2.2. Cucurbit Grafting:

The first vegetable crops to be grafted date back to the seventeenth century; however, it did not become popular until the late 1920's. Farmers in Korea and Japan grafted watermelon plant onto a gourd rootstock (*Lagenaria siceraria*) to provide resistance to soil borne diseases caused by successive cropping (Ashita, 1927). Research on cucurbit grafting began in the 1920s with the use of *Cucurbita moschata* as a rootstock for watermelon. Initial reports by Tateishi (1927) and Sato and Takamatsu

(1930) described several studies of grafting. Tateishi (1931) reported grafting of watermelon onto *Cucurbita moschata* rootstocks, a technique that was well known at the time. In France, research on cucurbit grafting started in the 1950s, with the grafting of cucumber and melon scion onto figleaf gourd to control fusarium wilt. During the 1960s melon plants were grafted onto *Benincasa* spp (Alabouvette *et al*., 1974). Cucumber grafting in Spain began in the mid-1990s, but is increasing in importance (Hoyos, 2001). In 1998, approximately 95% of watermelon and oriental melons were grafted onto squash or gourd rootstocks in Japan, Korea, and Taiwan (Lee and Oda, 2003).

According to Oda (2004), inter-generic grafting is used in the production of many fruit-bearing vegetables; i.e. cucumber (*Cucumis sativus* L.) grafted on pumpkin (*Cucurbita* spp.), watermelon (*Citrullus lanatus* Matsum et Nakai), on bottle gourd (*Lagenaria siceraria* Standl.), melon (*Cucumis melo* L.) on white gourd (*Benincasa hispida* Cogn.), are popular rootstock for watermelon production. Pumpkins and squash (*Cucurbita* spp.) are important crops and are grown in almost all arable regions of the world.

2.3. Effect of grafting on plant behavior:

Grafting is a routine technique in continuous cropping systems. Use of rootstocks can enhance whole plant biotic stress responses. However, the type of rootstock affects scion growth, yield, and fruit quality (King et al., 2010). In general, grafting vegetable plants onto resistant rootstocks is an effective tool that may enable the susceptible scion to control soil-borne diseases, environmental stresses and increase yield. However, these characteristics might be affected by grafting possible quality characteristics could be fruit appearance (size, shape, color, and absence of defects and decay), firmness, texture, and flavor (sugar, acids, and aroma volatiles) (Rouphael et al., 2010).

Different reports were published on the effect of grafting on plant growth and production of the scion. The effect of the rootstocks on plant growth, fruit yield and quality of watermelon cv. Crimson Tide grafted into different rootstocks were studied. Grafting resulted in higher yield by increasing in both fruit number and weight, however, no detrimental effect on fruit quality such as fruit index, rind thickness, and soluble solid contents on grafted plants was observed (Alan et al., 2007).

A study by Edelstein *et al*. (2004) showed that number of leaves, stem length, and fresh weight of melon plants increased using 22 different *Cucurbita* spp. rootstocks. It was demonstrated that rootstocks affect the number of nodes and lateral branches, and that the vigor of grafted watermelon plants was improved when grafted onto a gourd rootstock. They further showed that grafting did not affect length, circumference, or diameter of fruit, but decreased weight of the fruit, suggesting the fruit were less dense.

The interspecific hybrid rootstock, 'Shintosa' *[Cucurbita maxima* (Duchense ex. Lam.) x *C. ,noschata],* is resistant to *Fusarium* wilt but is almost never used for melon because it causes reduced fruit quality, including low sugar content, alcoholic fermentation, and fibrous flesh (Muramatsu, 1981). Yamasaki et al. (1994) reported that grafting watermelon *[Citrulus Lanatus* (Thunh.) Matsum and Nakai] to interspecific hybrid squash caused more vigorous growth and resulted in firmer flesh than plants grafted to bottle gourd *[Lageoaria siceraria* (Molina) Standl.] rootstock and non-grafted watermelon controls. In the same study, grafting to both squash and bottle gourd decreased Brix value.

The average yield of melon and watermelon plants grafted on different Cucurbita hybrids (*C. maxima* x *C. moschata*) as rootstocks were much more higher than the yields of the non-grafted plants: The yield increase was 44 % and 84 % for melon and watermelon respectively (Besri, 2008). Recent research has shown that rootstocks induce few changes in the nutritional status of the scion.

In another study, watermelons were grafted on *Cucurbita maxima, C. moschata*, and *Lagenaria siceraria* rootstocks. These rootstocks were influenced resistance to soil borne diseases, plant growth, yield, and fruit quality. Graft incompatibility and decrease in the fruit quality appeared depending on the scion-rootstock combination (Lee and Oda, 2003). The type of rootstock has been shown to affect watermelon plant growth and yields (Yetisir and Sari, 2003).

Two experiments were conducted to improve nitrogen efficiency in melon by grafting, the results indicated that the total leaf area, SPAD index, and shoot N uptake increased linearly and quadratically in response to an increase of the N concentration in the nutrient solution. At 2.5 mM of NO3- melon plants grafted onto both *C. melo* and *Cucurbita maxima* × *Cucurbita moschata* rootstocks had the highest NR activity, whereas no significant difference was observed at 10 mM of NO3-. However, under open field conditions, increasing the N fertilization rates from 0 to 120 kg ha-1 increased the total and marketable yields of melon plants. The N uptake efficiency were higher by 9%, 11.8%, and 16.3%, in 'Proteo' grafted onto 'P360' than in ungrafted 'Proteo' plants, respectively (Colla et al., 2010).

In another study, the effect of flooding on plant growth and photosynthetic activity of grafted watermelon were investigated. The watermelon *Citrullus lanatus* (Thunb.) Matsum and Nakai cv. ‘Crimson Tide’ was grafted onto *Lagenaria siceraria* SKP (Landrace). Grafted and un-grafted watermelon plants were flooded at the soil surface for 20 days. It was found that flooding caused chlorosis on both grafted and un-grafted plants but such effect was more pronounced on un-grafted watermelon plants (Yetisir et al., 2006).

Two greenhouse experiments were carried out to determine growth, net photosynthetic rate, electrolyte leakage, root Fe(III)-chelate reductase (FCR) activity, mineral composition, assimilate partitioning (experiment 1, 2007), and organic acid concentration in root exudates (experiment 2, 2008), of watermelon plants cv. 'Ingrid' either un-grafted or grafted onto four commercial rootstocks: 'Macis', 'Argentario'[*Lagenaria siceraria* (Mol.) Standl.] and 'P360', 'PS1313' (*Cucurbita maxima* Duchesne × *Cucurbita moschata* Duchesne) grown in a closed-loop system. The percentage of shoot biomass weight reduction was significantly lower in plants grafted onto pumpkins rootstocks in comparison to those grafted onto the bottle gourd rootstocks and the un-grafted plants. Moreover, at high pH level, the highest percentage of root biomass weight reduction was recorded in both grafting combinations 'Ingrid/P360' and 'Ingrid/Macis'. The high pH-related reduction in net assimilation was more severe in un-grafted plants in comparison with the grafted ones. The Fe concentration in leaves was significantly higher in plants grafted onto pumpkin rootstocks (avg. 109.5 $\mu g\ g^{-1}$) in comparison to that of bottle gourd rootstocks and un-grafted plants (avg. 86.7 $\mu g\ g^{-1}$) (Colla et al., 2010).

Grafting watermelons with saline-tolerant rootstocks showed yield increases up to 81% under greenhouse production in the Mediterranean (Colla et al., 2009). Yields were increased by grafting in melons (Ruiz and

Romero, 1999; Yetisir and Sari, 2003), similar results have been found in cucumber (Pavlou et al., 2002).

Davis and Perkins-Veazie (2005) reported that grafting can increase lycopene content and firmness of watermelon flesh. Perkins-Veazie demonstrated that grafting watermelon could increase lycopene and total carotenoids by 20% and amino acids, especially citrulline, by 35%. Citnilline (Lee et al., 1996).

Davis et al. (2006) studied the production characteristics of six watermelon cultivars from certified organic seed sources and compared them under high (black plastic and mechanical cultivation for weed control) and low input (no-till) organic culture. The high input production method almost doubled the number of fruit produced for all cultivars, producing greater yields and heavier average fruit weights, but produced fruit with decreased quality (lower Brix and lycopene content) compared to the low input production method.

Substantial studies confirmed that grafting altered the muskmelon fruit quality to varying degree , for example, total sugar contents in grafted melon and watermelon were lower than that in self-rooted ones (Liu et al., 2006). Carbohydrates are the most important biochemical compounds in determining the quality of muskmelon fruit, of which the soluble sugars mainly consist of sucrose, glucose, fructose and so on (Lalonde et al., 2003). The kind and amount of various carbohydrates directly influence fruit flavor components such as sweetness. Carbohydrate accumulation is closely related to stachyose metabolism (Taji et al., 2002), photosynthates translocation capacity in phloem (Brian et al., 2003), galactose metabolism and sucrose metabolism in fruit (Dai et al., 2006). The terminal sucrose metabolism is more important for its influence in the final carbohydrates accumulation (Zhang et al., 2003).

Previous researches though have indicated that grafting lessen sugar content in fruits, these are only restricted to the grafting effects on total soluble sugar or sucrose metabolism (Xu et al., 2006).

2.4. Watermelon's rootstocks:

There are three economically important *Cucurbita* species, namely: *C. pepo*, *C. maxima* and *C. moschata*, which have different climatic adaptations and are widely distributed in agricultural regions worldwide (Robinson and Decker-Walters 1997; Paris and Brown 2005; Wu et al. 2007). In watermelons, there are at least three species available as plausible rootstocks suited for grafting and disease resistance. Watermelon is currently grafted on *Lagenaria siceraria* (bottle gourd), *Citrullus lanatus* (wild watermelon), *Cucurbita moschata* x *Cucurbita maxima* (inter-specific squash hybrid), squash hybrids, (*Cucurbita moschata* x *Cucurbita maxima*). *Lagenaria siceraria* can be used to control Fusarium wilt (Yetisir and Sari, 2003). Over 95% of the commercial watermelon seedlings are grafted in Japan, Korea and Greece where farming areas are small, very intensive and crop rotation is an uncommon practice to overcome soil-borne pathogens (Kurata, 1994; Lee, 1994; Traka-Mavrona et al., 2000).

In Japan, watermelon plants are often grafted to some *Cucurbitaceae* rootstocks which are resistant to soil-borne *Fusarium* disease and tolerant to low temperature. Bottle gourd (*Lagenaria siceraria* Stand1.) has been mainly used as a rootstock for watermelon; but, recently, bottle gourd rootstock has become susceptible to soil-borne *Fusarium* disease and physiological wilt in some production sites problems, squash or pumpkin (*Cucurbita moschata Duch.*, *C. maxima* × *C. moschata* , or *C. pepo L.*), respectively, are sometimes used as rootstocks for watermelon instead of bottle gourd. However, squash or pumpkin rootstocks often lower fruit quality. The deterioration of melon quality on watermelon *Cucurbita* rootstocks is attributed to their vigorous nutritional uptake, these findings suggest that the fruit quality is related to the functions of rootstocks (Masuda et al., 1986). Grafting of watermelon scions on squash, pumpkin, or bottle gourd (*Lagernaria spp.*) rootstocks is practiced in all the major watermelon production regions of the world (Choi et al. 2002; Lee 1994, 2003).

In a another study, watermelons are grafted on *Cucurbita maxima*, *C. moschata*, and *Lagenaria siceraria* rootstocks. These rootstocks influenced resistance to soil borne diseases, plant growth, yield, and fruit quality. Graft incompatibility and decrease in the fruit quality appeared depending on the scion-rootstock combination (Lee and Oda, 2003).

Thirteen commercial melon rootstock and various *Cucurbitaceae* spp. were evaluated for potential grafting for resistance to pathogen and determined productivity and fruit quality characteristics of grafting on resistant rootstocks. Following inoculation, P360 and PGM 96-05 commercial rootstocks, as well as *Benincasa hispida*, *Cucumis metuliferus*, *Cucumis ficifolius*, *Cucurbita maxima*, *Cucurbita moschata*, and *Lagenaria siceraria* were resistant to the race 1, 2 of Fusarium. Yield and quality attributes of scion cultivars (Supermarket and Proteo) grafted on P360 and PGM 96-05 rootstocks were not improved relative to un-grafted controls. Grafts onto *B. hispida* negatively influenced both yield and fruit quality, while *C. metuliferus*, and *C. zeyheri* had negative impacts on productivity and fruit quality (Trionfetti Nisin et al., 2002).

Recently, bottle gourds (*Lagenaria siceraria*) and interspecific squash hybrids (*Cucurbita moschata* × *Cucurbita maxima*) were evaluated as rootstocks for commercial watermelon production in the southeastern United States (Hassell and Memmott, 2008). In North Florida field trials, a severe infestation of root-knot nematodes unexpectedly occurred on all bottle gourd and *Cucurbita* rootstocks (*unpublished data*). In China, where farm land is limited and farmers are being forced to grow the same crop in successive years, root-knot nematodes have become a serious limitation for grafting to bottle gourd and Cucurbita rootstocks (Yong Xu, National Engineering Research Center for Vegetables, Beijing, China). Identifying root-knot-resistant germplasm and developing resistant rootstocks would provide an economical and environmentally friendly method for managing root-knot nematodes in watermelon and melon.

Although BH and LCY showed high compatibility with watermelon (cv. Crimson Tide), they were not suitable rootstocks for early watermelon production, but they can be considered for late watermelon production because they were resistant to 3 known races of Fusarium oxysporum f. sp. niveum (Yetisir et al., 2003).

2.5. Current Grafting Methods in Watermelon:

Many different watermelon grafting techniques are available today namely “the tongue approach graft”, “one cotyledon graft”, “hole insertion graft”, and the “side insertion graft” (Cushman, 2006; Hassell and Memmott, 2008; Lee, 1994; Lee and Oda, 2003; Oda, 1995). The approach grafting method is one of the original grafting methods performed (Lee and Oda, 2003); however, the one cotyledon and hole insertion grafts are most commonly used today in commercial production. Preferences to grafting techniques are a compromise among a number of influential factors to maximize the benefit to fit the individual’s needs and available resources. These contributing factors include the ease and technicality of grafting, success rate, and overall cost (Davis et al., 2008; Hassell and Memmott, 2008; Lee, 1994).

2.5.1. Tongue Approach Graft:

The "tongue approach graft", or simply known as the "approach graft", is relatively simple to graft (Fig. 1) (Hassell and Memmott, 2008). It is the oldest grafting technique, which became widely used in the 1920's in Asia due to its higher success rate (Lee and Oda, 2003) and the growth uniformity (Hassell and Memmott, 2008). This method continues to be preferred by inexperienced growers because of its simplicity, high success rate, and little care since it does not require healing chambers (Lee and Oda, 2003). Referring to figure one at the first true RLNS and older RLNS a diagonal slice is made below the cotyledons, in both hypocotyls of the scion and rootstock; slices should be opposite to one another, upward and downward, respectively (Cushman, 2006; Oda, 1995). Each cut should be comparable in length so they can match up together. Each slit acts like a tongue and both are fitted together and sealed with an aluminum wrap to allow healing to take place.

The rootstock meristem and cotyledons are completely removed three days after grafting and the scion rootstock is removed at seven days after grafting. The scion is now solely dependent on the new rootstock (Oda, 1995). The plants must be individually handled manually at the time of grafting, again at three days after grafting to remove the meristem from the rootstock, and once more at day seven to remove the root portion from the scion. This makes it a very labor intensive and time consuming grafting method. Both rootstocks are then replanted together during the grafting procedure to increase the proximity during the healing time. This is a significant drawback if it's being done in a greenhouse as it occupies twice

the amount of space and is costly to maintain (Cushman, 2006). Because all meristematic tissue from the rootstock is removed during the grafting procedure, rootstock re-growth can no longer occur.

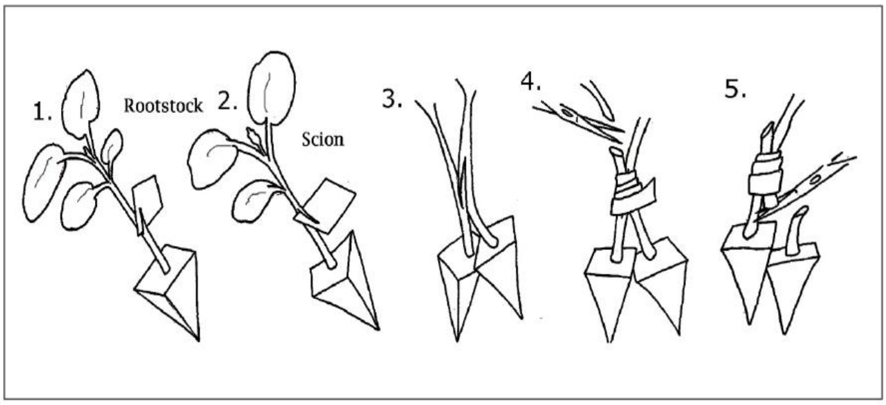

Figure 1. Tongue approach graft 1) the rootstock and 2) scion being cut; 3) union of scion and rootstock; 4) complete removal of rootstock meristem; and 5) complete removal of scion root. Picture provided by (Hassell and Memmott, 2008).

