GROWTH, FRUIT YIELD AND QUALITY OF GRAFTED WATERMELON (*Citrullus lanatus*) ON SEVERAL ROOTSTOCKS UNDER OPEN FIELD CONDITIONS IN JORDAN VALLEY AND HIGHLANDS

By

Fuad Ahmad Salama Suleiman

Supervisor

Dr. M.A. Suwwan, Prof.

This thesis was submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Horticulture and Crop Science

Faculty of Graduate Studies

University of Jordan

June 2007

This thesis was successfully defended and approved on June 19th, 2007
(Growth, fruit yield and quality of grafted watermelon (*Citrullus lanatus*) on several rootstocks under open field conditions in Jordan Valley and Highlands)

Examination Committee	**Signature**
1- Dr. M. A. Suwwan, Chairman Prof. of Vegetable Production and Physiology	
2. Dr. Dawud M. H. Al-Eisawi, Member Prof. of Botany	D. Al-Eisawi
3-Dr. Mahmoud A. Kasrawi, Member Prof. of Vegetable Breeding	M.A. Kasrawi
4- Dr. Nazir A. Hadidi, Member Assoc. Prof. of Vegetable production	N. Hadidi
5- Dr. Ibrahim M. Makhadmeh, Member Assist. Prof. of Hort./Vegetable Production (Jordan University of Science and Technology)	

Dedication

To my family

Parents, Wife, Sons and Daughter

Acknowledgement

Heartfelt appreciations and sincere gratitude are expressed to my advisor Dr. M. A. Suwwan for his great patience and efforts in guidance, supervision and advice throughout the course of field work and preparation of this thesis.

I am also grateful to all members of the examination committee, Dr. Dawud M. H. Al-Eisawi, Dr. Mahmoud A. Kasrawi, Dr. Nazir A. Hadidi and Dr. Ibrahim M. Makhadmeh for reviewing this manuscript.

Appreciation and thanks are also extended to Mr. Hazem Sharif, Mrs. Fadwa Shqadif, and Mrs. Fatima Abu-Hamour for their kind help.

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ABSTRACT

Two field experiments were conducted at Jordan Valley (Balawneh) and Highlands (Jerash) to study the effect of grafting on growth, fruit yield and quality of "Samara" watermelon. "Samara" watermelon was grafted on eight rootstocks: four of which were of the *Cucurbita* type (Tetsukabuto, PT 1313, Shintoza supreme and Azman) and the other four were from the *Lagenaria* type (Emphasis, FR Strong, Bottle gourd and 64-15 RZ) along with intact and self grafted controls.

Grafting "Samara" on Azman rootstock in both locations, significantly increased "number of leaves, dry weight, male and female flowers" per plant. These parameters were similar when "Samara" was grafted on *Cucurbita* rootstocks, but were generally superior to those obtained by grafting on *Lagenaria* rootstocks and the two controls. While Male : Female flower ratio was similar for all grafting treatments and the two controls in Balawneh, this ratio was generally higher for the *Cucurbita* type rootstocks than for those of the *Lagenaria* rootstocks and the controls in Jerash.

Marketable and total yields and fruit numbers were superior when "Samara" was grafted on Azman rootstock in both locations. In general, *Cucurbita* rootstocks were more effective in these parameters than those of the *Lagenaria* type. However, unmarketable yield was the least by grafting on *Cucurbita* rootstocks and highest by grafting on the *Lagenaria* rootstocks and the two controls in Balawneh. In Jerash, unmarketable yields of all treatments were similar, except for the intact control which gave significantly highest unmarketable yields. Grafting on *Cucurbita* rootstocks effectively increased average weight of marketable fruits in both locations especially when "Samara" was grafted on Tetsukaboto and Azman (*Cucurbita* type) in Balawneh location.

Grafting also exerted variable effects on the chemical properties of watermelon fruits. In each of the locations reducing sugar contents were similar for all treatments. In contrast, total sugars were significantly higher in fruits of the self grafted control and lower by grafting on 64-15 RZ (*Lagenaria* type); otherwise total sugars were similar for the other treatments in Balawneh, while all treatments in Jerash gave similar total sugar and total soluble solids values. In the Jordan Valley, total soluble solids increased significantly by grafting on the two rootstocks, Emphasis and Bottle gourd (*Lagenaria* type) and the two controls.

Lycopene increased significantly when "Samara" was grafted on Tetsukabuto than when grafted on Azman (*Cucurbita* type) or on the root-stocks of the *Lagenaria* type and the two controls. In Jerash, lycopene contents increased significantly by grafting "Samara" on Tetsukabuto over the other *Cucurbita* rootstocks and the two rootstocks, Bottle gourd and Emphasis (*Lagenaria* type).

Therefore, it is recommended that farmers of the Jordan Valley (Balawneh) and Highlands (Jerash) use "Samara" watermelon grafted on *Cucurbita* root-stocks especially Azman and Shintoza supreme.

1. INTRODUTION

In Jordan, watermelon is cultivated in both Jordan Valley and Highland, with an average total area (Table 1) of about 15,876 du (4.6 % of the total vegetable area (Table 2). About 2,438 du of this area is planted in the Jordan Valley (mainly the southern part) in the winter season, and the remaining area is planted in the Highland in the summer season (Table 1). The average yield of watermelon reaches 5.2 and 4.2 tons/du, in Jordan Valley and Highland, respectively (Table2).