2.5.2. Hole Insertion Graft:

The "hole insertion graft", which is also called "terminal", "cut" or "top insertion" graft (Fig. 2) (Hassell and Memmott, 2008), is favored by watermelon growers in Japan because of the shorter growing time required for scion material compared to the rootstock (Lee and Oda, 2003). Grafting can begin once the first leaf emerges from the rootstock. The scion is ready for grafting during the cotyledon stage and up to the first true leaf. Some experts report that it can be used even as soon as the shoot emerges from the soil (Lee and Oda, 2003).

The procedure for this method is outlined in figure two as follows: the scion hypocotyl is cut 2 cm below the cotyledons at a slant on opposing sides to expose the vascular tissue; During this step as much of the meristematic tissue should be removed as possible. A specialized tool, such as a bamboo stick or small drill bit, is used to make a hole that is slant to the longitudinal direction between the cotyledons and into the hypocotyls which should slightly pass through the hypocotyl on one side for the scion hypocotyl to be inserted allowing the vascular system of both hypocotyls to come into contact with each other. The pointed region on the scion is then snuggly inserted through the slanted hole in the hypocotyl to complete the graft . This method does not require the same scion/rootstock hypocotyl slant cut matchup, does not require clips, and the newly grafted plant is then placed inside a healing chamber for seven days as described previously. There is a high success rate on rootstocks that are compatible with Lagenaria; however, a great concern lies within the high rate of remaining meristematic tissue since which will necessitate future re-growth removal and increasing grafting cost. Rootstock plants that have a pronounced hollow stem, such as inter-specific squash hybrids, are less likely to work because of hollow stem creates a gap which prevents the scion from adhering to the rootstock and/or inserting the seedling into the pith cavity of the rootstock. By doing so allows adventitious roots from the scion to elongate downward through the pith center and into the soil which will void the resistance and lead to complete rootstock decline (Lee and Oda, 2003). This technique has not been successfully automated because of the technicalities of performing this graft.

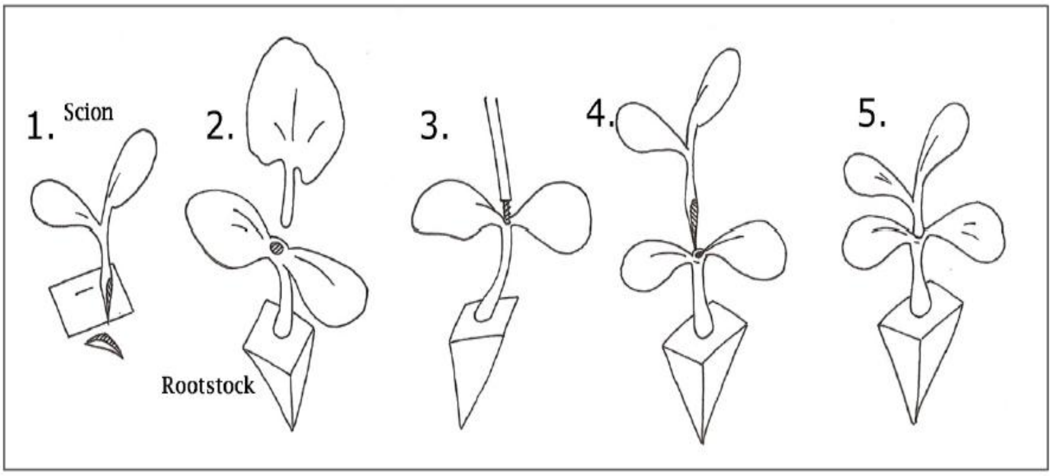

Figure 2. Hole insertion grafting method 1) the scion is cut at approximately 65º on two sides forming a point; 2) meristematic tissue is removed; 3) a hole for the scion to be fitted in is drilled at a slant between the cotyledons and just through the hypocotyl of rootstock; 4) the scion is aligned to fit snugly in the rootstock; and 5) it is then securely inserted into the rootstock. Picture provided by (Hassell and Memmott, 2008).

2.5.3. Side Insertion Graft:

The "side insertion graft", also known as the "cleft" or "splice" graft (Fig. 3) (Hassell and Memmott, 2008), is a modified whole insertion graft (Lee and Oda, 2003). Seedlings are ready to be grafted at the first true RLNS. The graft is as follows: Using a sharp blade, the scion is cut at an angle on both sides of the hypocotyl below the cotyledons to form a v-shape. Cut a small vertical slit through the middle of the rootstock stem instead of at the top of the meristem. The slit is propped open with a toothpick. The scion is then inserted into the slit at an approximate 30º to the rootstock tip and a clip is placed over the union to secure the graft during the healing process, but its removal will be required once healing is complete. Three days after grafting carefully cut off the rootstock vegetative tissue just below its cotyledons. This grafting technique seems very simple, but inserting the scion into the rootstock can be somewhat difficult. The involvment of toothpick, makes it more time consuming and cumbersome. Once grafting is complete, the seedlings must be placed inside a healing chamber for three days after grafting, but an intense amount of labor is required to remove the rootstock shoot above the graft once the embedded scion has healed. Because of this step, this procedure cannot be automated; however, meristematic re-growth is no longer a problem. A further reason why this grafting technique is unpopular is the failure of vascular bundles to align sufficiently for a strong healing to take place to secure the graft.

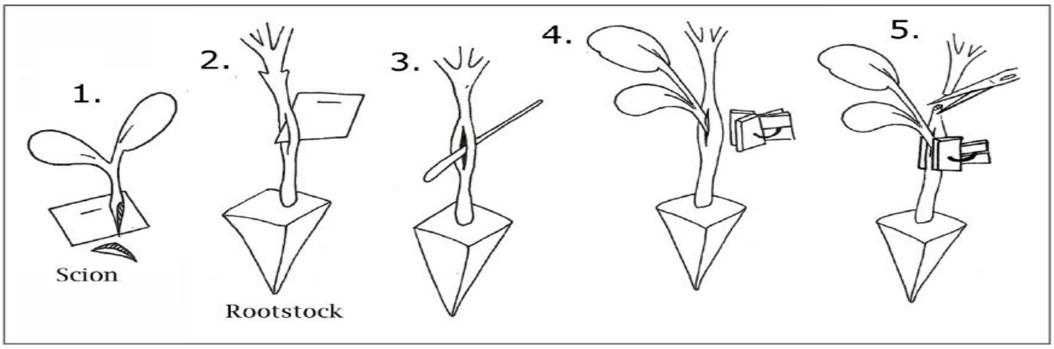

Figure 3. Side graft 1) the scion is cut at approximately 65º on two sides forming a point; 2) a simple slice is made through the rootstock hypocotyl; 3) the splice is then prop open using a toothpick or stick; 4) the scion is inserted into the rootstock, and secured with a graft clip; and 5) the vegetative portion from the rootstock is cut just below the cotyledons**.** Picture provided by (Hassell and Memmott, 2008).

2.5.4. One Cotyledon Graft:

The "one cotyledon graft" is also known as "splice", "slant" or "tube" graft. This graft is moderately simple being less labor intensive than the approach graft (Fig. 4) (Hassell and Memmott, 2008). The one cotyledon graft can be completed at one time and minimizes greenhouse occupancy making this method the most popular grafts among experienced growers and commercial nurseries in Korea. It is performed by either by hand, semi-automatic, and with automatic robots (Kurata, 1994; Lee and Oda, 2003). Plants are ready for grafting when the first true leaf is present on the rootstock or as young as the scion cotyledon stage (Cushman, 2006; Oda, 1995). The meristematic region becomes increasingly difficult to completely remove when the rootstock plant material ages past the first true RLNS. The procedure is as follows: The scion is cut at an opposing 45º to 65º angle to the rootstock, approximately one inch below the cotyledons to facilitate clamping. The rootstock meristem and one of the cotyledons are cut simultaneously from the plant at a 45º to 65º angle to maximize the grafting surface area. The sliced portion of the scion and rootstock hypocotyl is then joined together to ensure the vascular tissues are contacting each other. The graft secured with a spring clamp that is placed around the outside region of the splice. Immediately following grafting, plants require special environmental conditions for healing. This includes: high levels of dark and humidity, and healed at approximately 23 ºC in a healing chamber. The healing chamber minimizes environmental stresses to allow newly grafted plants to heal without undue environmental stress rather than continue with photosynthetic activity until healing is complete. Under low light conditions, the stomata on the leaf close forcing gas exchange and photosynthetic activity to cease which slow wilting to maintain the plant vascular system at optimal survivability.

The high humidity prevents the plant from excessive wilting and assists in maintain high tugor pressure which aids in graft healing. Newly grafted seedlings should be kept in the healing chamber for the duration of the graft healing lasting approximately seven days. Three days into graft healing, light intensity is increased, and humidity is gradually decreased in the healing chamber to prepare the seedlings for ambient environmental conditions outside the chamber.

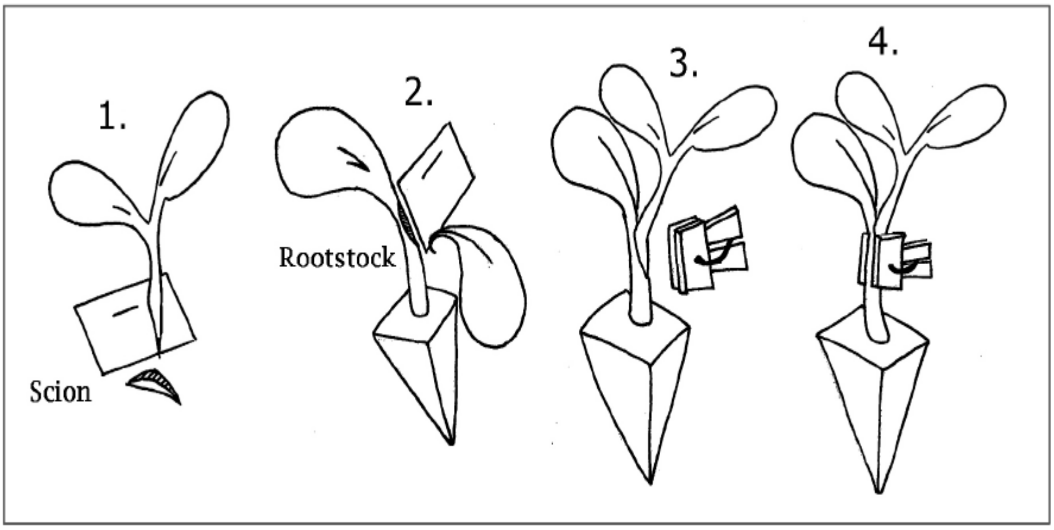

Figure 4. One cotyledon graft 1) cut scion at an approximate 65º angle; 2) remove apical meristem and one cotyledon; 3) cut off cotyledon at an approximate 65º angle; 4) attach scion onto rootstock; and 5) secure the graft with a clip. Picture provided by (Hassell and Memmott, 2008).

2.6. Advantages and drawbacks of Watermelon Grafting.

2.6.1. Advantages:

Valuable benefits can also be introduced from grafting watermelons on intra- and interspecific rootstocks (Cohen et al., 2007). Resistant rootstocks can be alternated to overcome disease to maintain high watermelon production yields (Edelstein, 2004a). *Fusarium oxysporum* f. sp. *melonis* can be avoided by using interspecific rootstocks (Cohen et al., 2007). Some rootstocks from *Lagenaria* are able to confer resistance in Cucurbitaceae against carmine spider mite, *Tetranychus cinnabarinus*, (Edelstein et al., 2000). Other rootstocks display tolerance for other soil-borne pathogens such as *Monoaporascus* and *Macrophomia* (Koren and Edelstein, 2004). Another highly positive benefit is that some rootstocks have been known to effect fruit quality (Core, 2005; Davis and Perkins-Veazie, 2005-2006).

By grafting watermelons on to different rootstocks, the quality of the fruit has been known to increase fruit firmness and thus increase shelf life. These results have added to the quality of the fruit, in other countries, when shipping to foreign lands. This is a valuable potential preservation characteristic for this country in the fact that this may extend fruit longevity for both a harvest window for growers and on the shelf storage for produce buyers. It could also open new markets for the fresh cut industry. One benefit is that some grafts increase nutrient and water uptake due to a higher capacity for nitrogen uptake and transport to the scion, which greatly increases its growth (Pulgar et al., 2000). This advantage allows the plants to better use fertilizers and other nutrients that would have been left in the soil. The absorption efficiency of water is increased by vigorous rootstocks (Lee, 1994). These benefits have the potential to lower nutrient costs and amount of required water per plant to harvest the same yield.

Grafted plants show a greater cold tolerance which is a great benefit since non-grafted watermelon plants have such little tolerance for low temperatures (Oda, 1995; Venema et al., 2008). Water logging is another watermelon production problem which causes the root to suffocate and crop production to halt. Studies show an increase in water logging tolerance with grafted plants (Yetisir and Sari, 2003). In another study, grafted watermelons had a greater tolerance when watered with saline water than did the non-grafted plants (Cohen et al., 2007) which implied the increase in drought tolerance in grafted plants as well (Koren and Edelstein, 2004).

2.6.2. Drawbacks:

Although there are many impressive advantages to grafting, some disadvantages have discouraged this technology from use. These disadvantages are distributed between incompatibility, fruit quality, and cost. Incompatibility is the failure of the scion to unite and adhere to the rootstock. Lesser but still problematic incompatibilities occur when the plant is unable to grow in a healthy manner, or exhibits premature death (Garner, 1979). Other incompatibilities can cause poor fruit quality, yield reduction, and possibly plant collapse. This may be due to the reduction in or blocking of photosynthate transport. Vascular bundles must come in contact with each other in order for grafting to be successful and to avoid incompatibility (Oda et al., 1993). In order for healing to take place, vascular bundles from the scion and rootstock, severed during grafting, must come into intimate contact with one another for correct healing to take place. Vascular tissue differentiation from the callusing cells occurs in compatible grafts only (Andrews and Marquez, 1993). Grafting success can be increased by increasing the surface area and contact region between the scion and rootstock by increasing the sliced region allowing the vascular bundle on the whole to increase contact. Different plant species have a varying number of vascular bundles. This may increase the difficulty to adequately align vascular bundles from the rootstock and scion if they are unequal to achieve a successful graft (Oda et al., 1993). Some studies also shown that rootstocks can adversely affect the taste and shape of watermelon fruits (Edelstein, 2004a). Plant proteins, either structural or nonstructural that are synthesized in the root, are translocated to the scion can give the fruit an off flavor that has been reported. These discrepancies are not reported in all rootstocks and can be overcome through screening procedures to evaluate for rootstock performance.

Overall cost versus benefit becomes the bottom line when growers think about production within the United States: A grafted seedling in the U.S. is estimated to cost more than \$ 0.75, as suggested by Taylor et al. (2008) being far more than \$ 0.28 for a non-grafted seedling. There is an additional cost for growing the rootstock seedlings in comparison with a non-graft seedling transplant. This cost can be broken down into twice the amount of growing material, space, and time. Additionally equipment is needed for grafting such as a sharp blade, clips and a healing chamber. Labor is necessary to carefully handle the seedlings while performing the grafting procedure and with removing rootstock re-growth and this removal can be very expensive and of major concern due to overall cost. Rootstock re-growth occurs at the base of the rootstock cotyledons where meristematic tissue is present. Current grafting techniques attempt to remove all meristematic tissue during the grafting procedure. When the meristematic tissue is not removed, re-growth occurs at high rates. Even when grafting experience is increased and rootstock re-growth minimized, the remaining re-growth is yet too costly to remove at a reasonable cost. Overall cost must be decreased in order for grafting technology to be considered for commercial practice. This problem can be reduced by completely removing the cotyledon during grafting which eliminates the meristematic region; however, some attempts to successfully graft by removing both rootstock cotyledons in a one step fashion has not been successful (Oda, 2002a).

The overhead cost of the humidity chamber increases the overall cost to produce a quality grafted transplant. The unique spring loaded clips which are used require labor costs for placement and removal. Finally, removal of meristematic re-growth which occurs using this graft method increases overall cost. Costs can be further increased using this method if grafting is performed on older plants. Rootstock re-growth occurs at even higher rates because it is more difficult to remove all meristematic tissue during grafting which adds to the cost of labor even once the seedlings are planted in the field (Oda, 2002b).