In vegetable production, most of the damage from continuous cropping is caused by soil borne diseases and nematodes (Oda, 2004). According to Yetisir *et al*. (2003) *Fusarium* wilt may have strong adverse effects on intensive watermelon production either during early cultivation under plastic tunnels or later in the season under open field conditions. One classical solution to overcome this problem is crop rotation which recommends that watermelon should not be cultivated at least five years in the same field infected with fusarium disease (Yetisir and Sari, 2003). Other alternatives include fumigation with methyl bromide, soil sterilization and grafting. Since soil sterilization can never be complete and methyl bromide has been phased out by several countries following the Copenhagen Amendment to the Montreal protocol, where methyl bromide was added to the list of substances that deplete the ozone layer (Marsic and Osvald, 2004), grafting became very popular in Japan as a counter measure to the damage caused by soil borne diseases such as fusarium wilt, bacterial wilt and nematodes (Oda, 2004).

Expanding the use of resistant rootstocks, in combination with integrated pest management (IPM) practices, may help to reduce the need for soil

Table 1: Winter, summer season and total area, yield and production of watermelon in Jordan from 2000-2005.

Year	Winter season			Summer season			Total		
	Area (du)	Yield (ton/ du)	Prod-uction (ton)	Area (du)	Yield (ton/ du)	Prod-uction (ton)	Area (du)	Yield (ton/ du)	Prod-uction (ton)
2000	1,904	4.72	8,988	8,748	2.97	26,023	10,652	3.29	35,011
2001	748	5.20	3,888	14,906	2.04	30,360	15,653	2.19	34,248
2002	2,074	3.72	7,705	14,324	4.47	64,072	16,398	4.38	71,777
2003	5,831	4.12	24,010	19,938	3.54	70,576	25,769	3.67	94,587
2004	2,809	7.27	20,430	10,055	6.31	63,473	12,864	6.52	83,903
2005	1,256	5.16	6,479	12,662	6.20	78,519	13,918	6.11	84,998
Average	2,439	5.19	11,917	13,339	4.24	55,504	15,876	4.36	67,421

http://www.dos.gov.jo/agr/agr_a/index.htm

Table 2: The percentage of watermelon planted area of winter, summer season and total areas of irrigated vegetables during 2000- 2005 in Jordan.

Year	Summer season		Winter season		Total	
	Vegetable area (du)	Water-melon %	Vegetable area (du)	Water-melon %	Vegetable area (du)	Water-melon %
2000	166,003	5.27	162,814	1.17	328,817	3.24
2001	139,223	10.71	166,398	0.45	305,622	5.12
2002	170,813	8.39	171,867	1.21	342,681	4.79
2003	157,936	12.62	186,298	3.13	344,234	7.49
2004	165,655	6.07	203,386	1.38	369,042	3.49
2005	191,975	6.60	209,680	0.60	401,656	3.47
Average	165,268	8.28	183,407	1.32	348,675	4.60

http://www.dos.gov.jo/agr/agr_a/index.htm

fumigation with methyl bromide for many crops (Anonymous, 2006). According to Oda (2004), grafting has become an essential technique for the production of repeated crops of fruit bearing vegetables grown under greenhouses.

Growing grafted vegetables was first launched in Japan and Korea in the late 1920,s by grafting watermelon on gourd rootstock (Lee, 1994). Since then, the popularity of grafting vegetables increased in several countries, and the demand for successfully grafted seedlings is growing rapidly in commercial vegetable culture (Traka-Mavrona, *et al*., 2000). 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 Nakia) on Bottle gourd (*Lagenaria siceraria* Standle) and melon (*Cucumis melo* L.) on white gourd also known as wax gourd (*Benicasa hispida.* Cogn) (Oda, 2004).

In 1994, the percentage of cultivated area of grafted seedlings in outdoor commercial vegetable culture amounted to 81% and 54% in Korea and Japan, respectively; the respective percentages in greenhouse cultivation were 69% and 81% (Kurata, 1994). The ratio of the cultivated watermelon area using grafted plants to the total watermelon area amounts to almost 90-100%, and reaches 40-50% for grafted melon compared to the total melon area in the southern part of Greece (Traka-Mavrona *et al*., 2000). Grafting was also introduced to Turkey where seedling companies started to produce tomato and cucumber grafted seedlings and continued to carry on research on grafting watermelon, melon and cucumber (Yetisir *et al*., 2003).

Methyl bromide is still used for soil fumigation mainly for watermelon cultivation in Jordan Valley because of high infestation of soil borne diseases. However, grafting of watermelon and some vegetables like tomato has been introduced to Jordan as an effective alternative for methyl bromide fumigation. Furthermore, studying the effect of different rootstocks on grafted watermelon under Jordan conditions may find answers for many questions that farmers might raise, beside saving the environment by stopping the use of chemicals, especially methyl bromide, for soil fumigation.

Therefore, the objectives of the present study were:

1. To study the effect of different rootstocks on growth, yield and fruit quality of grafted watermelon under open field conditions in Jordan Valley and highlands.
2. To find the best rootstock - scion combination in watermelon which expresses highest yield and best fruit quality.
3. To provide scientific evidence for local adoption of grafting, as an alternative for chemical soil fumigation and as a component in integrated pest management and organic culture.

2. LITRATURE REVIEW

2.1 Effect of rootstock on vegetative growth and its components.

Grafting watermelon on different rootstocks showed remarkable effects on fresh weight of scion vegetative growth. According to Yetisir and Sari (2004), grafted "Crimson Tide" watermelon on *Lagenaria* and *Cucurbita* rootstocks produced more fresh matter than did the control. In another experiment the same cultivar grafted on different rootstocks had 6-136% heavier fresh weight than control except for 216 (*Lagenaria* hybrid) rootstock (Yetisir and Sari, 2003).

Reductions in vegetative fresh weight were more drastic in non-grafted "Crimson Tide" watermelon under flooding, while vegetative growth of grafted plants on *Lagenaria siceraria* rootstock were moderately affected (Yetisir *et al.,* 2006). Vegetative fresh weight of "Malika F_1", Galia type melon, grafted on *Cucurbita* TZ-148 rootstock was significantly higher than its non-grafted control (Cohen *et al*., 2005).

The impact of grafting on vegetative dry weight of "Sugar baby F_1" watermelon was very remarkable especially for RS841 rootstock (*Cucurbita* hybrid) (Chouka and Jebari, 1999); on the other hand, "Crimson Tide" watermelon grafted on different rootstocks gave higher vegetative dry weights than the control. (Yetisir and Sari, 2004). Under flooding, grafting on *Lagenaria siceraria* rootstock gave heavier dry vegetative growth than did the "Crimson Tide" watermelon control (Yetisir *et al*., 2006). The dry vegetative weight of "Tmk nvf2" tomato grafted on RX-335 rootstock grown at 35°C was reduced most in non-grafted plants (Rivero *et al*., 2003). While the shoot dry weight of "Fanny F_1" tomato was reduced progressively as NaCl concentration increased in irrigation water, values obtained for grafted plants on AR-9704 rootstock were significantly higher than those for non-grafted plants (Fernandez-Gracia *et al.,* 2004).

Rootstock showed significant effects on leaf area of scion in watermelon. "Crimson Tide" watermelon grafted on different rootstocks had larger leaf area than the control except for the rootstocks 216 (*Lagenaria* hybrid), Strong Toza and P360 (*Cucurbita* hybrids) (Yetisir and Sari, 2003). Largest leaf area was obtained in "Sugar baby F_1" watermelon grafted on RS841 (*Cucurbita* hybrid) rootstock (Chouka and Jebari, 1999).

Yetisir and Sari (2003) found that grafted watermelon plants had different number of leaves depending on rootstock and were higher than the control. Number of leaves of "Brunex F_1" cucumber plants grafted on the rootstocks Peto 42.91 F_1, TS- 1358 F_1 and TZ- 148F_1 (all are *Cucurbita maxima* X *Cucurbita moschata*) were greater than those grafted on the rootstocks A27 (*Cucurbita ficifolia*) and Patron F_1 (*Cucurbita moschata*) as well as the non-grafted control (Pavlou *et al.,* 2002).

Grafting melon (Bletsos, 2005), cucumber (Pavlou *et al.,* 2002) and watermelon (Chouka and Jebari, 1999), increased branch length, plant height and internode' length, respectively. Branch length of "Galia F_1" melon increased significantly when grafted on Mamouth F_1 (*Cucurbita*) and Nun 9075 RT F_1 (*Lagenaria*) rootstocks, compared with the control (Bletsos, 2005). Cucumber plants (Brunex F_1) grafted on (*Cucurbita maxima* X *Cucurbita moschata*) rootstocks had greater plant height than *Cucurbita ficifolia* and *Cucurbita moschata* rootstocks and the control. (Pavlou *et al.,* 2002). Chouka and Jebari (1999) found that the internode' length of "Sugar baby F_1" watermelon grafted on RS 841 (*Cucurbita* hybrid) rootstock was similar to the control and longer than grafted plant on *Lagenaria* rootstock (Chouka and Jebari, 1999).

2.2 Effect of rootstock on yield and yield components

Yields of watermelon scions increased to variable extents when grafted on different rootstocks. "Crimson Tide" watermelon grafted on *Lagenaria* type rootstock produced higher yield than the control and than those grafted on *Cucurbita* type rootstocks; the highest yields of "Crimson Tide" (146 and 137 ton/ha) were obtained when Skopje (*Lagenaria* hybrid) and a Turkish *Lagenaria* landrace rootstocks were used, respectively (Yetisir *et al*., 2003).

Moreover, Yetisir and Sari (2003) found that "Crimson Tide" watermelon grafted on *Lagenaria* type rootstock produced higher yield than the control and *Cucurbita* rootstocks except for Gold Toza (*Cucurbita* hybrid) rootstock; the highest (13.26 kg/m^2) and lowest (1.89 kg/m^2) yields of "Crimson Tide" were obtained when Skopje (*Lagenaria* hybrid) and P360 (*Cucurbita* hyprid) were used as rootstocks, respectively. According to Chouka and Jebari (1999), production of "Sugar baby F_1" watermelon was doubled compared to the control when grafted on RS 841 (*Cucurbita* hybrid) and *Lagenaria* rootstocks. Marketable yield of watermelon was also influenced by rootstock. Scions grafted on *Lagenaria* type rootstocks produced higher marketable yield than the control and *Cucurbita* type rootstocks (Yetisir *et al.,* 2003).

Yields of other vegetables including melons (Cohen *et al.,* 2005 and Ruiz and Romero, 1999), cucumber (Pavlou *et al.,* 2002), tomato, (Lopez-Perez *et al.,* 2006) sweet pepper (Oka *et al.,* 2004) and aubergine (Khah, 2005) were increased by grafting. Significant yield increases were observed in grafted melons of Galia type cultivars (Carrera F_1 and 6003 F_1) on TZ 148 *Cucurbita* rootstock (Cohen *et al.,* 2005). The fruit yield was two times higher in the majority of grafted melon plants than the controls when Yuma, Melina and Gallicum melon F_1 hybrid cultivars were grafted on Shintoza, RS 841 and Kamel *Cucurbita* rootstocks (Ruiz and Romero, 1999). Total fruit yield of "Brunex F_1" cucumber grafted on nine rootstocks, from *Cucurbita ficifolia*, *Cucurbita moschata* hybrid and *Cucurbita maxima* **X** *Cucurbita moschata*, were greater than the non-grafted control (Pavlou *et al.,* 2002). Compared to the non-grafted "Blitz" tomato, grafting on Beaufort rootstock significantly increased the total fruit mass and reduced the number of nematode eggs produced on the roots (Lopez-Perez *et al.*, 2005). Also, the yield of "Celica" sweet pepper grafted on AR-96023 rootstock was more than 2-fold that of non- grafted control when grown in a greenhouse infected with nematode *Meloidogyne incoginta* (Oka *et al.,* 2004). Both the greenhouse and the open field "Rima" aubergine grafted on tomato rootstock (Heman) gave a significantly higher total yield than plants grafted on Primavera rootstock and the non-grafted control (Khah, 2005).