CHAPTER THREE

MATERIALS AND METHODS

3. Materials and Methods

3.1. Grafting Experiment:

3.1.1. Seedling Development:

Four rootstocks (Pumpkin, Al-kamari squash, Ein-senna squash, and Gladioter watermelon) were used with two watermelon cultivars (Crimson Sweet and Jaddoai watermelon) (table 1).

Table (1): Rootstocks and scions used in the experiment.

No.		Common name	Scientific name
1	**Rootstocks**	Pumpkin	*Cucurbita moschata*
2		Al-kamari squash	*Cucurbita pepo var. melopepo*
3		Ein-senna squash	*Cucurbita maxima*
4		Gladioter watermelon	*Citrullus lanatus var. Gladioter*
5	**Scion cultivars**	Crimson Sweet watermelon	*Citrullus lanatus var. Crimson Sweet.*
6		Jaddoai watermelon	*Citrullus lanatus var. Jaddoai.*

Seeds of all rootstocks and cultivars were planted in soil mixture of 75% nursery peat, 25% coarse perlite.

Rootstocks were grown in the plug trays is vented (cell depth of 6 cm with top and bottom cell diameters tapering from 3.5 cm to 2.0 cm Polystyrene. The scions were seeded in the plug trays is vented (cell depths of 6 cm with top and bottom cell diameters tapering from of 3.5 cm. to 2.0 cm Polystyrene.

Rootstock and scion seeds were placed in a truss built plastic greenhouse at the Juneidi nursery for vegetables, West Bank Palestine in November 6, 2010.

The environmental conditions were not controlled inside the greenhouse.

Each rootstock and scion seeds were sown (approximately 2 trays of each) at different dates. The four rootstocks were seeded one week later into 187 cell/ tray, Rootstock seeds were sown at approximately 1.5 cm depth in the soilless mix and maintained moist until germination was completed. All scion seeds were sown at approximately 1 cm depth in soilless mix using germination methods developed by Hassell and Schulthies (2002). 100 seeds per variety were used with a total number of 600 seeds. The total germination rates for all seeds planting were 97%.

3.1.2. Before grafting:

- Scion and rootstock were exposed to sunshine for two to three days.
- The plants were not watered for 2-3 days before grafting.

One night prior to grafting, the seedlings were placed inside the head house (shading) with approx. room temperature at 23ºC (Oda *et al.* 1993).

All seedlings were fertilized with 100 ppm with NPK 13-13-13 Compound fertilizer.

3.1.3. Grafting method:

The two cultivars were grafted onto the four rootstocks by using splice grafting method (one cotyledon graft) (fig. 5). After two weeks all grafted seedlings were ready for planting in the field. Grafting clips were removed during this period (2 week) after grafting.

1) Preparing the rootstock and scion.

(2) Slant cutting.

(3) Joining the plants. **4) Securing the joined region with a grafting clip.**

Figure 5. The steps of slant-grafting adopted in the experiment.

3.1.4. Schedule grafting technology by the splice grafting for watermelon:

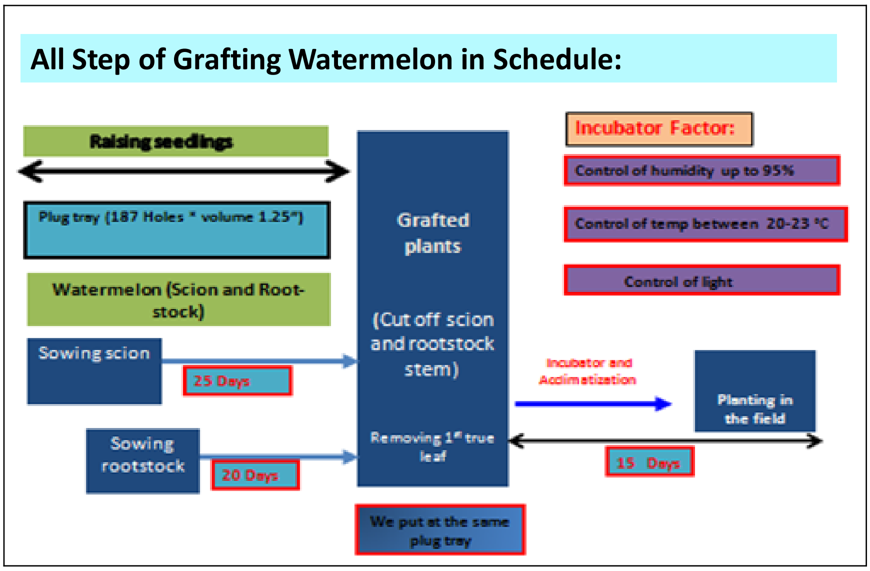

Figure (6): Time schedule grafting technology by the splice grafting for watermelon during the experiment.

3.2. Field Evaluation Experiment:

The study was conducted in the North- Ghor region/Bardalla (Tubas), during the winter season of 2011. The experimental design was conducted in factorial treatment in a completely randomized design. with four replications for each treatment. Each treatment was replicated four times with ten plants in each replicate. Drip irrigations lines were installed and transparent plastic mulch was used.

3.2.1. Soil preparation:

The land was prepared by removing the different plant debris then plowing (deep plowing) up to 20 cm deep or more where the land is good leveling and Harrowing.

Two dunums, were used in the experiments, all grafted plants were planted at (2m x 2m). The rows were directed east-west. Plants were transplanted on 2 January 2011; To ensure no contact between soil and the graft union seedlings were planted at the same level.

3.2.2.The grafted combinations were used:

1. Watermelon ACC.5/ Pumpkin.
2. Watermelon ACC.5/ Al-kamari squash.
3. Watermelon ACC.5/ Ein-senna squash.
4. Watermelon ACC.5/ Gladioter watermelon.
5. Watermelon ACC.5/ Self-grafted.

6. Watermelon ACC.5/ Non-grafted (Control).
7. Watermelon 9/ Pumpkin.
8. Watermelon 9/ Al-kamari squash.
9. Watermelon 9/ Ein-senna squash.
10. Watermelon 9/ Gladioter watermelon.
11. Watermelon 9/ Self-grafted.
12. Watermelon 9/ Non-grafted (Control).

3.2.3.Farm Layout in Bardalla Village a Tubas Province:

Plan land use to allow for crop mix that will enable rotation. These arrangements of treatments were randomization in the field.

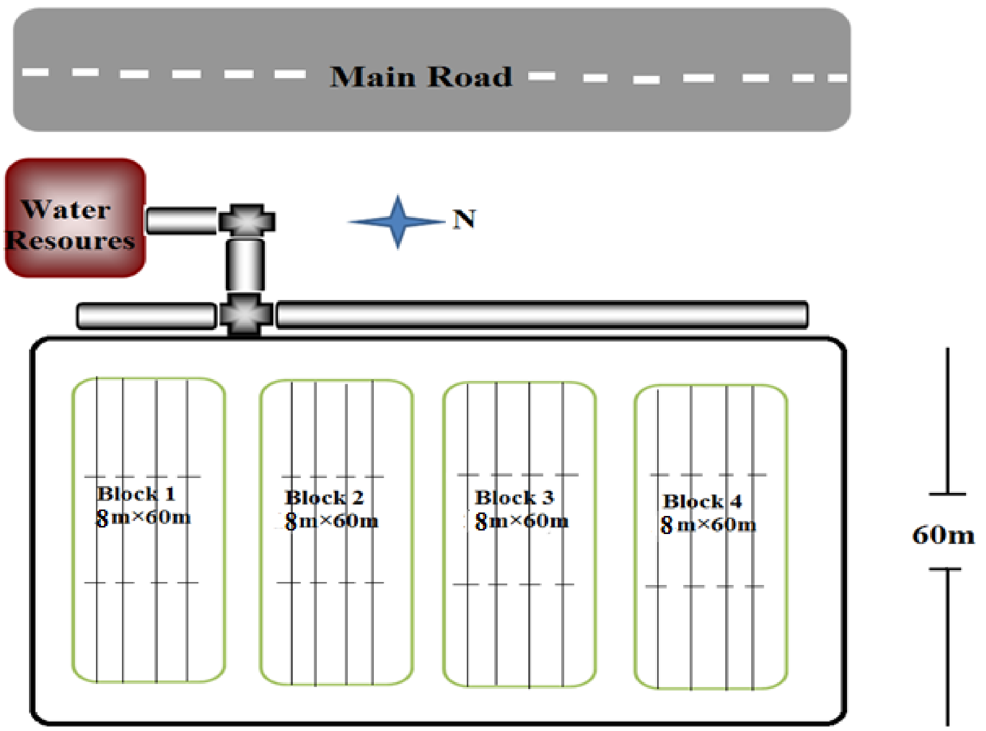

Figure (7) : The treatments were distributed in the field as the following layout.

3.2.4.Cultural Practices:

Chemical fertilizers were added during the growing season including; (Ammonium sulfate 21%N and 17%N-10%P2O5-27%K2O). According to the quantities recommended by the Palestinian Ministry of Agriculture.

Table (2): Cultural practices performed:

Activity	Date	Details
Preparation of soil	15/11/2010	Plant debris, Plowing, Disc plough, land leveling and Harrowing.
Drip irrigations	10/12/2010	Using emitter 4l/ hr
Transparent plastic mulch	20/12/2010	Covering soil before planting.
Planting	2/1/2011	Grafted and non-grafted seedling.
Plastic cover (Low tunnels)	3/1/2011	Covering seedlings with transparent plastic mulch (Low tunnels).
Herbicide application	20/1/2011	Using Ronstar and Super select
Plastic cover (tunnels)	25/3/2011	Removing plastic cover (Low tunnels)
During growing season	20/4/2011	Collected sampling for the biomass measurements of grafted and non-grafted watermelon.
Pesticide and Fungicide application	30/3/2011	Using Confidor, Marshal, Antrcol.
Fruit quality	23/5/2011	Using a hand refractometer, Brix values were measured.
Fruit harvested	24/5/2011	Total number of fruits harvested per plant according weighted (kg).
Off-season crop	25/5/2011	Roots of all treatments would be dugged and evaluated for both length and weighted of root system.

3.3. Data collection :

The following of collection data in the list:

No.	During the cultivation period	The termination data
1	Plant length(cm).	Vegetative fresh and dry weight (g).
2	Number of branch per plant.	Root fresh and dry weight
3	The number of leaves per branch and the number of days to first male and female flower appearance in all treatments.	Total number of fruits harvested per plant according weighted (production less than 2 kg, production between 2-5 kg and production more than 5 kg).
4	****	Root length (cm).
5	****	Total soluble solid (°Brix).

3.4. Statistical analysis:

Data were analyzed using PROC GLM procedure of PC SAS (SAS v.8, Cary, N.C) to determine the effects of rootstocks treatment and their interactions. If the F test was significant at p=0.05 and 0.01, the means were separated by LSD at p= 0.05.

CHAPTER FOUR

RESULTS

4. RESULTS

The analysis of variance for the different data collected indicated a non significant interaction effect between cultivars and rootstocks, therefore, the result of each cultivars was presented separately.

4.1. The effects of different rootstocks cucurbita spp. on Survival rate of grafting combinations.

The survival rates of plants grafted onto different rootstocks are presented in Table (3). Although the difference in survival rates was not biggest in all treatments, the lowest survival rate was 90% in Ein-senna rootstock and the highest rate was 100% in both self-grafted and Gladioter rootstock. There was a 10% difference between rootstocks, while the total number of survival rate was 97% in all rootstocks, and this difference in survival rate was practically important.

Table 3. Survival rate of grafting combinations.

Scion/Rootstock	No. of seedling grafting	Survival number	Survival rate (%)
W. ACC.5 /Pumpkin	50	48	96%
W. ACC.5 /Al-Qamri squash	50	47	94%
W. ACC.5 /Ein-senna squash	50	45	90%
W. ACC.5 /Gladioter watermelon	50	50	100%
Watermelon ACC.5 (Self-grafted)	50	50	100%
Control (non-grafted)	50	50	100%
W. 9/Pumpkin	50	50	100%
W. 9/Al-Qamri squash	50	49	98%
W. 9/Ein-senna squash	50	45	90%
W. 9/Gladioter watermelon	50	50	100%
Watermelon 9 (Self-grafted)	50	50	100%
Control (non-grafted)	50	50	100%
Total No.	600	584	97%

4.2. Effects of rootstocks on biomass Production:

4.2.1. Cultivar Crimson Sweet.

The effect of grafting watermelon ‘Crimson Sweet’ onto different rootstock on biomass is shown in table (4). Vegetative fresh weight was significantly affected by rootstocks. Pumpkin rootstock resulted in the highest vegetative Fresh weights (7738gm/plant) while Ein-senna rootstock had the lowest vegetative fresh weight (3713gm/plant). Similar results were obtained to those for vegetative dry plant weight: Pumpkin rootstock produced the highest dry weight (1074gm/plant) whereas Ein-senna rootstock had the lowest dry weight (460gm/plant). Grafted plants had longer roots than those of Cucurbita type rootstocks, except for watermelon Crimson Sweet (Self-grafted). Pumpkin had the longest roots at 92.5 cm.

The highest root fresh weight was recorded in Pumpkin rootstock (91.5gm/plant) while Control (non-grafted) rootstock had the smallest (31.0 gm/plant) root fresh weight. All rootstocks had higher root fresh than the Control (non-grafted) rootstock, except for Al-Qamri squash and Ein-senna rootstocks. The same trend was observed with the dry weight where Pumpkin rootstock was superior than other rootstock.

The results showed that leaf per branch, number of branch, branch length, days to first flowering (male), and days to first flowering (female) were significantly influenced by grafting (Table 6). Number of leaves branch of Pumpkin and Gladioter watermelon rootstocks were significantly higher than other grafted and control plants (78.8 and 69.8 leaf/branch respectively). Number of branches per plant gave similar results. Pumpkin and Gladioter watermelon rootstocks produced more branches (12.0 and 10.5 branch/plant respectively) than non-grafted (control) plants (3.8 branch/plant).

The main stem length was also affected by grafting. Control plants had the shortest main stem with 100 cm when compared to the grafted plants.

Table 4: Biomass measurements of grafted watermelon CV 'Crimson Sweet' on different rootstocks.

Rootstock	Vegetative Fresh Weight (gm)	Vegetative Dry Weight (gm)	Root Fresh weight (gm)	Root Dry Weight (gm)	Root length (cm)	Leaf / branch	Branch number	branch length (cm)
Pumpkin	7738 a*	1074 a	91.5 a	11.0 a	92.5 a	78.8 a*	12.0 a	193 a
Al-Qamri squash	5300 c	596 c	42.5 c	5.5 cd	70.0 b	40.0 bc	5.8 b	123 bc
Ein-senna squash	3713 e	460 e	55.0 b	6.3 c	59.0 c	27.8 c	4.5 b	128 bc
Gladioter watermelon	6905 b	930 b	80.0 a	8.9 b	74.0 b	69.8 a	10.5 a	188 a
Watermelon cv. Crimson Sweet (Self-grafted)	4625 d	506 de	40.5 c	4.7 de	35.0 d	43.0 b	5.5 b	145 b
Control (non-grafted)	5200 c	560 cd	31.0 c	3.3 e	26.0 d	32.0 bc	3.8 b	100 c

*Numbers in each column followed by the same letter(s) are not significantly differ according LSD (.05 prob.)

4.2.2. Cultivar Jaddoai:

The effect of grafting watermelon Jaddoai onto different rootstocks is shown in table (5). There were significant differences in vegetative growth among the different rootstocks. The highest and lowest vegetative fresh weight was obtained when Pumpkin and Ein-senna rootstocks (8363 and 4263gm/plant respectively) were used, similarly, the highest and lowest vegetative dry weight was obtained in Pumpkin and Ein-senna rootstocks (1355 and 474gm/plant respectively). The highest and lowest root fresh weight was obtained in Pumpkin and non-grafted watermelon plants (105.3 and 35.3 gm/plant respectively). The same result was obtained with root dry weight. Significant differences were observed with root length among the different rootstocks, Pumpkin rootstocks significantly gave the highest root length (97.5 cm) followed by Gladioter rootstock (78.3 cm).

Pumpkin and Gladioter watermelon rootstock had the highest numbers of leaves/branch (82.5, and 73.5 respectively), whereas Ein-senna rootstocks produced the lowest number of leaves per branch (29.5). Rootstocks had different numbers of branches in the plants. The highest number of branches was recorded in Pumpkin rootstocks with 14.5 branches per plant, while control (non-grafted) rootstocks had the lowest number of branches per plants with 4.3. Al-Qamri squash and Jaddoai watermelon (Self-grafted) type rootstocks had similar numbers of branches (about 6.5 branches) in their plant while Ein-senna squash and Control (non-grafted) had about 5 branches in theirs.