Average fruit weight and fruit number of grafted watermelons were also affected by rootstock. "Crimson Tide" grafted on *Lagenaria* type rootstocks produced larger fruits than those of the control and that grafted on *Cucurbita* type rootstocks; the biggest fruit (8.8 kg/fruit) and the smallest (5.8 kg/fruit) were obtained from "Crimson Tide" on Skopje rootstock, and the control, respectively (Yetisir *et al.,* 2003). When Yuma, Melina and "Gallicum F_1" melon were grafted on Shintoza, RS 841 and Kamel *Cucurbita* rootstocks, the average fruit weight was much higher than the controls (Ruiz and Romero, 1999).

According to Yetisir and Sari (2003), watermelon scions on *Lagenaria* type rootstocks and the control had more fruits per plant than those grafted on *Cucurbita* type rootstocks; "Crimson Tide" on Skopje rootstock gave the highest number of fruits (2.4 fruit/plant), while the control gave 1.5 fruit/plant. The highest number of fruits (5.25 fruit/plant) was obtained from "Top Yield" watermelon grafted on Bottle gourd rootstock (Salam *et al.,* 2002).

2.3 Effect of rootstock on fruit quality

Quality characteristics of grafted watermelons, such as fruit shape, skin color, skin or rind thickness and soluble solids concentration are, to one degree or the other, influenced by rootstock despite similar cultural practices.

The fruit size of watermelons grafted on rootstocks having vigorous root systems is often significantly increased compared to fruit from intact plants, and many growers are practicing grafting mainly for this reason (Lee, 1994). "Crimson tide" watermelon grafted on *Lagenaria* type rootstocks produced larger fruit than the control and than those plants grafted on *Cucurbita* type rootstocks; the biggest (8.81 kg) and the smallest (3 kg) fruit weights were induced by Skopje (*Lagenaria* hybrid) and *Cucurbita* rootstocks, respectively; the average fruit of the control weighed 5.85 kg (Yetisir *et al*., 2003). Grafting on Lageneria type rootstocks produced larger fruit size than the control plants (Yetisir and Sari, 2004). However, Shintoza (*Cucurbita* hybrid) rootstock had direct enhancing effect on fruit growth and size (Miguel *et al*., 2004).

Fruit index (fruit length/fruit diameter) of "Crimson Tide" watermelon was not significantly affected by the rootstock, but fruit rind was thicker when *Lagenaria* type rootstocks were used (Yetisir *et al*., 2003); although the difference was not economically important, bigger fruits had thicker rinds. Flesh firmness was greatest when "Crimson Tide" watermelon was grafted on CMO and CMA rootstocks (Turkish *Cucurbita* landraces) (Yetisir *et al*., 2003).

"Sugar baby F_1" watermelon grafted on RS 841 (*Cucurbita* hybrid) rootstock gave fruits with the best refractive index (total soluble solids)

(Chouka and Jebari, 1999). Soluble solids of "Crimson Tide" watermelon fruits were similar when grafted on most of the rootstocks tested (Yetisir *et al*., 2003), except for the two Turkish *Cucurbita* landraces CMO and CMA which induced the lowest soluble solids values (7.4% and 8.0%, respectively).

The total soluble solids concentration was identical in grafted and non-grafted triploid "Reina de Corazones" watermelon when grafted on nine different rootstocks, including four *Cucurbita maxima* X *Cucurbita moschata*, one *Cucurbita moschata,* three *Citrullus lanatus* and one *Lagenaria siceraria* rootstock (Miguel *et al.,* 2004). Total soluble solids percent of "Top Yield" watermelon fruits grafted on Bottle gourd were significantly higher than that of the non-grafted (Salam *et al.,* 2002).

Grafting "Crimson Tide" watermelon on Turkish *Lagenaria siceraria* landrace gave the highest reducing sugar (6.51%) and highest total sugar contents (8.97%) compared with grafting on the other rootstocks from *Lengenaria* and *Cucurbita* type rootstocks (Yetisir *et al*., 2003).

Grafting on *Cucurbita* rootstock may have adverse effects on watermelon fruit quality (Miguel *et al*., 2004), including the formation of yellowish bands in the red flesh, the development of off-flavor, an insipid taste and the internal decay of the endocarp. Shintoza rootstock (*C. maxima* X *C. moschata*) had no effect on the soluble solids of endocarp and did not increase the development of yellowish bands on the flesh or the internal breakdown of the endocarp (Miguel *et al*., 2004).

3. MATERIALS AND METHODS

3.1 Plant material

"Samara" watermelon from Japan, the most common cultivar in Jordan market, was grafted on eight rootstocks (Table 3) using the tongue approach grafting technique (Plate 1) as described by Lee (1994). Non-grafted (intact) and self grafted "Samara" plants were used as control.

Table 3: Rootstocks, their definitions and sources.

Rootstock		Definition	Source
Cucurbita	Tetsukabuto	*C.maxima* X *C.moschata*	Taiwan
	PT 1313	*C.maxima* X *C.moschata*	U.S.A
	Shintoza supreme	*C.maxima* X *C.moschata*	Korea
	Azman	*C.maxima* X *C.moschata*	Holland
Lagenaria	Emphasis	*Lagenaria siceraria*/ hybrid	Korea
	FR Strong	*Lagenaria siceraria*/ hybrid	Holland
	Bottle gourd	*Lagenaria siceraria*/ landrace	Jordan
	64-15 RZ	*Lagenaria siceraria*/ hybrid	Holland

Scion seeds were planted 5 days before the *Lagenaria* type rootstock seeds and two days later *Cucurbita* rootstock seeds were planted to ensure suitable hypocotyl diameter for grafting the scion on the rootstocks. Ten to twelve days later, seedlings were grafted at the 1st true leaf stage. Grafted seedlings were healed and acclimated in a plastic tunnel in a small plastic house in the Jordan Valley (Fig. 1).

The plastic tunnel was covered with a white cloth to provide shade and maintain high humidity (95%) and temperature (30 ºC) for 3-4 days.

Foliar water spraying was performed as needed to keep relative humidity high. Gradually, the relative humidity was lowered and the light intensity was increased by adjusting the shading cloth according to weather and sunshine during the day. One week later, the scion hypocotyls were cut. After 4-5 days, clips were removed. One week later grafted seedlings were ready to be transplanted in the field.

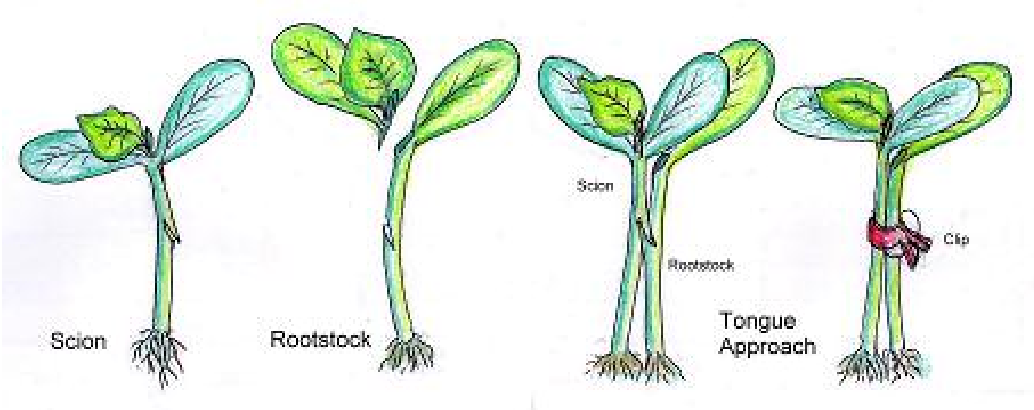

Plate 1: Tongue approach grafting technique.

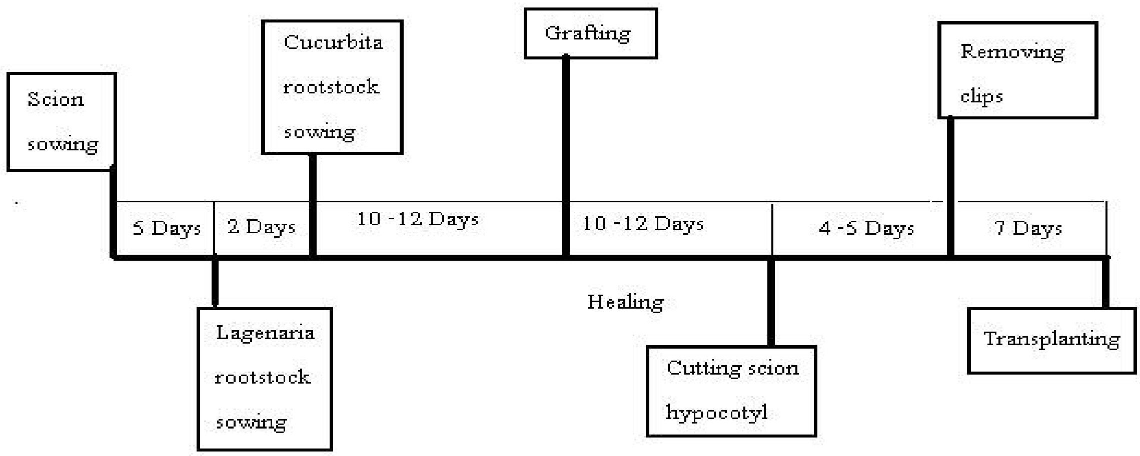

Figure 1: Time schedule for tongue approach grafting of watermelon.

3.2 Field experiments

Open field experiments in two locations, in Jordan Valley (Balawneh / 32° 17N latitude and 35º 58E longitude) and the Highlands (Jerash / 32º 09N latitude and 35° 36E longitude) were conducted to study the effect of different rootstocks on growth, yield and fruit quality of grafted watermelon.

Fermented cow manure was applied during soil preparation at the rate of 30 tons/ha. Planting beds, (60 cm wide and 15 cm high) were prepared and 20 mm T-tape irrigation laterals, with two l/hr discharge drippers 15 cm apart, were centered on the middle of beds two meters apart. Beds were then covered with black plastic mulch.

Forty day old seedlings were planted in single rows at 0.5 m within the row. Planting date was March 11 and April 3, 2006 in Balawneh and Jerash sites, respectively.

Treatments were arranged in a randomized complete block design with 3 replicates (Fig. 2) and twelve seedlings each. Plants were covered by netted tunnels for about four weeks to protect seedlings from insects and wind.