Main stem length was also significantly affected by rootstocks. Pumpkin and Gladioter watermelon type rootstocks produced longer main stems than did the control and other rootstocks. Control (non-grafted) rootstock produced the shortest main stems with 110 cm.

Table 5: Biomass measurements of grafted watermelon CV 'Jaddoai' on different rootstocks.

Rootstock	Vegetative Fresh Weight (gm)	Vegetative Dry Weight (gm)	Root Fresh weight (gm)	Root Dry Weight (gm)	Root length (cm)	Leaf / branch	Branch number	branch length (cm)
Pumpkin	**8363 a***	**1355 a**	**105.3 a**	**15.5 a**	**97.5 a**	**82.5 a**	**14.5 a**	**220 a**
Al-Qamri squash	**5700 b**	**569 c**	**53.5 b**	**6.4 b**	**52.3 c**	**41.3 bc**	**6.5 c**	**140 bc**
Ein-senna squash	**4263 c**	**474 c**	**51.5 b**	**6.9 b**	**46.0 cd**	**29.5 c**	**5.0 c**	**160 b**
Gladioter watermelon	**8050 a**	**1165 b**	**90.0 a**	**12.2 a**	**78.3 b**	**73.5 a**	**12.0 b**	**200 a**
Watermelon cv. Jaddoai (Self-grafted)	**5293 b**	**583 c**	**46.3 b**	**6.9 b**	**35.0 de**	**45.0 b**	**6.3 c**	**130 bc**
Control (non-grafted)	**5555 b**	**552 c**	**35.3 b**	**4.0 b**	**29.0 e**	**35.0 bc**	**4.3 c**	**110 c**

*Numbers in each column followed by the same letter(s) are not significantly differ according LSD (.05 prob.)

4.3. Effect of different rootstocks on days to flowering male and female of grafted watermelon in both cultivars ‘Crimson Sweet and Jaddoai’.

The effect of grafting watermelon **Crimson Sweet** cultivar onto different rootstocks on days to flowering is shown in table (6). The onset of flowering was first observed in non-grafting and self grafted plants days to the appearance of first male and female flower with control (non-grafted) and self grafting were 39.8, 45.3 and 49.3, 53.5 days respectively. Flowering was delayed in grafted plants, the number of days to first flowering in both male and female flowers of Pumpkin rootstock were 61.3 and 65.3 days respectively, these numbers were not significantly differ from that observed in Gladioter rootstock.

The effect of grafting watermelon cultivar Jaddoai onto different rootstocks on flowering is shown in table (6). Result regarding the days to flowering of first male and female flowers reveals that the non-grafted (control) produced earlier male and female flowers. (40.3 and 47.0 days respectively). Flowering was delayed significantly in all other treatments. However, flowering of self-grafted plants was delayed 11 days for male and about 8 days in female flower from the control.

Table 6: Effect of rootstock on days to flowering of grafted watermelon in both cultivars ‘Crimson Sweet and Jaddoai’.

Rootstock	Crimson Sweet Watermelon		Jaddoai Watermelon	
	Day to flowering (male)	Day to flowering (female)	Day to flowering (male)	Day to flowering (female)
Pumpkin	61.3 a*	65.3 a	61.8 a*	65.0 a
Al-Qamri squash	55.5 b	59.3 b	57.0 b	61.0 a
Ein-senna squash	56.0 b	59.8 b	58.5 ab	62.8 a
Gladioter watermelon	61.0 a	62.3 ab	60.0 ab	64.3 a
Self-grafted	49.3 c	53.5 c	51.3 c	55.8 b
Control (non-grafted)	39.8 d	45.3 d	40.3 d	47.0 c

*Numbers in each column followed by the same letter(s) are not significantly differ according LSD (.05 prob.)

4.4. Effect of different rootstocks on fruit quality of grafted watermelon in both cultivars ‘Crimson Sweet and Jaddoai’

The effect of grafting **Crimson Sweet** watermelon cultivar onto different rootstocks on fruit quality is shown in table (7). All treatments resulted in significantly similar brix value except with Ein-senna squash in the rind and Ein-senna and Al-Qamri squash inside the fruit. The highest brix% was measured in both the rind and inside the fruit with both Gladioter and the non-grafted (7.0 and 10.3%, respectively). The lowest brix value (6.5%) was obtained with Ein-senna squash.

The brix values obtained from fruits of the different treatments is shown in table (7). There were significant differences in brix value among the different rootstocks in brix inside percentage. All treatments gave significantly similar brix% in the rind was obtained in all excepted with Ein-senna rootstock. However, a significant higher brix value was obtained inside the fruit with Gladioter (12.5%), followed by Pumpkin, non-grafted and self grafted. The lowest value inside fruits was again obtained with Ein-senna rootstock (7.8%).

Table 7: Effect of rootstock on fruit quality of grafted watermelon in both cultivars ‘Crimson Sweet and Jaddoai’.

Rootstock	**Crimson Sweet Watrmelon**		**Jaddoai Watermelon**	
	Brix rind %	**Brix inside %**	**Brix rind %**	**Brix inside %**
Pumpkin	**6.3 a***	**9.8 a**	**6.8 a***	**11.0 b**
Al-Qamri squash	**6.3 a**	**8.5 b**	**6.5 a**	**9.5 c**
Ein-senna squash	**3.5 b**	**6.5 c**	**4.5 b**	**7.8 d**
Gladioter watermelon	**7.0 a**	**10.3 a**	**7.0 a**	**12.5 a**
Self-grafted	**6.3 a**	**9.8 a**	**6.8 a**	**10.8 b**
Control (non-grafted)	7.0 a	10.3 a	6.8 a	11.0 b

*Numbers in each column followed by the same letter(s) are not significantly differ according LSD (.05 prob.)

4.5. The effects of different rootstocks cucurbita spp. on production of watermelon CV. 'Crimson Sweet'

The effect of grafting **Crimson Sweet** watermelon cultivar onto different rootstocks is shown in table (8). There were significant differences in fruit production among the different rootstocks. The highest total production was obtained when both Gladioter and Pumpkin rootstocks (12.5 and 12.2 kg/plant respectively) were used, however, without significant difference from plants grafted onto Al-Qamri rootstock. Similar trend was obtained with production grade (>5 kg/plant). The lowest total production was obtained in both self and non-grafted plants (10.1 and 11.1kg/plants respectively), however, regarding production grades (<2 kg and 2-5 kg) all treatment gave significantly similar fruit production except self-grafted plants.

Table 8: Effect of rootstock on production of watermelon CV '**Crimson Sweet**'.

Rootstock	Prod. < 2 Kg/plant	Prod. 2 - 5 Kg/plant	Prod. > 5 Kg/plant	Total Prod. Kg/plant
Pumpkin	**1.7 a***	**4.45 a**	**6.0 ab**	**12.2 a**
Al-Qamri squash	**1.68 ab**	**4.23 ab**	**5.8 bc**	**11.6 ab**
Ein-senna squash	**1.4 c**	**3.7 bc**	**5.4 cd**	**10.5 cd**
Gladioter watermelon	**1.8 a**	**4.3 ab**	**6.4 a**	**12.5 a**
Watermelon Crimson Sweet (Self-grafted)	**1.45 bc**	**3.45 c**	**5.2 d**	**10.1 d**
Control (non-grafted)	**1.58 abc**	**3.88 abc**	**5.7 bcd**	**11.1 bc**

*Numbers in each column followed by the same letter(s) are not significantly differ according LSD (.05 prob.)

4.6. Effect of different rootstocks cucurbita spp. on production of watermelon CV. 'Jaddoai'.

The effect of grafting watermelon cultivar Jaddoai onto different rootstocks is shown in table (9). There were significant differences in fruit production among the different rootstocks. Pumpkin and Gladioter rootstocks gave significantly the highest total production (15.1 and 14.2 kg/plant respectively) when used as rootstocks. Similar trend was obtained with production grade (>5 kg/plant). On the other hand, both Ein-senna and self-grafted plants resulted in the lowest production (10.4 and

11.3kg/plants respectively), however, regarding production grades (<2 kg and 2-5 kg) all treatment gave significantly similar fruit production except Ein-senna rootstocks. Total production was highest in all of the grafted treatments except Ein-senna rootstocks. About 50% of the production was of the higher grade (>5 kg) in all treatments.

Table 9: Effect of rootstock on production of watermelon CV 'Jaddoai'.

Rootstock	Prod. < 2 Kg/plant	Prod. 2 - 5 Kg/plant	Prod. > 5 Kg/plant	Total Prod. Kg/plant
Pumpkin	**1.9 a***	**4.9 a**	**8.4 a**	**15.1 a**
Al-Qamri squash	**1.7 ab**	**4.2 b**	**6.3 bc**	**12.1 bc**
Ein-senna squash	**1.6 b**	**3.4 c**	**5.4 c**	**10.4 d**
Gladioter watermelon	**1.7 ab**	**4.7 a**	**7.8 a**	**14.2 a**
Watermelon Jaddoai (Self-grafted)	**1.5 b**	**4.2 b**	**5.6 c**	**11.3 cd**
Control (non-grafted)	**1.7 ab**	**4.0 b**	**6.8 b**	**12.5 b**

*Numbers in each column followed by the same letter(s) are not significantly differ according LSD (.05 prob.)

CHAPTER FIVE

DISCUSSION

5. Discussion

5.1. Effect of rootstock on survival rates of grafted watermelon:

The survival rate in Gladioter, Self-grafted, and Pumpkin increased in Ein-senna squash rootstock. Cucurbita type rootstocks (Ein-senna squash) had a lower survival rate than other type rootstocks. This decrease can be explained by the larger pith in these rootstocks. Scion may be inserted in pith without contacting any cut surface, and then the scion will die (Yetisir, 2001, Yetisir and Sari, 2004).

The total number of survival rate was high in all rootstocks because there was choose a suitable time of grafting (fig. 8). However an increase in grafting success was not seen until the rootstock had reaches the third leaf stage but the diameter, length of hypocotyl and vascular bundles was play important role in grafting. As hypocotyls increased in both length, diameter and area grafting success also increased. Oda et al. (1993) reported a survival rate increase in *C. maxima* in which the larger number of vascular bundles was assumed to increase the chance of contact between the vascular bundles at the cut surface of hypocotyls. It was observed that the survival rate of the small scions was lower than that of the large scions in all the cultivars of the rootstocks. I could believe that by minimizing the difference in the diameter of the hypocotyls between the scion and rootstock so, could be enhance combination success, then the survival rate and growth of watermelon would be successes. Yetisir and Sari (2004) demonstrated that the survival rate of grafted plants was inversely correlated with the difference in diameters of scion and rootstock, and that the number of vascular bundles positively affected the growth rate of the grafted watermelon plants.

5.2. Biomass measurements of grafted watermelon on different rootstocks:

The recorded results of biomass production of grafted watermelon showed significant variation between grafted and non grafted plants. This technique enhanced vigorous root system resulting in growth promotion and production increases in growing conditions. Moreover, many researchers report that an interaction between rootstocks and scions exists resulting in high vigor of the root system and greater water and mineral uptake leading to increase yield and fruit enhancement (Lee, 1994; Oda, 1995; Leoni *et al.*, 1990).

Grafted Pumpkin and Gladioter rootstocks plants showed an increased vine biomass associated with an increased root biomass. All measured variables were superior than the non-grafted plants, all the characteristics were significantly affected by type of rootstock used for grafting. It has been reported that grafting promotes vegetative growth at different levels depending on rootstock characteristics. Promoted vigor and vegetative growth could be explained by existing resistance to soil borne diseases (Lee, 1994) increased water and plant nutrition uptake (Rivero et al., 2003) augmented endogenous hormone production (Zijlstra et al., 1994), tolerance to low soil temperature (Den Nijs, 1981) and salinity tolerance in the rootstocks (Rivero et al., 2003). Pumpkin and Gladioter watermelon rootstocks provided vigorous plant and an increase in the production, however, Ein-senna squash caused weaker plant growth and lower production, one reason for this contribution could be the efficiency of the rootstock in providing water and nutrients to the scion. On the contrary, Leoni *et al.*, (1990) state that vegetable grafting does not improve the yield of the cultivation when the selection of the rootstock is not suitable, for example the self-grafted plant had a lower yield than the non-grafted plants.

Therefore, the higher biomass production of this treatment was likely a combination of rootstock vigour and the act of grafting, which subsequently promote larger fruit production. Similar results have been reported elsewhere (Cohen et al., 2005; Lee and Oda, 2003).

In this experiment, Pumpkin and Gladioter rootstocks used the plant’s resources to increase its biomass, and length, in comparison with non-grafted plants, or with self- grafted ones (fig.9). In addition, the root biomass was improved in Pumpkin plants in comparison with non-grafted plant, with the added advantage that this biomass corresponded to a healthy root. As mentioned by Alan et al. (2007), grafted plants have longer main stem, more lateral vine and higher root dry weight than the control plants, and fruit yield of grafted plants is superior to the control.

Pulgar *et al.* (2000) observed increased production of leaves in grafted plants as a result of an increased uptake of water and nutrients. It is well known that the root system of the plants affects vegetative growth and yield. So, the effects of grafting recorded in most research papers are obviously related to the differences in the root system between grafted and non-grafted plants, *i.e.* to the efficiency of water and nutrient uptake by the roots, or even to the distribution of growth regulators. (Oda, 1995; Bletsos et al., 2003; Yetisir et al., 2003).

Plant grafting is a widely used means of plant propagation and growth control that is of considerable importance in the adaptation of interesting cultivars in the appropriate areas (Pina & Errea 2005).

5.3. Effect of rootstock on days to flowering of grafted watermelon:

The result of this study indicated a delay in flowering of both male and female flowers in the two watermelon cultivars grafted onto the different rootstocks. The observed delay in fruit maturity may be explained by Salam *et al*. (2002) who recorded a 4-day delay in the appearance of first female flowers when watermelon was grafted onto *L. siceraria*. It was observed that in open field cultivations flowering began earlier in the self-rooted plant and grafted, probably due to the fact that grafting caused stress and delayed flower formation.

The differences in flower initiation are negligible when suitable temperatures occur at the beginning of the growing season, but with less than optimal conditions, similar findings was reported by Xu *et al*., (2005a) who reported a delay flowering for up to one week in grafted watermelons, resulting in an equal delay in fruit maturity, and Yamasaki *et al*. (1994) who reported that flowering was delayed in watermelon grafted onto bottle gourd rootstocks. In contrast, enhanced flowering was noticed in wild cucurbit species grafted onto squash interspecific rootstock (Nienhuis and Rhodes, 1977; Nienhuis and Lower, 1979), in addition, watermelon grafted onto bottle gourd caused early formation of female flowers when compared to other rootstocks (Kurata, 1976b; Sakata *et al*., 2007).

Sex expression and flowering order are controlled by plant hormones. The rootstock/scion combination may alter amount of hormones produced and their influence on grafted plants organs (Satoh, 1996). Kurata (1976b) and Sakata et al. (2007) stated that compared with other rootstocks, watermelon grafted onto bottle gourd causes early formation of female flowers. In contrast, flowering was delayed in pumpkin, bottle gourd, wax gourd and watermelon-grafted watermelon, especially in plants with ‘Shintosa’-type rootstocks.

Are secondary metabolites and have several functions in plants. They functions as visual traps and antioxidants and play important roles on enzymatic activities, plant growth, fruit quality, graft compatibility and provide resistance against pathogenic microorganisms, herbivores, UV radiation, oxidative and thermal stress (Paolacci et al., 2001; Jaakola et al., 2002; Lorenc-Kukula et al., 2007).

There were six vascular bundles in Nankyoku No. 2, mainly six in Unryuh No. 1 and Kongoh (*C. moschata*), and mainly 12 in Dairoku (*C. maxima*). Since these common cultivars for rootstock show a grafting compatibility, it was assumed that compatibility would not be a major factor in the survival rate which tended to be higher in Unryuh No. 1 than in Kongoh and the lowest in Dairoku. Thus, the survival rate was different between the two cultivars in the same *C. moschata* species, and did not increase in *C. maxima* in which the larger number of vascular bundles was assumed to increase the chance of contact between the vascular bundles at the cut surface of the hypocotyls. It was observed that the survival rate of the small scions was lower than that of the large scions in all the cultivars of the rootstocks. Therefore, the difference in the hypocotyls diameters between the scion and rootstock was correlated with the survival rate. These results suggest that smaller differences in the hypocotyl diameter between the scion and rootstock may increase the survival rate after horizontal grafting at the hypocotyl level while the number of vascular bundle did not affect the survival rate in the present combination (Oda et al., 1993).

Yetisir and Sari (2004) demonstrated that the survival rate of grafted plants was inversely correlated with the difference in diameters of scion and rootstock, and that the number of vascular bundles positively affected the growth rate of the grafted watermelon plants. Edelstein et.al. (2004) showed that stem diameter and number of vascular bundles of the rootstock did not correlate with scion plant fresh weight for *C. melo*scions and 22 *Cucurbita* spp. rootstocks.

On the basis of these results, it was concluded that the reduction in the difference in the diameter of the hypocotyls between the scion and rootstock was effective in increasing the survival rate and promoting the growth of cucumber plants horizontally grafted on Cucurbita spp. at the hypocotyls level. It is extremely important during the grafting process to ensure the vascular fusion between the scion and rootstock by using a cut that maximizes the contact surface and creating the proper conditions for close contact between those two plants. (Assenza, 2004).

Carbohydrates are the most important biochemical compounds in determining the quality of muskmelon fruit, of which the soluble sugars mainly consist of sucrose, glucose, fructose and so on (Lalonde et al., 2003). The kind and amount of various carbohydrates directly influence fruit flavor components such as sweetness. Carbohydrate accumulation is closely related to stachyose metabolism (Taji et al., 2002), photosynthates translocation capacity in phloem (Brian et al., 2003), galactose metabolism and sucrose metabolism in fruit (Dai et al., 2006). The terminal sucrose metabolism is more important for its influence in the final carbohydrates accumulation (Zhang et al., 2003).

5.4. Effect of rootstock on fruit quality of grafted watermelon:

Sugar content is one of the most important characteristics of a good-quality watermelon, based on the fruit quality indices measured, all treatments resulted in significantly similar brix value except with Ein-senna squash in the rind and Ein-senna and Al-Qamri squash inside the fruit which resulted in lower brix values. The above results in general agree with other researchers who found that fruit descriptive and qualitative characteristics were not affected by grafting (Lee, 1994; Leoni et al., 1990; Alan et al., 2007). In another study, Miguel *et al*. (2004) noted no significant effect on TSS of fruit when grafting watermelon onto *C. moschata*, *C. maxima* x *C. moschata*, or *L. siceraria* rootstocks under field conditions. But in other study, some rootstock-scion combinations increase flesh firmness, along with sugar and lycopene content in watermelon (Davis and Perkins-Veazie, 2005).

During the study, fruit maturity of grafted watermelon was delayed about 5 days beyond the non-grafted counterpart which could account for reduced brix value and off flavor as noted in some grafting studies. Mondal *et al*. (1994) reported late maturation of watermelon fruit using *L. leucantha*, *C. moschata*, and *C. maxima* x *C. moschata* as the rootstocks.

Meanwhile, other studies indicated similar findings with our results, Davis and Perkins-Veazie (2005) reported an increase in sugar and lycopene content in watermelon grafted onto different rootstocks. Others found a negative impact on productivity and fruit quality when using *C. metuliferus, and C. zeyheri* as watermelon rootstocks (Trionfetti Nisin et al., 2002). It has been stated that grafting watermelon on *cucurbita* rootstocks may have adverse effects on watermelon fruit quality (Salam et al., 2002). The amount of reducing brix value in fruit varied slightly with the rootstocks, cropping season, and the amount of fertilizer applied. The total sugar content of watermelons grafted onto bottle gourd rootstock was reported to be lower than in self-rooted watermelons (Yao *et al*., 2003; Qian *et al*., 2004; Liu *et al*., 2006).

Watermelon grafted with both Pumpkin and Gladiator rootstock showed high graft compatibility, and therefore , resulted in better fruit quality than other rootstocks. However, with pumpkin rootstock fruit cracking was occurred and therefore, reducing fruit quality (Fig. 10). The big root system observed with pumpkin could be the reason for this phenomena, the bigger the root system, the more water absorption.

It has been reported that pH, flavor, sugar, color, and texture can be affected by grafting vegetables and the type of rootstock used. There are many conflicting reports on changes in fruit quality due to grafting. The differences in reported results may be due in part to different production environments, type of rootstock used, interactions between specific rootstocks and scions, and harvesting date (Proietti et al., 2008).

In our experiment, we detected significant negative effect on watermelon fruit quality with Ein-senna squash rootstock, Abnormal fruit quality were also observed including increased number of yellowish bands in the flesh, thicker rind, insipid taste, poor texture (fig. 11), and decreased firmness. Similar observations were reported with other researchers (Yamasaki et al. 1994; Lee and Oda 2003; Alan et al. 2007, Alexopoulos et al. 2007). Lee (1994) stated that quality traits such as fruit shape, skin color, skin or rind smoothness, flesh texture and colour, soluble solids concentration etc. are influenced by the rootstock. Khan *et al.*, (2007) reported similar results for pH and mineral contents as well as plant growth and yield. However, some other researchers showed that grafting did not affect fruit quality (Leoni *et al.*, 1990; Traka-Mavrona et al., 2000).

5.5. Effect of rootstock on watermelon's production:

This study demonstrates that all variables measured were consistently affected by grafting watermelon scion onto different rootstocks. It includes both biomass and production traits. However, biomass measurements were strongly influenced by many factors. Higher fruit production was observed when both Gladioter and Pumpkin rootstocks were used. The production was increased 50% for fruit grade (>5 kg) in all treatments (fig.12).

The higher total production of watermelon fruit of the cv. 'Crimson Sweet and Jaddoai' grafted onto ' Gladioter and Pumpkin rootstocks ' could be attributed to the vigorous root system of the rootstock as both gave the largest biomass including the root system (table 4 and table 5). These results agreed with the finding of other researchers (Lee, 1994., Besri, 2008). The increased yield of grafted plants is also believed to be due to enhanced water and mineral uptake (Rivero et al., 2003). Pulgar et al. (2000) found that grafting influences absorption and translocation of phosphorus, nitrogen, magnesium, and calcium. Therefore, improving nutrient uptake increases photosynthesis, these conditions allow grafted plants to produce higher yields, sometimes with improved fruit quality (Hu et al., 2006). In addition, many researchers also reported that an interaction between rootstocks and cultivars exists resulting in high vigor of the root system and greater water and mineral uptake leading to increased yield and fruit enhancement (Lee, 1994; Oda, 1995; Lee and Oda 2003; Yetisir and Sari, 2003) (fig.13).

However, grafting decreased total production of grafted watermelon onto Ein-senna squash rootstock. There are many reasons why rootstocks affect scion production. The most obvious is rootstock/scion incompatibility, which induces undergrowth or overgrowth of the scion, (Fig. 14) leading to decreased water and nutrient flow through the grafted union, causing wilting. Incompatibility can be affected by tissue and structure difference, physiological and bio-chemical characteristics, growing stage of rootstock and scion, and the environment (Davis and Perkins-Veazic, 2005).

However, the compatibility differs with varieties even in the same species. In our experiment, all rootstocks were used from *Cucurbita* sp. has the highest growth ability at the same environmental conditions, except Ein-senna rootstock. Watermelon grafted on Ein-senna rootstock is apt to poor growth, resulting in unstable fruit bearing, poor fruit quality with cracks appeared on the rootstock. Cracks will affect water absorption and nutrients uptake. In addition, signs of incompatibility were observed on the graft union (Fig.15). These results agreed with the finding of Dias *et al*., 2004 who stated that vegetable grafting does not improve the yield when the selection of the rootstock is not suitable. When grafting conditions have been successfully ensured, graft incompatibility could be attributed to other factors such as failure of rootstock and scion to establish a strong union, failure of the grafted plant to grow, or premature death of either rootstock or scion after grafting (Andrews and Marquez 1993). The total production was varying by rootstock type. These results agreed with Miguel *et al*., (2004), Yetisir and Sari (2003) and Yetisir *et al*. (2003) who found differences in watermelon production grafted onto multiple rootstocks of *Cucurbita moschata, Cucurbita maxima*, squash interspecific hybrids, and bottle gourd.

There are root lesions on some rootstocks occurred, these correlated in arid areas because these problem in our experiment, occur in closed emitter (fig. 16). Where plants with a highly damaged root system may not wilt, due to the environmental conditions that change from one year to another. Additionally, the wilt caused by *M. cannonballus* can be masked by the occurrence of rootstock-scion incompatibility (Dias *et al*., 2004).

The severity of root lesions and the percentage wilt are highly correlated in arid areas, such as those in some closed emitter, where fields with 100% wilted plants are commonly found. However, the percentage wilt is not an accurate indicator of the response to the disease in more temperate areas, such as in coastal areas of eastern Spain, where plants with a highly damaged root system may not wilt, due to the environmental conditions that change from one year to another. Additionally, the wilt caused by *M. cannonballus* can be masked by the occurrence of rootstock-scion incompatibility (Dias *et al*., 2004).

CHAPTER SIX

CONCLUSIONS

Conclusion

On the basis of these results, Cucurbita species may be used as rootstocks for watermelon production areas. The differences found in the rootstock and scion material before and after grafting, indicated that the development of seedlings before grafting is critical for the success of the cotyledon devoid graft method (one cotyledon graft). Although the survival rate of plants grafted onto Cucurbita type rootstocks was higher in all treatments exception in Ein-senna rootstock to compare of other rootstocks. Therefore, economic analysis should be conducted before the use of these rootstocks to make sure survival rates. Pumpkin, and Gladioter used in this study were suitable rootstocks for grafted watermelon production. Since they showed a similar emergence performance of all watermelon cultivars. Other advantages of Pumpkin and Gladioter are their strong and thick main stem that causes eases in grafting. It may also be concluded that the reduction in the difference in hypocotyl diameters of rootstocks and scion increase the survival rate: however, this is not enough to explain the difference in survival rates of plants grafted onto different rootstocks. The Lagenaria type rootstocks, BH and LCY were in close histological structure and showed higher survival rates, and Lagenaria species have been used as main rootstocks for watermelon worldwide (Lee, 1994).

It can be concluded that grafting, in watermelon plants positively affected plant growth and yield. These effects were changed by the rootstocks being used. Grafted plants produced more fresh and dry matter than did control plants, except for the Crimson Sweet or Jaddoai watermelon/Ein-senna graft combination.

In the measurement of the brix value, it was concluded that grafting resulted a decrease of the values registered in some rootstocks as Ein-senna. None of the plants grafted on either of the rootstock had fruits showing the same or a higher Brix% compared to the fruits of the non grafted plants.

According to this field experiment it can be concluded that grafting did produce increased watermelon yields in each case. The production was increased 50% for fruit grade (>5 kg) in all treatments. . ' Crimson Sweet or Jaddoai watermelon ' grafted on the rootstock in Pumpkin type, 'Gladioter, produced higher yields than the non grafted plant. On the other hand, the interspecific hybrid rootstock 'Ein-senna' showed lower yield than the non-grafted variant. In the course of the field tests sign of postponement of ripening was seen (four days), mentioned by many authors. Based on the respective tests, the rootstocks 'Pumpkin and Gladioter ' proved to be superior to rootstock 'Ein-senna' in all treatments.

References

1. Alabouvette, C., Rouxel, F., Louvet, J., Bremeersch, P., and Mention, M. (1974). Recherche d’un porte-greffe resistant au Phomopsis sclerotioides et au Verticillium dahliae pour la culture du melon et du concombre en serre. PHM **152**:19–24.

2. Alan, Ö., Özdemir, N., and Günen, Y. (2007). Effect of grafting on watermelon plant growth, yield and quality. J. Agron. 6(2): 362-365.

3. Alexopoulos, A., A, Kondylis, A., and Passam, H. (2007). Fruit yield and quality of watermelon in relation to grafting. J Food Agric Environ; 5: 178-9.

4. Andrews, P.K. and Marquez, C.S. (1993). Graft incompatibility. Hort. Rev. 15:183-232.

5. Aounallah, S., H. Jebari and M. El Mahjoub. (2002). Etude de la resistance des porte-greffes de la pasteque (*Citrullus lanatus*) au *Fusarium oxysporum* f. sp. *niveum* et au *Fusarium solani* f. sp. *cucurbitae*. Annales de l'INRAT., 75: 191-204.

6. Ashita E. (1927). Grafting of watermelons (in Japanese). Korea (Chosun) Agricultural Newsletter, 1: 9.

7. Assenza, M. (2004). Grafting tomatoes, an alternative to methyl bromide, Informatore Agrario Vol.60, No.46,41-43.

8. Bell, A.A. (1981). Biochemical mechanism of disease resistance. Annu. Rev. Plant Physiol. 32: 21-81.

9. Besri, M. (2008). Cucurbits grafting as an alternative to methyl bromide for cucurbits production in Morocco.

http://mbao.org/2008/Proceedings/060BesriMGraftingCucurbitsOrlando08.pdf

10. Biles, C.L., Martyn, R.D., Wilson, H.D.1989. Isozymes and general proteins from various watermelon cultivars and tissue types. Hort. Science 24 (5): 810-812.

11. Bletsos, F., Thanassoulopoulos, C., and Roupakias, D. (2003). Effect of grafting on growth, yield, and verticillium wilt of eggplant. Hortscience, 38, 2: 183-186.

12. Boughalleb, N., Mhamdi, M., El Assadi, B., El Bourgi, Z., Tarchoun, N., and Romdhani, M.S. (2008). Resistance evaluation of grafted watermelon (*Citrullus lanatus* L.) against *Fusarium* wilt and *Fusarium* crown and root rot. Asian J. Plant Pathol. 2(1): 24-29.

13.Brian, G.A., Felix, K., and Robert, T. (2003). Symplastic continuity between companion cells and the translocation stream: Long-distance transport is controlled by retention and retrieval mechanisms in the phloem. Plant Physiol. 131: 1518-1528.

14. Bruton, B.D. (1998). Soilborne diseases in Cucurbitaceae: Pathogen virulence and host resistance., p. 143-166. In: McCreight, J. (ed.). in: Cucurbitaceae '98 J. McCreight, ed. Amer. Soc. Hort. Sci, Alexandria, Va.

15. Choi, D.C., SW. Kwon, BR. Ko., JS. and Chou. (2002). Using chemical controls to inhibit axillary buds of *Lagernaria* rootstock for grafted watermelon (*Citrullus lanatus*). Acta Hort. 588:43-48.

16. Clausen, T.P., Reichhardt, P.B., Bryant, J.P., and Provenza, F. (1992). Condensed tannins in plant defense, a perspective on classical theories. In Hemingway RW and Laks PE (eds) Plant Polyphenols, Plenum Press, New York pp. 639-651.

17. Cohen, R., Burger, Y., and Horev, C. (2007). Introducing grafted Cucurbits to modern agriculture: The Israeli experience. Plant Dis. 91:916-923.

18. Cohen, R., Y. Burger, C. Horev, A. Porat, and M. Edelstein. (2005). Peformance of Galia-type melons grafted on to *Curcurbita* rootstock in *Monosporascus cannonballus*-infested and noinfested soils. Ann. Appl. Biol. 146:381-387.

19. Colla, G., Rouphael, Y., Cardarelli, M., Salerno, and Rea, E. (2009). The effectiveness of grafting to improve alkalinity tolerance in watermelon. Enivronmental Exp. Botany. 68(3) 283-291.

20. Colla, G., Suãrez, C.M.C., Cardarelli, M., and Rouphael, Y. (2010). Improving nitrogen use efficiency in melon by grafting HortScience Vol. 45(4) 559-565.

21. Core, J. (2005). Grafting watermelon onto squash or gourd rootstock makes firmer, healthier fruit. Agric. Res. July issue.

22. Cushman, K. (2006). Grafting techniques for watermelon. Univ. Fla. Inst. Food Agr. Sci. HS1075:1-5.

23. Dai, N., Petreikov, M., Portnoy, V., Katzir, N., Pharr, D. M., and Schaffer, A. A. (2006). Cloning and expression analysis of a UDP galactose/glucose pyrophosphorylase from melon fruit provides evidence for the major metabolic pathway of galactose metabolism in raffinose oligosaccharide metabolizing plants. Plant Physiol. 142:294-304.

24. D'amorer., Morral., and Parisib. (1996). Grafted watermelon production results. Colture Protette 25,9: 29-31.

25. Davis, A.R., and Perkins- Veazie, P. (2005-2006). Rootstock effects on plant vigor and watermelon fruit quality. Cucurbit Genet. Coop. Rpt. 28-29:39-41.

26. Davis, A.R., and P. Perkins-Veazic. (2005). Rootstock effects on plant vigor and watermelon fruit quality. Cucurbit Genet. Coop. Rpt. 28:39-42.

27. Davis, A.R., Perkins- Veazie, P., Sakata, Y., López- Galarza, S., Maroto, J.V., Lee, S. G., Huh, Y.C., Miguel, A., King, S.R., Cohen, R., and Lee, Y. M. (2008). Cucurbit grafting. Critical Rev. Plant Sci. 27:50-74.