Block 1	**T1**	**T3**	**T9**	**T4**	**T7**	**T10**	**T5**	**T6**	**T8**	**T2**
Block 2	**T2**	**T1**	**T10**	**T5**	**T6**	**T8**	**T9**	**T4**	**T3**	**T7**
Block 3	**T4**	**T7**	**T5**	**T9**	**T1**	**T6**	**T2**	**T10**	**T3**	**T8**

Figure 2 : Layout of the experiment at Jordan Valley and highland.

Plants were irrigated as needed and N-P-K fertilizers were applied as fertigation at an accumulative rate of 216 kg N/ha, 156 kg P_2O_5/ha and 245kg K_2O/ha during the growing season (Table 4) as N-P-K soluble fertilizer (Appendix table 19).

Yellow and blue insect traps were distributed between blocks to avoid insect attack and viral infections. Minimal application of protective pesticides was performed (Appendix table 20).

Fruits were harvested at the ripe stage on May 26 and June 19, 2006, for Balawneh and Jerash locations, respectively.

Daily temperature (Figs. 3 and 5) and relative humidity (Figs. 4 and 6) were recorded by using thermo-hydrograph in each location.

Analysis of variance and correlation coefficients were performed using SAS statistical program.

Fertigation		**Weeks**			**Total**
		0-3	**3-6**	**6-11**	
Nutrient (kg/du)	N	5.6	6.3	9.7	21.6
	P_2O_5	7.6	4	4	15.6
	K_2O	5.6	10	8.9	24.5
Water (m^3/du)	Balawneh	96	72	143	311
	Jerash	68	96	136	300

Table 4: Fertigation schedule for Balawneh and Jerash experiments.

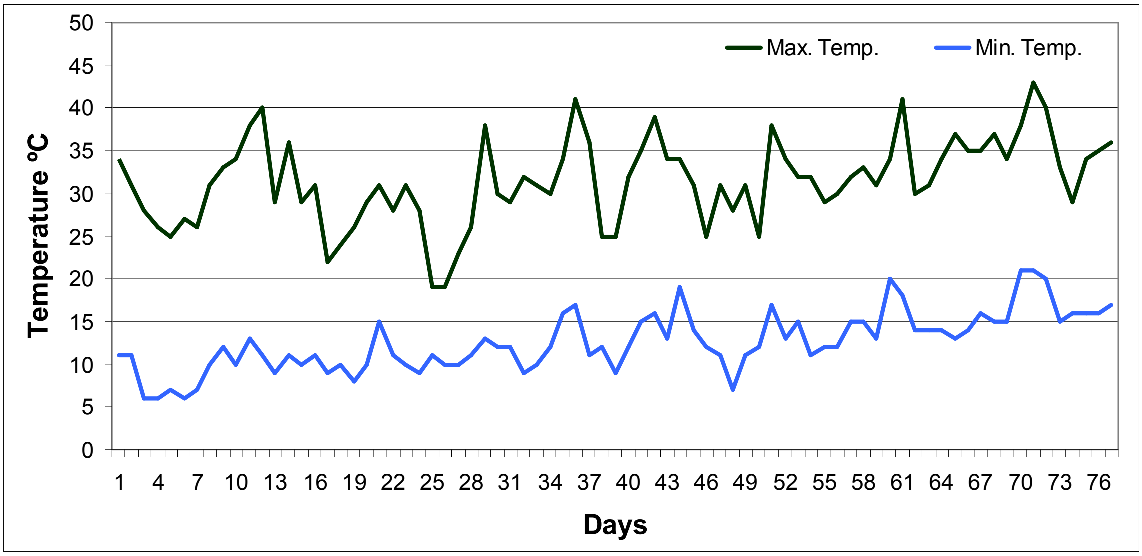

Figure 3: Daily maximum and minimum temperatures (°C) from March 11 to May 26, 2006 in the Jordan Valley (Balawneh).

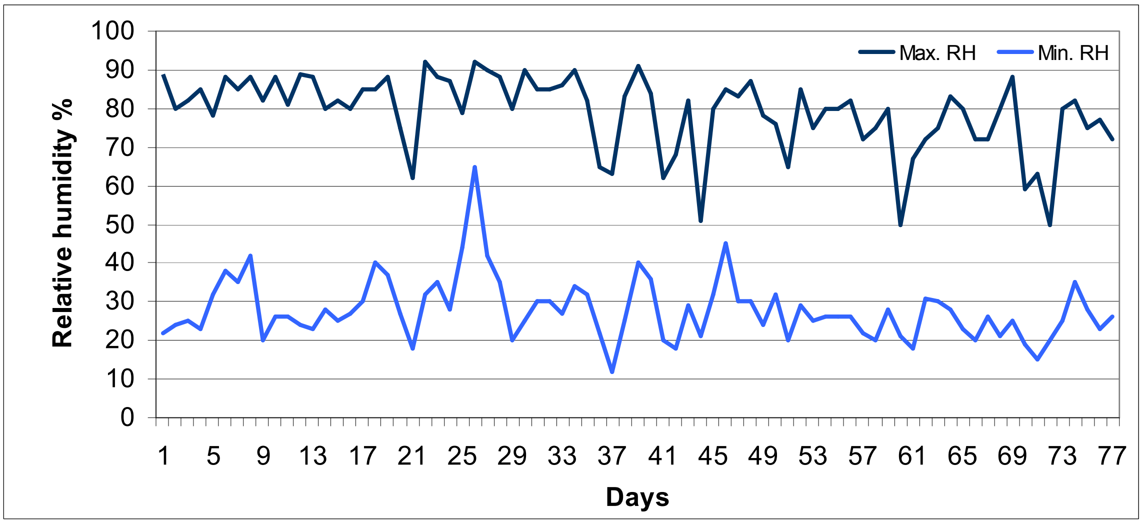

Figure 4: Daily maximum and minimum relative humidity (%) from March 11 to May 26, 2006 in the Jordan Valley (Balawneh).