28. Davis, AR., Webber, III CL., Perkins-Veazie, P., Collins, J. (2006). Impact of cultivar and production practices on yield and phytonutrient content of organically grown watermelon. J Veg Sci 12: 83-91.

29. Den Nijs, and A.P.M. (1981). The effect of grafting on growth and early production of cucumbers at low temperature. Acta Hort. 118, 57-64.

30. Dias, R. C. S., Pico, B., Espinos, A. and Nuez, F. (2004). Resistance to melon vine decline derived from *Cucumis melo* ssp. *agrestis*: genetic analysis of root structure and root response. *Plant Breeding*, 123, 66–72.

31. Dinelli, G., Bonetti, A., Minelli, M., Marotti, I., Catizone, P. and Mazzanti, A. (2006). Content of flavonols in Italian bean (*Phaseolus vulgaris* L.) ecotypes. http://rss.sciencedirect.com/getMessage?

registrationId=JGEFJHEFKMEGRGGLGEMKHENKGIMKMLFQYGN MPKJOS.

32. Ebel, J. (1986). Phytoalexin synthesis: The biochemical analysis of the induction process. Ann. Rev. Phytopathol. 24: 235-264.

33. Edelstein, M. (2004a). Grafting vegetable-crop plants: Pros and cons. Acta Hort. 659:235-238.

34. Edelstein, M., R. Cohen, Y. Burger, SR. Shriber, Pivonia, S., and Shtienberg, D. (1999). Integrated management of sudden wilt in melons, caused by *Monosporascus cannonballus*, using grafting and reduced rates of methyl bromide. Plant Disease 83:1142-1145.

35. Edelstein, M., Tadmor, Y., Abo-Moch, F., Karchi, Z., and Mansour, F. (2000). The potential of *Lagenaria* rootstock to confer resistance to the carmine spider mite, *Tetranychus cinnabarinus* (Acari: Tetranychdae) in Cucurbitaceae. Bul. Entomol. 90:113-117.

36. Edelstein, M., Y. Burger, C. Horev, A. Porat, A. Meir and R. Cohen. (2004). Assessing the effect of genetic and anatomic variation of *cucurbita* rootstocks on vigour, survival and yield of grafted melon. J. Hortic. Sci. Biotechnol., 79 (3): 370-374.

37. Garner, R. (1979). Compatibility and cambial contact. In: The Grafter's handbook. 4th ed. Oxford University Press, New York 1:49-67.

38. Hang, S. D., Zhao, Y. P., Wang, G. Y. and Song, G. Y. (2005). Vegetable Grafting, Beijng, , China: China Agriculture Press.

39. Hassell, R.L. and F. Memmott. 2008. Grafting methods for cucurbit production. HortScience 43:1677–1679.

40. Heo, Y.C. (1991). Effects of rootstocks on exudation and mineral elements contents in different parts of oriental melon and cucumber. MS. Thesis, Kyung Hee Univ., Seoul, Korea.

41. Hoyos, P. (2001). Influence of different rootstocks on the yield and quality of greenhouses grown cucumbers. Acta Horticulturae, **559**: 139–143.

42. Jaakola, L., Määttä, K., Pirttilä, A.M., Törrönen, R., Kärenlampi, S. and Hohtola, A. (2002). Expression of genes involved in anthocyanin biosynthesis in relation to anthocyanin, proanthocyanidin, and flavonol levels during Bilberry fruit development. Plant Physiol. 130: 729-739.

3. Khan, M. S., A. Zaidi, and P. A. Wani. (2007). Role of phosphate-solubilizing microorganisms in sustainable agriculture - A review. Agron. Sustain. Dev. 27:29-43.

44. King, S.R., Davis, A.R., Zhang, X., Crosby, K., 2010. Genetics, breeding and selection of rootstocks for Solanaceae and Cucurbitaceae. Sci. Hort. 127, 106-111.

45. King, S. R. and Davis, A. R. (2006). Transplant survival for watermelon in high wind areas. In: Holmes, G. J. (ed) Proc. *Cucurbitaceae 2006*. Universal Press, Raleigh, NC. pp. 258–264. (Proceedings).

46. King, S. R., Davis, A. R., LaMolinare, B., Liu, W., and Levi, A. (2008). Grafting for disease resistance. Hortsci. 43:1673–1676.

47. Koren, A. and Edelstein, M., 2004. Advantages and limitations of grafted vegetable transplants in Israel. Hort Sci 39:873.

48. Kurata, H. (1976a). Grafting. In: Noubunkyo (ed.), Yasai Zensyo, Melon and Watermelon. Kluwer Academic Publishers, Noubunkyo, Japan: 416–425 .

49. Kurata, H. (1976b). Studies on the sex expression of flowers induced by day-length and temperature in pumpkin and watermelon. Mem. Fac. Agr.Kagawa Univ. 29:1-49.

50. Kurata, K. (1994). Cultivation of grafted vegetables II. Development of grafting robots in Japan. Hort Sci 29:240-244.

51. Lalonde, S., Tegeder, M., Throne-Holst, M., Frommer, W.B. and Patrick, J.W. (2003). Phloem loading and unloading of sugars and amino acids. Plant Cell Environ. 26: 37-56.

52. Lee, J.M. (1994). Cultivation of grafted vegetables. I. Current status, grafting methods and benefits. HortScience, 29: 235-239.

53. Lee, J.M. (2003). Vegetable grafting: advances in vegetable grafting. Chronica Horticulturae, 43, 2, 13- 19.

54. **Lee, J. M. and Oda, M. (2003).** Grafting of herbaceous vegetable and ornamental crops. Hortic. Rev, 28: 61–124.

55. Lee, J.M., Bang, H.J. and Ham, H.S. (1998). Grafting of vegetables. J. Japan Soc. Hort. Sci. 67:1098-1104.

56. Lee, T.J., Sarwinski, S., Ishine, T., Lai, C.C. and Chen, F.Y. (1996). Inhibition of cerebral neurogenic vasodilation by L-glutamine and nitric oxide synthase inhibitors and its reversal by Lcitrulline. J. Pharmacol Expt. Therapeutics 276: 353-358.

57. **Leoni, S., R. Grudina, M. Cadinu, B. Madeddu and M.C. Garletti. (1990).** The influence of four rootstocks on some melon hybrids and a cultivar in greenhouse. Acta Horticulturae, 287: 127-134.

58. Lin, F.C., Zhang, B.X. and GE, Q.X. (1990). Effects of antagonistic substances produced by three isolates of *Bacillus subtilis* on conidia of *Fusarium oxysporum* f. sp. *niveum*. Acta Agric. Universitatis Zhejiangensis 16, Suppl. 2: 235-240.

59. Liu, H.Y., Zhu, Z.J., Diao, M. and Guo, Z.P. (2006). Characteristic of the sugar metablolism in leaves and fruits of grafted watermelon during fruit development. Plant Physiol. Commun. 42: 835-840.

60. Lorenc-Kukuła, K., Wróbel-Kwiatkowska, M., Starzycki, M. and Jan Szopa, J. (2007). Engineering flax with increased flavonoid content and thus *Fusarium* resistance. http://rss.sciencedirect.com

/getMessage?registrationId=EBFJECFJFHFKMB

GGBFQFCFRFFJRJFJLHTHRHFGONL.

61. Masuda, M., T. Takamori, T. Tanaka, H. Takahashi and M. Sugio. (1986). Studies on the characteristics of nutritional uptake of the rootstocks of grafted fruit crops. VII. Fruit quality and water and mineral absorption in watermelon grafted to squash and to bottle gourd interstock. Abstr. Japan. Soc. Hort. Sci. Spring Meet. 180 – 181.

62. Miguel, A., J.v. Maroto, A. San Bautista, C. Baixauli, V. Cebolla, B. Pascual, S. Lopez and J.L. Guardiola. (2004). The grafting of triploid watermelon is an advantageous alternative to soil fumigation by methyl bromide for control of fusarium wilt. Sci. Hortic., 103: 9-17.

63. Ministry of Agriculture (MOA). (2008). Grafting vegetables in Palestine. Technical report (JICA).

64. Misirli, A., Gulcan, R. and Tanrisever, A. (1995). A relationship between the phenolic compounds and the resistance to *Sclerotinia* (monilia) *laxa* (Aderh et ruhl.) in some apricot varieties. Acta Hort. 384: 209-211.

65. Mondal, S.N., Hossainakma, Hossain, A.E., Islamm. A. and Bashar M.A. (1994). Effect of various rootstocks in the graft culture of watermelon in Bangladesh. Punjab Vegetable Grower. 29: 15-19.

66. Morra, L., Bilotto, M. and Castrovilli, M. (2007). Integrated approach with grafting and soil disinfection to protect pepper in greenhouse. Colture Protette, 367: 57-63.

67. Mukherjee, K. and Sen, B. (1998). Biological control of Fusarium wilt of muskmelon by formulations of *Aspergillus niger*. Isr. J. Plant Sci. 46: 67-72.

68. Muramatsu, V. (1981). Problems on vegetable grafting. Shisetu Engei. 10:48-53: 11:46-52.

69. Nicholson, R.L. and Hammerschmidt, R. (1992). Phenolic compounds and their role in disease resistance. Annu. Rev. Phytopathol. 30: 369-389.

70. Nienhuis, J. and Lower, R. L. (1979). Squash interspecific grafting to promote flowering in *Cucumis hardwickii*. *Cucurbit Genetics Coop*. 2: 11–12.

71. Nienhuis, J. and Rhodes, A. M. (1977). Squash interspecific grafting to enhance flowering in wild species of Cucurbits. HortSci. 12: 458–459.

72. Oda, M. (1995). New grafting methods for fruit-bearing vegetables in Japan. JARQ 29:187- 194.

73. Oda, M. (1999). Grafting of vegetables to improve greenhouse production. Food and Fertilizer Tech. Center. www.agnet.org/library/eb/480/ Accessed Dec. 7, 2007.

74. Oda, M. (2002a). Grafting of vegetable crops. Sci. Rep. Agric. Biol. Sci., Osaka Pref. Univ., 53: 1–5.

75. Oda, M. (2002b). Grafting of vegetable crops. Sci. Rep. Agric. & Biol. Sci., Osaka Pref. Univ., 54: 49–72.

76. Oda, M. (2004). Grafting of vegetable to improve greenhouse production. Bull. National.

77. Oda, M., Tsuji, K. and Sasaki, H. (1993). Effect of hypocotyl morphology on survival rate and growth of cucumber seedling grafted on *Cucurbita* spp. Jap. Agric. Res. Quart. 26(4):259-263.

78. Palestinian Central Bureau of *Statistics.* (PCBS). (2005-2006).

79. Paplomatas, E. J., Elena, K., Tsagkarakou, A., and Perdikaris, A. (2002). Control of Verticillium wilt of tomato and cucurbits through grafting of commercial varieties on resistant rootstocks. Acta Hortic. 579:445-448.

80. Paris, S.H. and Brown, R.N. (2005). The genes of pumpkin and squash. Hortscience 40: 1620-1630.

81. Pavlou, G.A., Vakalounakis, D.J. and Ligoxigakis, E.K. (2002). Control of root and stem rot of cucumber, caused by *Fusarium oxysporum* f. sp. *radicis-cucumerinum*, by grafting onto resistant rootstock. Plant Dis. 86: 379-382.

82. Pina A., Errera P. (2005). A review of new advances in mechanism of graft compability-incompability. Scienta Horticulturae 106: 1-11.

83. Proietti, S., Rouphael, Y. and Colla, G., et al. (2008). Fruit quality of miniwatermelon as affected by grafting and irrigation regimes. J Sci Food Agric; 88: 1107-14.

84. Pulgar, G., Villorar, G., D.A., M., and Romero, L. (2000). Improving the mineral nutrition in grafted watermelon plants: Nitrogen metabolism. Biologia Plantarum 43:607-609.

85. Qian, Q. Q., Liu, H. Y., and Zhu, Z. J. (2004). Studies on sugar metabolism and related enzymes activity during watermelon fruit development as influenced by grafting, J. Zhejiang Univ. 30: 285–289.

86. Qian, w., Luj, L., Shengy, Z., Jiangy, T. (1995). Effects of stock types and leaf number on the compatibility and growth of grafted seedlings of melon and watermelon. Acta Agric. Zhejiangensis 7(1): 27-30.

87. Rivero, R.M., J.M. Ruiz and L. Romero. (2003). Role of grafting in horticultural plants under stress conditions. Food Agric., 1 (1): 70-74.

88. Rivero, R. M., Ruiz, J. M., and Romero, L. (2004). Iron metabolism in tomato and watermelon plants: influence of grafting. J. Plant Nutr. **27**: 2221–2234.

89. Robinson, R.W. and Decker-Walters, D.S. (1997). Cucurbits. CAB Int. University Press, Cambridge (GB) 226 pp.

90. Rouphael, Y., Schwarz, D., Krumbien and Colla, G. (2010). Impact of grafting on product quality of fruit vegetables. Scientia Hort. 27, 172-179.

91. Ruiz, J.M. and L. Romero. (1999). Nitrogen efficiency and metabolism in grafted melon plants. Sci. Hortic., 81: 113-123.

92. Sakata, Y., Takayoshi, O., and Mitsuhiro, S. (2007). The history and present state of the grafting of cucurbitaceous vegetables in Japan. Acta Hort. **731**: 159– 170.

93. Salam, M.A., Masum, A.S.M.H., Chodhury, S.S., Dhar, M., Saddeque, M.A. and Islam, M.R. (2002). Growth and yield of watermelon as influenced by grafting J. Biol. Sci. 2, 298-299.

94. SAS Institute. (1990). User's Guide. Statistics. Ver.8. 4th ed. SAS Inst. Cary, N.C.

95. Schultz, J.C., Hunter, M.D., Appei, H.M. (1992). Antimicrobial Activity of Polyphenol Mediates Plant-Herbivare Interactions. In Hemingway RW, and Laks PE (eds) Plant Polyphenols, Plenum Press, New York pp. 621-639.

96. Sun, S.K. and Huang, J.W. (1985). Formulated soil amendment for controlling Fusarium wilt and other soilborne diseases. Plant Disease 69,11: 917-920.

97. Tagliavini, M., D. Scudellari, B. Marangoni, A. Bastianel, F. Franzin and M. Zamborlini. (1992). Leaf mineral composition of apple tree: sampling date and effects of cultivar and rootstock. J. Plant Nutr. 15:605–619.

98. Taji, T., Ohsumi, C., Iuchi, S., Seki, M., Kasuga, M. and Kobayashi, M. (2002). Important roles of drought and cold-inducible genes for galactinol sythase in stress tolerance in *Arabidopsis thaliana*. Plant J. 29: 417-426.

99. Tarchoun, N., N. Boughalleb and A. EL Mbarki. (2005). Agronomic evaluation of nine cucurbit rootstocks and watermelon grafted (*Citrullus lanatus* T.). Revue de l'INAT, 20: 125-140.

100. Tateishi, K. (1927). Grafting watermelon onto pumpkin. J. Jpn. Hortic., 39: 5–8.

101. Tateishi, K. (1931). Study on watermelon grafting. Jissaiengei, 11: 283–282.

102. Taylor, M., Bruton, B., Fish, W., and Roberts, W. (2008). Cost benefit analyses of using grafted watermelon transplants for fusarium wilt disease control. Acta Hort. 782:343- 350.

103. Thies, J. A. and Levi, A. (2007). Characterization of watermelon (Citrullus lanatus var. citroides) germplasm for resistance to root-knot nematodes. HortScience 42: 1530-1533.

104. Traka-Mavrona, E. M. Koutsika-Sotiriou and T. Pritsa. (2000). Response of squash (Cucurbita spp.) as rootstock for melon (Cucumis melo L.). Scientia Hortic., 83: 353-362.

105. Trionfetti Nisini, P., Colla, G., Granati, E., Temperini, O., Crinò, P. and Saccardo, F. (2002). Rootstock resistance to fusarium wilt and effects on fruits yield and quality of two muskmelon cultivars. Scientia Hort. 93:281-288.

106. USDA. Federal Costs of School Food Programs.(2007). Accessed at <http://www.fns.usda.gov/pd/cncosts.htm> on January 17, 2007.

107. USDA. Foods Sold in Competition with USDA School Meal Programs: A Report to Congress January 12, 2001. Washington, DC: USDA, 2001. USDA. Federal Costs of School Food Programs. Accessed at <http://www.fns.usda.gov/pd/cncosts.htm> on January 17, 2007.

108. Venema, J.H., Dijk, B.E., Bax, J.M., Van Hasselt, P.R., and Elzenga, J.T.M., 2008. Grafting tomato (*Solanum lycopersicum*) onto the rootstock of a high-altitude accession of *Solanum habrochaites* improves suboptimal-temperature tolerance. Environ. Expt. Bot. 63:359-367.