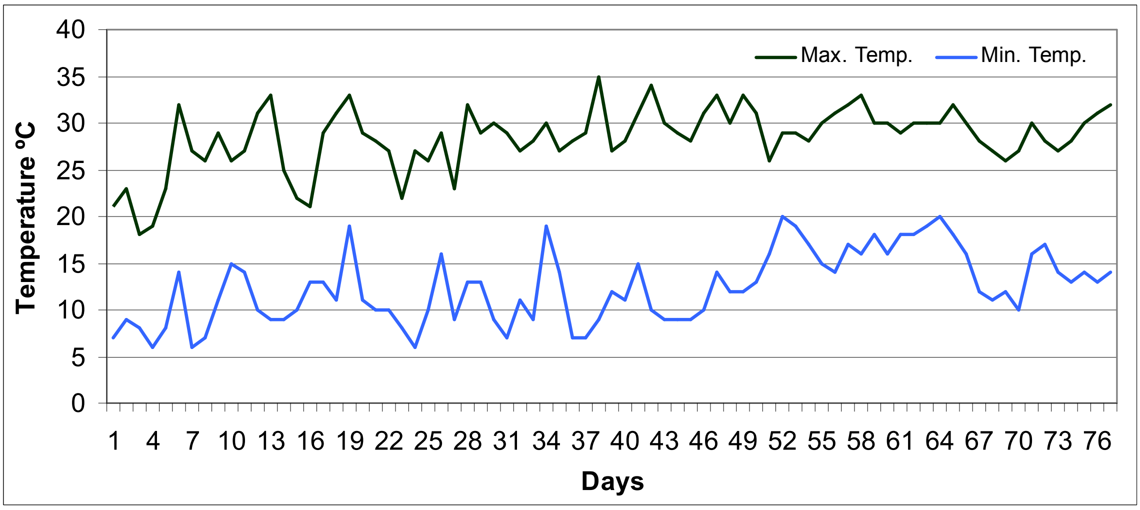

Figure 5: Daily maximum and minimum temperatures (ºC) from April 3 to June 19, 2006 in Jerash.

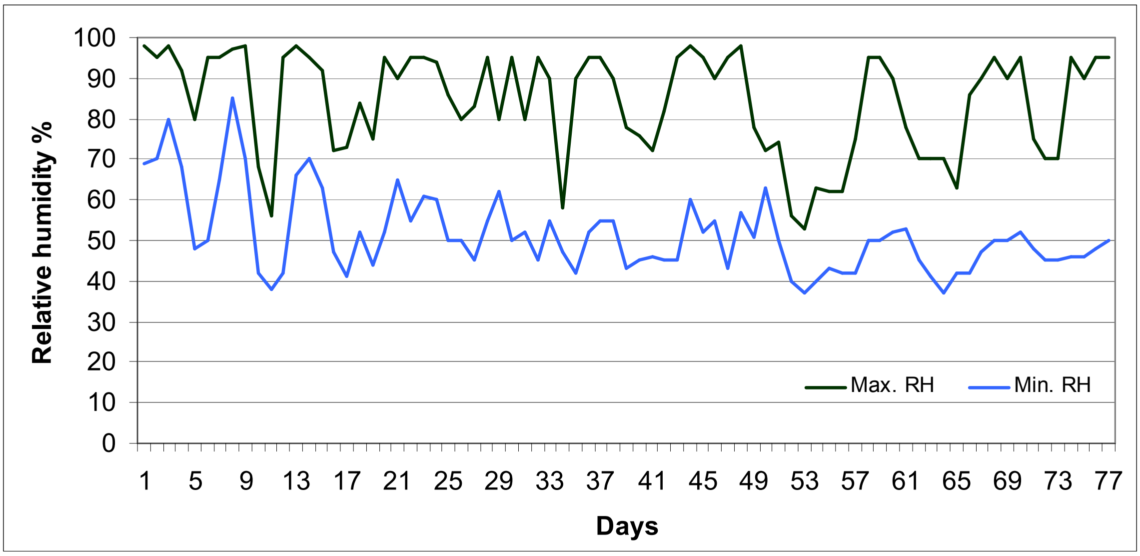

Figure 6: Daily maximum and minimum relative humidity (%) from April 3 to June 19, 2006 in Jerash.

3.3 Compatibility experiment

3.3.1. Survival rate

"Samara" watermelon scion was grafted on 36 plants of each rootstock using the tongue approach technique (Table 3), starting on August 6, 2006 in Jerash at three stages of growth (cotyledon stage, first true expanded leaf stage and second true expanded leaf stage) for both scion and rootstock. Grafting was performed according to the schedule shown in Fig. 1. Hypocotyls diameter of rootstock and scion were measured by using hand caliber at grafting time. When grafted seedlings reached transplanting stage, the surviving seedlings were counted.

3.3.2. Anatomy of the graft union:

When grafted seedlings were ready to be transplanted, the graft union (10 mm long) of five seedlings from each rootstock was cut. Samples were prepared for the histological study according to the paraffin method (Daykin and Hussey, 1985).

3.3.2.1. Fixation:

The fixation solution Formalin Aceto-Alcohol (FAA) was prepared by mixing 90 ml of 50 % ethanol, 5 ml of glacial acetic acid and 5 ml of 37% formaldehyde. Graft union was submerged for at least 24 hr in the solution. Volume of the solution was at least 10 times greater than the volume of the tissue.

3.3.2.2. Dehydration:

Dehydration was accomplished by moving the tissue stepwise through increasing concentration of alcohols (Table 5).