109. Wu, T., Zhou, J., Zhang, Y. and Cao, J. (2007). Characterization and inheritance of a bush-type in tropical pumpkin (*Cucurbita moschata* Duchesne). Scient Horticult 114: 1-4.

110. Xu, C. Q., Li, T. L., and Qi, H. Y. (2005a). Effects of grafting on the photosynthetic characteristics, growth situation, and yield of netted muskmelon, China Watermelon and Melon **2**: 1–3.

111. Xu, C.Q., Li, T.L. and Qi, H.Y. (2006). Effects of grafting on development, carbohydrate content and sucrose metabolizing enzymes activities of muskmelon fruit. Acta Hort. Sinica. 33: 773-778.

112. Yamasaki, A., M. Yamashita and S. Furuya. (1994). Mineral concentrations and cytokinin activity in the xylem exudate of grafted watermelons as affected by rootstocks and crop load. I. Jpn.Soc. Hort, Sci, 62:817-826.

113. Yao, F. J., Huang, D. F., Xu, J. H., Zhang, H. M., and Liu, Y. Q. (2003). Effects of rootstocks on growth and fruit quality of grafted watermelon, J. Shanghai Jiaotong Univ. (Agricultural Science) **21**: 289–294.

114. Yetisir, H. (2001). Effect of grafted seedling on plant growth, fruit yield and quality in watermelon and investigation of grafting point histologically. Ph.D. thesis, .ukurova University, Department of Horticulture, Adana-Turkey, p 178.

115. Yetisir, H. and Sari, N. (2003). Effect of different rootstock on plant growth, yield and quality of watermelon. Australian Journal of Experimental Agriculture 43(10) 1269 – 1274.

116. Yetisir, H. and N. Sari. (2004). Effect of hypocotyl morphology on survival rate and growth of watermelon seedlings grafted on rootstocks with different emergence performance at various temperatures. Turkish J. Agric. and For. 28:231-237.

117. Yetisir, H., Caliskan, M., Soylu and Sakar, M. (2006). Some physiological and growth responses of watermelon [C*itrullus lanatus* (Thunb.) Matsum. and Nakai] grafted onto *Lagenaria siceraria* to flooding. Environmental and Experimental Botany.Vol 58 (1-3) 1-8.

118. Yetisir, H. N. (2003). Rootstock resistance to fusarium wilt and effect on watermelon fruit yield and quality. Phytoparasitica 31:1-7.

119. Yetisir, H., N. Sari and S. Y.cel. (2003). Rootstock resistance to Fusarium wilt and effect on watermelon fruit yield and quality. Phytoparasitica, 3: 163-169.

120. Yilmaz, S., Gocmen, M., Unlu, A., Aydinsakir, K., Mutlu, N., Baysal, O., Celikyurt, M.A., Firat, A.F., Celik, I., Aktaş, A., Oztop, A., Zengin, S., Devran, Z., Tekşam, I. (2008). MB consumption in Turkey, Pp: 23-32. In: Pizano, M., ed., Phasing out Methyl Bromide in Turkey Final Report. Kutlu Avcı Ofset, Antalya.

121. Yılmaz, S., Ünlü, A., Gocmen, M., Mutlu, M., Andinsakir, K., Fırat, F. F., Kuzgun, M., Celikyurt, M. A., Sayın, B. And Çelik, İ. (2007). Phase out of methyl bromide for soil fumigation in protected horticulture and cut flower production in Turkey. First Progress Report, 2007. Antalya, Turkey.

122. Zhang, M.F., Li, Z.L., Chen, K.S., Qian, Q.Q., Zhang, S.L. (2003). The relationship between sugar accumulation and enzymes related to sucrose metabolism in developing fruits of muskmelon. J. Plant Physiol. Mol. Biol. 29: 455-462.

123. Zijlstra, S., Groot, S.P.C. and Jansen, J. (1994). Genotypic variation of rootstocks for growth and production in cucumber; Possibilities for improving by plant breeding. Sci. Hort. 56, 185-196.

Appendices

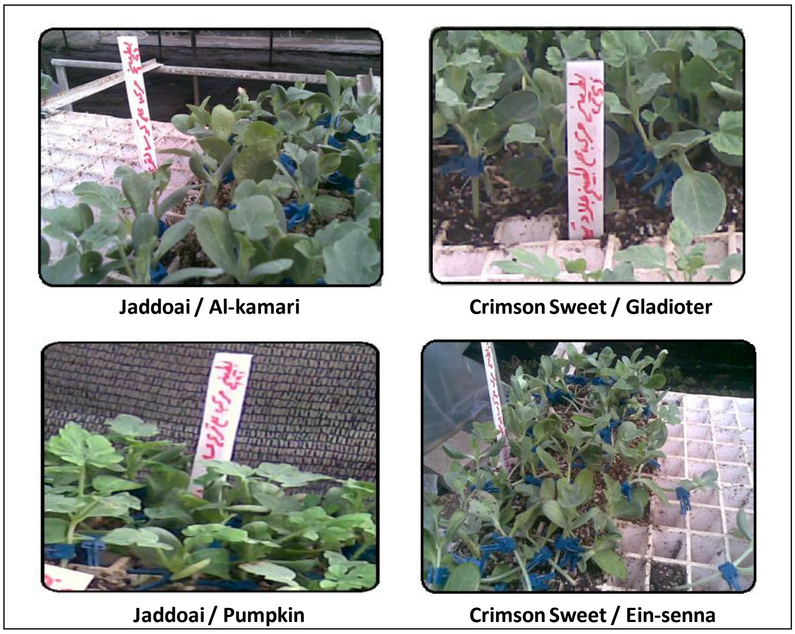

Fig.8. The effects of different rootstocks on the Survival rate of grafting combinations after 40 days.

Fig.9. The effects of different rootstocks on plant biomass.

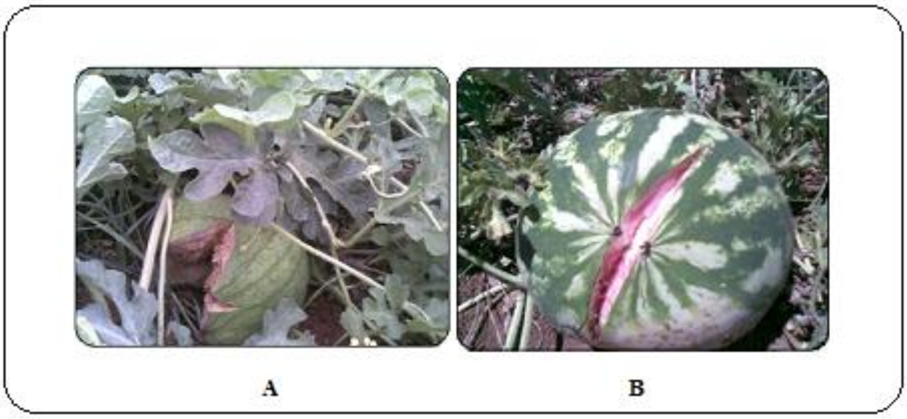

Fig. 10: The effect of rootstock on fruit quality: Fruit cracks onto Pumpkin rootstock in both cultivars.

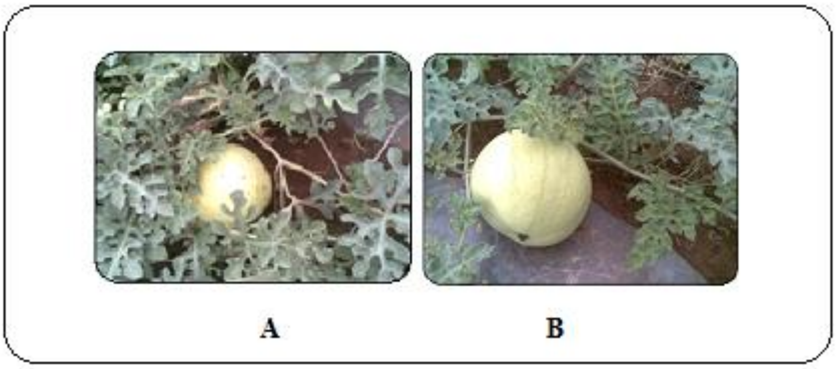

Fig. 11: The effect of rootstock on fruit quality: Fruit yellowish onto Ein-senna rootstock in both cultivars.

Fig.12. Yield production for two cultivars (Crimson Sweet and Jaddoai watermelon).

Fig.13. Yield production for Gladioter rootstocks (Crimson Sweet and Jaddoai watermelon).

Fig. 14: The different compatibility into different rootstocks. (**A**) Crimson Sweet / Ein-senna rootstock. (**B**) Crimson Sweet / Pumpkin rootstock. (**C**) Crimson Sweet / Al-kamari rootstock. (**D**) Crimson Sweet / Gladioter rootstock.

Fig. 15: Root lesions on Ein-senna rootstocks in both cultivars.

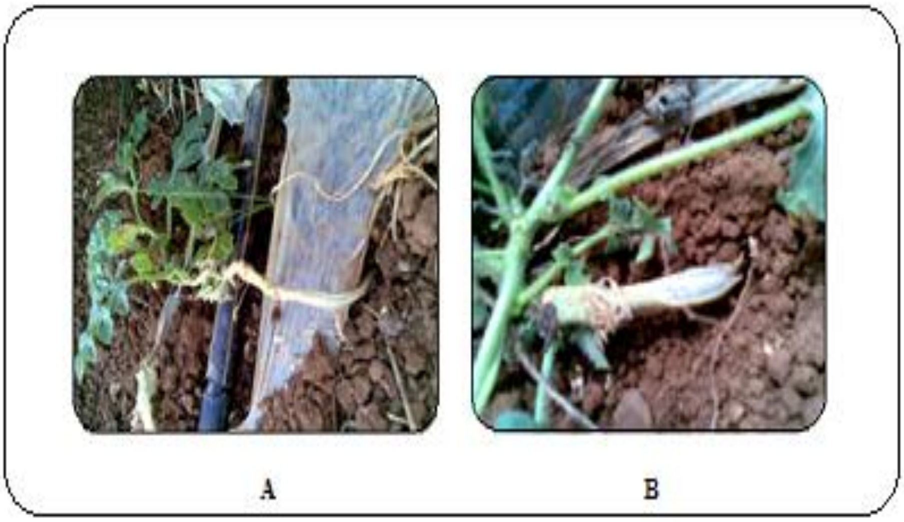

Fig. 16: Root lesions on some different rootstocks (**A**) Ein-senna rootstock grafted onto Jaddoai watermelon (**B**) Al-Qamri squash rootstock grafted onto Jaddoai watermelon.

Fig. 17: Pumpkin and Gladioter as Rootstock.

```
  The GLM Procedure
Dependent Variable: vegfresh
                                                 Sum of
       Source                      DF          Squares     Mean Square    F Value
Pr > F

       Model                       11      102169256.3       9288114.2      87.02
<.0001

       Error                       36        3842275.0        106729.9

       Corrected Total             47      106011531.3


                      R-Square     Coeff Var      Root MSE    vegfresh Mean

                      0.963756      5.544845      326.6954         5891.875


       Source                      DF        Type I SS     Mean Square    F Value
Pr > F

       cv                           1       4668768.75      4668768.75      43.74
<.0001
       rootstock                    5      96697793.75     19339558.75     181.20
<.0001
       cv*rootstock                 5        802693.75       160538.75       1.50
0.2129


       Source                      DF      Type III SS     Mean Square    F Value
Pr > F

       cv                           1       4668768.75      4668768.75      43.74
<.0001
       rootstock                    5      96697793.75     19339558.75     181.20
<.0001
       cv*rootstock                 5        802693.75       160538.75       1.50
0.2129
                                       The SAS System          23:32 Tuesday,
June 6, 2000   9

                                        The GLM Procedure

Dependent Variable: vegdry

                                                  Sum of
       Source                      DF          Squares     Mean Square    F Value
Pr > F

       Model                       11      4211347.729      382849.794      79.83
<.0001

       Error                       36       172653.250        4795.924

       Corrected Total             47      4384000.979
```

R-Square	Coeff Var	Root MSE	vegdry Mean
0.960617	9.422391	69.25261	734.9792

Source	DF	Type I SS	Mean Square	F Value	Pr > F
cv	1	109921.021	109921.021	22.92	<.0001
rootstock	5	3927931.604	785586.321	163.80	<.0001
cv*rootstock	5	173495.104	34699.021	7.24	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
cv	1	109921.021	109921.021	22.92	<.0001
rootstock	5	3927931.604	785586.321	163.80	<.0001
cv*rootstock	5	173495.104	34699.021	7.24	<.0001

The GLM Procedure

Dependent Variable: rootlength

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	26665.72917	2424.15720	38.37	<.0001
Error	36	2274.25000	63.17361		
Corrected Total	47	28939.97917			

R-Square	Coeff Var	Root MSE	rootlength Mean
0.921415	13.73831	7.948183	57.85417

Source	DF	Type I SS	Mean Square	F Value	Pr > F
cv	1	111.02083	111.02083	1.76	0.1933

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rootstock	5	25654.85417	5130.97083	81.22	<.0001
cv*rootstock	5	899.85417	179.97083	2.85	0.0288

Source	DF	Type III SS	Mean Square	F Value	Pr > F
cv	1	111.02083	111.02083	1.76	0.1933
rootstock	5	25654.85417	5130.97083	81.22	<.0001
cv*rootstock	5	899.85417	179.97083	2.85	0.0288

The SAS System 23:32 Tuesday, June 6, 2000 11

The GLM Procedure

Dependent Variable: rootfresh

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	27221.16667	2474.65152	18.50	<.0001
Error	36	4815.50000	133.76389		
Corrected Total	47	32036.66667			

R-Square	Coeff Var	Root MSE	rootfresh Mean
0.849688	19.22266	11.56563	60.16667

Source	DF	Type I SS	Mean Square	F Value	Pr > F
cv	1	560.33333	560.33333	4.19	0.0480
rootstock	5	26276.16667	5255.23333	39.29	<.0001
cv*rootstock	5	384.66667	76.93333	0.58	0.7186

Source	DF	Type III SS	Mean Square	F Value	Pr > F
cv	1	560.33333	560.33333	4.19	0.0480

rootstock	5	26276.16667	5255.23333	39.29	<.0001
cv*rootstock	5	384.66667	76.93333	0.58	0.7186

The GLM Procedure

Dependent Variable: rootdry

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	576.3466667	52.3951515	10.18	<.0001
Error	36	185.3300000	5.1480556		
Corrected Total	47	761.6766667			

R-Square	Coeff Var	Root MSE	rootdry Mean
0.756682	29.82168	2.268933	7.608333

Source	DF	Type I SS	Mean Square	F Value	Pr > F
cv	1	52.5008333	52.5008333	10.20	0.0029
rootstock	5	495.6266667	99.1253333	19.25	<.0001
cv*rootstock	5	28.2191667	5.6438333	1.10	0.3793

Source	DF	Type III SS	Mean Square	F Value	Pr > F
cv	1	52.5008333	52.5008333	10.20	0.0029
rootstock	5	495.6266667	99.1253333	19.25	<.0001
cv*rootstock	5	28.2191667	5.6438333	1.10	0.3793

Class Level Information

Class	Levels	Values
cv	2	5 9

rootstock 6 1 2 3 4 5 6

Number of observations 48

The SAS System 23:32 Tuesday, June 6, 2000 2

The GLM Procedure

Dependent Variable: leafperbranch

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	18158.66667	1650.78788	23.03	<.0001
Error	36	2580.00000	71.66667		
Corrected Total	47	20738.66667			

R-Square	Coeff Var	Root MSE	leafperbranch Mean
0.875595	16.98786	8.465617	49.83333

Source	DF	Type I SS	Mean Square	F Value	Pr > F
cv	1	80.08333	80.08333	1.12	0.2975
rootstock	5	18067.16667	3613.43333	50.42	<.0001
cv*rootstock	5	11.41667	2.28333	0.03	0.9994

Source	DF	Type III SS	Mean Square	F Value	Pr > F
cv	1	80.08333	80.08333	1.12	0.2975
rootstock	5	18067.16667	3613.43333	50.42	<.0001
cv*rootstock	5	11.41667	2.28333	0.03	0.9994

The SAS System 11:44 Sunday, April 23, 2000 3

The GLM Procedure

Dependent Variable: branchnumber

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	591.9166667	53.8106061	22.01	<.0001
Error	36	88.0000000	2.4444444		
Corrected Total	47	679.9166667			

R-Square	Coeff Var	Root MSE	branchnumber Mean
0.870572	20.73112	1.563472	7.541667

Source	DF	Type I SS	Mean Square	F Value	Pr > F
cv	1	14.0833333	14.0833333	5.76	0.0217
rootstock	5	571.6666667	114.3333333	46.77	<.0001
cv*rootstock	5	6.1666667	1.2333333	0.50	0.7708

Source	DF	Type III SS	Mean Square	F Value	Pr > F
cv	1	14.0833333	14.0833333	5.76	0.0217
rootstock	5	571.6666667	114.3333333	46.77	<.0001
cv*rootstock	5	6.1666667	1.2333333	0.50	0.7708

The GLM Procedure

Dependent Variable: branchlength

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F

```
                    Model              11      6.41229167      0.58293561
8.13    <.0001

                    Error              36      2.58250000      0.07173611

                    Corrected Total    47      8.99479167

                                R-Square     Coeff Var      Root MSE
branchlength Mean

                                0.712889      17.53905      0.267836
1.527083


                    Source             DF       Type I SS     Mean Square    F
Value    Pr > F

                    cv                  1      0.22687500      0.22687500
3.16    0.0838
                    rootstock           5      5.96354167      1.19270833
16.63    <.0001
                    cv*rootstock        5      0.22187500      0.04437500
0.62    0.6864


                    Source             DF     Type III SS     Mean Square    F
Value    Pr > F

                    cv                  1      0.22687500      0.22687500
3.16    0.0838
                    rootstock           5      5.96354167      1.19270833
16.63    <.0001
                    cv*rootstock        5      0.22187500      0.04437500
0.62    0.6864

                          The SAS System                          11:44 Sunday,
April 23, 2000   5

                                                     The GLM Procedure

Dependent Variable: flowermale

                                                       Sum of
                    Source             DF          Squares     Mean Square    F
Value    Pr > F

                    Model              11     2617.416667      237.946970
27.77    <.0001

                    Error              36      308.500000        8.569444

                    Corrected Total    47     2925.916667
```

R-Square	Coeff Var	Root MSE	flowermale Mean
0.894563	5.391917	2.927361	54.29167

Source	DF	Type I SS	Mean Square	F Value	Pr > F
cv	1	12.000000	12.000000	1.40	0.2444
rootstock	5	2589.416667	517.883333	60.43	<.0001
cv*rootstock	5	16.000000	3.200000	0.37	0.8635

Source	DF	Type III SS	Mean Square	F Value	Pr > F
cv	1	12.000000	12.000000	1.40	0.2444
rootstock	5	2589.416667	517.883333	60.43	<.0001
cv*rootstock	5	16.000000	3.200000	0.37	0.8635

The SAS System 11:44 Sunday, April 23, 2000 7

The GLM Procedure

Dependent Variable: flowerfemale

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	2006.666667	182.424242	23.21	<.0001
Error	36	283.000000	7.861111		
Corrected Total	47	2289.666667			

R-Square	Coeff Var	Root MSE	flowerfemale Mean
0.876401	4.799602	2.803767	58.41667

Source	DF	Type I SS	Mean Square	F Value	Pr > F

```
                    cv                    1       36.750000       36.750000
4.67    0.0373
                    rootstock             5     1958.166667      391.633333
49.82    <.0001
                    cv*rootstock          5       11.750000        2.350000
0.30    0.9102


                    Source               DF     Type III SS     Mean Square    F
Value    Pr > F

                    cv                    1       36.750000       36.750000
4.67    0.0373
                    rootstock             5     1958.166667      391.633333
49.82    <.0001
                    cv*rootstock          5       11.750000        2.350000
0.30    0.9102

                          The SAS System                       11:44 Sunday,
April 23, 2000   8


The GLM Procedure

Dependent Variable: brixrind

                                                  Sum of
       Source                      DF          Squares     Mean Square    F Value
Pr > F

       Model                       11      52.41666667      4.76515152      11.07
<.0001

       Error                       36      15.50000000      0.43055556

       Corrected Total             47      67.91666667


                      R-Square     Coeff Var      Root MSE    brixrind Mean

                      0.771779      10.56914      0.656167         6.208333


       Source                      DF       Type I SS     Mean Square    F Value
Pr > F

       cv                           1      1.33333333      1.33333333       3.10
0.0869
       rootstock                    5     49.16666667      9.83333333      22.84
<.0001
       cv*rootstock                 5      1.91666667      0.38333333       0.89
0.4978


       Source                      DF     Type III SS     Mean Square    F Value
Pr > F
```

cv	1	1.33333333	1.33333333	3.10	0.0869
rootstock	5	49.16666667	9.83333333	22.84	<.0001
cv*rootstock	5	1.91666667	0.38333333	0.89	0.4978

The SAS System 23:32 Tuesday, June 6, 2000 7

The GLM Procedure

Dependent Variable: brixinside

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	113.4166667	10.3106061	18.11	<.0001
Error	36	20.5000000	0.5694444		
Corrected Total	47	133.9166667			

R-Square	Coeff Var	Root MSE	brixinside Mean
0.846920	7.706711	0.754615	9.791667

Source	DF	Type I SS	Mean Square	F Value	Pr > F
cv	1	18.75000000	18.75000000	32.93	<.0001
rootstock	5	91.91666667	18.38333333	32.28	<.0001
cv*rootstock	5	2.75000000	0.55000000	0.97	0.4516

Source	DF	Type III SS	Mean Square	F Value	Pr > F
cv	1	18.75000000	18.75000000	32.93	<.0001
rootstock	5	91.91666667	18.38333333	32.28	<.0001
cv*rootstock	5	2.75000000	0.55000000	0.97	0.4516

The SAS System 23:32 Tuesday, June 6, 2000 8

The GLM Procedure

```
Dependent Variable: numberfruits

                                         Sum of
                    Source            DF       Squares       Mean Square    F
Value    Pr > F

                    Model             11     21.25000000      1.93181818
4.97    0.0001

                    Error             36     14.00000000      0.38888889

                    Corrected Total   47     35.25000000


                                 R-Square     Coeff Var      Root MSE
numberfruits Mean

                                 0.602837      38.37597      0.623610
1.625000


                    Source             DF       Type I SS     Mean Square    F
Value    Pr > F

                    cv                  1      0.75000000      0.75000000
1.93    0.1734
                    rootstock           5     20.00000000      4.00000000
10.29    <.0001
                    cv*rootstock        5      0.50000000      0.10000000
0.26    0.9334


                    Source              DF     Type III SS     Mean Square    F
Value    Pr > F

                    cv                   1      0.75000000      0.75000000
1.93    0.1734
                    rootstock            5     20.00000000      4.00000000
10.29    <.0001
                    cv*rootstock         5      0.50000000      0.10000000
0.26    0.9334

                         The SAS System                       11:44 Sunday, April
23, 2000   6

                                     Class Level Information

                              Class          Levels    Values

                              cv                  2    5 9

                              rootstock           6    1 2 3 4 5 6


                                  Number of observations    48
```

```
                                 The SAS System          23:32 Tuesday,
June 6, 2000   2

    The GLM Procedure

  Dependent Variable: prolesstwo

                                                        Sum of
         Source                      DF          Squares     Mean Square    F
  Value    Pr > F

         Model                       11      0.83229167      0.07566288
  3.16    0.0044

         Error                       36      0.86250000      0.02395833

         Corrected Total             47      1.69479167


                     R-Square     Coeff Var      Root MSE    prolesstwo Mean

                     0.491088      9.440496      0.154785           1.639583


         Source                      DF       Type I SS     Mean Square    F
  Value    Pr > F

         cv                           1      0.07520833      0.07520833
  3.14    0.0849
         rootstock                    5      0.63604167      0.12720833
  5.31    0.0009
         cv*rootstock                 5      0.12104167      0.02420833
  1.01    0.4258


         Source                      DF     Type III SS     Mean Square    F
  Value    Pr > F

         cv                           1      0.07520833      0.07520833
  3.14    0.0849
         rootstock                    5      0.63604167      0.12720833
  5.31    0.0009
         cv*rootstock                 5      0.12104167      0.02420833
  1.01    0.4258
                                  The SAS System          23:32 Tuesday,
  June 6, 2000   3

                                      The GLM Procedure

  Dependent Variable: twotofive

                                                        Sum of
         Source                      DF          Squares     Mean Square    F
  Value    Pr > F
```

```
       Model                        11      9.19416667      0.83583333
7.33    <.0001

       Error                        36      4.10500000      0.11402778

       Corrected Total              47     13.29916667

                     R-Square     Coeff Var      Root MSE    twotofive Mean

                     0.691334      8.227736      0.337680          4.104167


       Source                       DF       Type I SS     Mean Square    F
Value    Pr > F

       cv                            1      0.56333333      0.56333333
4.94    0.0326
       rootstock                     5      7.24166667      1.44833333
12.70    <.0001
       cv*rootstock                  5      1.38916667      0.27783333
2.44    0.0531


       Source                       DF     Type III SS     Mean Square    F
Value    Pr > F

       cv                            1      0.56333333      0.56333333
4.94    0.0326
       rootstock                     5      7.24166667      1.44833333
12.70    <.0001
       cv*rootstock                  5      1.38916667      0.27783333
2.44    0.0531
                                  The SAS System          23:32 Tuesday, June
6, 2000   4

                                         The GLM Procedure

Dependent Variable: morethanfive

                                                Sum of
       Source                       DF         Squares     Mean Square    F
Value    Pr > F

       Model                        11     42.81166667      3.89196970
15.09    <.0001

       Error                        36      9.28500000      0.25791667

       Corrected Total              47     52.09666667

                    R-Square     Coeff Var      Root MSE    morethanfive Mean

                    0.821774      8.180214      0.507855             6.208333
```

```
      Source                      DF       Type I SS     Mean Square    F
Value    Pr > F

      cv                           1     11.21333333     11.21333333
43.48    <.0001
      rootstock                    5     24.71666667      4.94333333
19.17    <.0001
      cv*rootstock                 5      6.88166667      1.37633333
5.34    0.0009


      Source                      DF     Type III SS     Mean Square    F
Value    Pr > F

      cv                           1     11.21333333     11.21333333
43.48    <.0001
      rootstock                    5     24.71666667      4.94333333
19.17    <.0001
      cv*rootstock                 5      6.88166667      1.37633333
5.34    0.0009
                                   The SAS System           23:32 Tuesday,
 June 6, 2000   5

                                       The GLM Procedure

Dependent Variable: total

                                                Sum of
      Source                      DF          Squares     Mean Square    F
Value    Pr > F

      Model                       11      98.8572917       8.9870265
19.92    <.0001

      Error                       36      16.2425000       0.4511806

      Corrected Total             47     115.0997917


                       R-Square     Coeff Var      Root MSE    total Mean

                       0.858883      5.619939      0.671700      11.95208


      Source                      DF       Type I SS     Mean Square    F
Value    Pr > F

      cv                           1     19.12687500     19.12687500
42.39    <.0001
      rootstock                    5     69.04104167     13.80820833
30.60    <.0001
      cv*rootstock                 5     10.68937500      2.13787500
4.74    0.0020
```

```
       Source                          DF     Type III SS     Mean Square    F
Value    Pr > F

       cv                               1     19.12687500     19.12687500
42.39    <.0001
       rootstock                        5     69.04104167     13.80820833
30.60    <.0001
       cv*rootstock                     5     10.68937500      2.13787500
4.74    0.0020
                              The SAS System           23:32 Tuesday, June 6,
2000   6
```

جامعة النجاح الوطنية

كلية الدراسات العليا

سلوك البطيخ المُطعَّم على أصول مختلفة

إعداد

هاشم درداح أحمد علي

إشراف

الدكتور حسان أبو قاعود

قدمت هذه الأطروحة استكمالاً لمتطلبات الحصول على درجة الماجستير في الإنتاج النباتي بكلية الدراسات العليا في جامعة النجاح الوطنية في نابلس، فلسطين.

2012

سلوك البطيخ المُطعَّم على أصول مختلفة

إعداد

هاشم درداح أحمد علي

إشراف

الدكتور حسان أبو قاعود

الملخَّص

يتناول هذا البحث بالدراسة والتحليل تأثير استخدام أصول محلية مختلفة على نجاح عمليّة التطعيم، ونمو النبات، وإنتاجيَّة البطيخ، وجودة الثِّمار على صِنْفَيْنِ اثنين من البطيخ [بطيخ كرمسون حلو و جدوعي] في حقل مفتوح – أنفاق صغيرة – في قرية بردلة بمحافظة طوباس والأغوار الشمالية (فلسطين)، حيث استخدم الصنفان كطعم، وهما: بطيخ (كرمسون حلو) وبطيخ (جدوعي) على الأصول الآتية: القرع (*Cucurbita moschata*)، وكوسا عين سينيا *(Cucurbita maxima)*، وبطيخ جلادوتير *(Citrullus lanatus var. Gladioter)*، وكوسا القمري *(Cucurbita pepo var. melopepo)*.

استخدمت طريقة التطعيم القطعي المائل في القرعيات، بحيث كانت المعاملات في كل صنف على النحو الآتي: التطعيم على أصل قرع *(Cucurbita moschata)*، وكوسا عين سينيا *(Cucurbita maxima)*، وبطيخ جلادوتير *(Citrullus lanatus var. Gladioter)*، وكوسا القمري *(Cucurbita pepo var. melopepo)*)، وقد تمَّ تطعيم الصنف على نفسه، والشاهد (غير مطعم).

تمّت زراعة النباتات المطعمة وغير المطعمة باليد على مسافات ثابتة (2م × 2م)، وذلك بتاريخ الثاني من شهر كانون ثاني لعام 2011، علماً بأنَّ تغطية التربة بالبلاستيك الشفاف، والري بالتنقيط، والأنفاق صغيرة. وأجريت التجربة على نظام عشوائية كاملة(CRD) بأربعة مكررات، تتكون كل وحدة تجريبية من عشر شتلات.

تم تسجيل القراءات الآتية: عدد النباتات التي نجحت حتى تاريخ الزراعة، قياسات الكتلة الحيوية: طول النبات (سم)، وعدد الفروع في النبات، وعدد الأوراق لكل فرع، والوزن الخضري للنبات الطازج والجاف (غم)، ووزن الجذر الطازج والجاف (غم)، وطول الجذر (سم)، وعدد الأيام الأولى من ظهور الزهرة الذكرية والإنثوية، مجموع الثمار التي تم قطفها عن النبات الواحد حسب تدرّج الوزن، وإنتاجية الثمار (كغم/نبات)، مجموع الموادّ الصلبة الذائبة في الثمار (بركس %).

ولُوحظ نجاح عمليَّة التطعيم بنسبة عالية لصنفي البطيخ على الأصول المختلفة، حيث وصلت النسبة من (90%– 100%). لذا تشير تلك النسبة إلى أن الاختلافات الصغيرة في قطر السويقة الجنينية بين التركيبة والأصل من الممكن أن يزيد أو يقلل من معدل نجاح الشتلات.

وكان مجموع إنتاجية الثمار على النباتات المطعمة أعلى بكثير من النباتات غير المطعمة لكلا الصنفين على الأصول المختلفة، فمن ناحية تم الحصول على أعلى مجموع إنتاج عندما كانت تستخدم على كلا الأصلين، وهما: القرع والبطيخ جلادوتير (15.1 و14.2 كغم / نبات على التوالي). ومن ناحية أخرى أدى كل من الأصل عين سينيا والنباتات المطعمة ذاتياً الى أدنى إنتاج (10.4 و 11.3 كغم / نبات على التوالي).

وكانت النباتات المطعمة على أصل القرع والبطيخ جلادوتير أكثر نشاطاً في النمو الخضري من تلك المطعمة على أصل كوسا عين سينيا، إذ انتجت النباتات المطعمة على أصل "القرع والبطيخ جلادوتير (8363 غم / نبات و8050 غم / نبات على التوالي) أكثر من الوزن الخضري للجذر الطازج من النباتات المطعمة على أصل عين سينيا والمطعمة ذاتياً (4263 غم / نبات و5293 جم / نبات على التوالي)، في حين أن النباتات غير المطعمة (الشاهد) أعطت وزن أقل من النباتات الخضرية الطازجة في كلا المعاملتين. ومع ذلك أظهر كل من الشاهد والنباتات المركبة ذاتياً الإنتاج مبكراً، كما أظهر أيضاً تحسين طول الساق وعدد الأفرع الجانبية للنبات وعدد الأوراق لكل فرع، وطول الجذور والوزن الخضري للساق الطازج والجاف والأوراق

والجذر، في حين أن الشاهد له ساق قصير، وأقل عدداً من الفروع الجانبية للنبات، وانخفاض الوزن النباتي للأوراق والساق والجذر الطازج والجاف.

فقد أظهرت هذه النتائج أن هناك اختلافات هامة بين الأصول المطعمة على أصل عين سينيا، فهو ضعيف من حيث الكتلة الحيوية، كما أن استخدام التطعيم يمكن أن يكون بديلاً جيداً في إنتاج البطيخ.