3.3.2.3. Infiltration:

Tissues were placed in 1:1 TBA (Tertiary Butyl Alcohol) and paraffin oil solution for one hr., 0.75 of the needed volume of the test tube was filled with paraffin which was allowed to solidity slightly and the tissue was then placed on the top and covered with 1:1 TBA, and paraffin oil solution and put in an oven at 60°C for 1-3 hrs. The mixture was then replaced with melted paraffin for 3 hrs and repeated at least once. Next, the melted paraffin was replaced by special type of paraffin for histological use (Paraplast) and put in the oven overnight.

3.3.2.4. Embedding:

In embedding, the tissue was positioned in cooling paraffin so that it can be sectioned after hardening. Special molds made of metal were used for this purpose.

3.3.2.5. Sectioning:

Paraffin blocks were sectioned using a rotary microtome. During sectioning ribbon was formed and parts of this ribbon were transferred onto glass microscope slides, the surface of the slide was coated with a thin film of Haupt's adhesive (1g gelatin in 100 ml distilled water, 2g phenol crystal and 15 ml glycerin). Slides were placed on warm plate (35° C) to flatten the ribbon and evaporate the liquid.

3.3.2.5. Staining:

Safranin and fast green stains were used (Table 6). After completion of the staining procedure, cover slips were mounted with few drops of Canada balsam; the slides kept overnight on a hot plate at 60 °C. The slides were then examined microscopically and the representative slides were photographed.

Table 5: Tertiary butyl alcohol (TBA) dehydration schedule.

Step	% Alcohol	Time	Distilled water	95 % Ethanol	100% Ethanol	100% TBA
1	50	2 hr or more	50	40	0	10
2	70	Overnight	30	50	0	20
3	85	1-2 hr	15	50	0	35
4	95	1-2 hr	0	45	0	55
5	100	1-3 hr	0	0	25	75
6	100	1-3 hr	0	0	0	100
7	100	1-3 hr	0	0	0	100
8	100	overnight	0	0	0	100

Table 6: Safranin and fast green staining schedule.

step	solution	time
1	Xylene	5 min
2	Absolute ethanol	5 min
3	95% ethanol	5 min
4	70% ethanol	5 min
5	50% ethanol	5 min
6	30% ethanol	5 min
7	1% aqueous safranin 0	1-12 hr
8	Rinse in water	
9	30 % ethanol	3 min
10	50 % ethanol	3 min
11	70 % ethanol	3 min
12	95 % ethanol	3 min
13	0.1 % fast green FCF in 95 % ethanol	5-30 sec
14	Absolute ethanol	15 sec
15	Absolute ethanol	3 min
16	Xylene –absolute ethanol (1:1)	5 min
17	Xylene	5 min
18	Xylene	5 min or longer

3.4 Parameters evaluated.

3.4.1 Yield and its components

a- Total yield.

b- Marketable yield (fruits over 4 kgs only).

c- Unmarketable yield (fruits less than 4 kg).

d-Average fruit weight of marketable, unmarketable and total yield.

e- Marketable, unmarketable and total fruit number per plant.

3.4.2 Fruit quality

3.4.2.1 Physical properties:

Five fruits from each replicate were chosen randomly to determine:

a- Fruit index (fruit length/fruit diameter): Fruit length and diameter were measured by manual large compasses.

b- Rind thickness (mm) was measured for each fruit after being cut from the middle part using a manual caliber.

c- Flesh firmness: the heart portion of mesocarp was tested with fruit firmness tester which involves measuring the force required for 11.3 mm probe to penetrate the cut surface at 3 locations in the mesocarp tissue expressed as kg-force.

3.4.2.2 Chemical properties: The heart portion from the mesocarp was pressed by hand through a metallic sieve. Juice samples were taken in 100 ml plastic bottles and stored immediately in a deep freezer
(-20ºC) for later laboratory analysis:

a- Total soluble solids (TSS %) concentration (Brixº) was measured in the field using hand refractometer.

b- Total sugar content was determined as described by Dubois *et al*. (1956) using the sulfuric acid-phenol technique:

Two milliliters of sugar solution (containing about 0.4-1 mg of sugar) were pipetted into 16 cm test tubes. One ml of 5% phenol solution was added. Then 5 ml of concentrated sulfuric acid was added rapidly (using fast-delivery 5-ml pipette). The mixture was allowed to stand 10 minutes, then shaken and placed for 10-20 minutes in a water bath at 25 to 30°C before readings were taken. The absorbance of yellow-orange color was measured in quartz cuvettes at 490 nm by using spectrophotometer (Cary model 100 conc.) and the amount of sugar was determined from a standard curve prepared by using five concentrations of sucrose (0.01, 0.02, 0.03, 0.04, 0.05%), and the calculated regression equation:

($Y = 51.299X + 0.0733$. $R^2 = 0.9925$), where Y is the sugar concentration and X is the absorbance and R^2 is the regression coefficient.

c- Reducing sugar content was determined using the dinitrophenol technique described by Ross (1959) and cited by Yetitsir *et al.* (2003).

Solution A was prepared by dissolving 7.145 g of 2,4-dinitrophenol in 230 ml of 5% sodium hydroxide. Solution was then heated on hot water bath to dissolve the solute, and 2.5 g of phenol crystal were added. Heating was continued to have orange clear solution. Solution B was prepared by dissolving 100g of sodium potassium tartarate in 500 ml of distilled water. To make dinitrophenol solution, solutions A and B were mixed in 1000 ml volumetric flask and brought to volume with distilled water.

One ml of sugar solution was pipetted into a 16 cm test tube and 2ml of dinitrophenol solution were added. Solution was then thoroughly mixed and heated in a boiling water bath for 6 minutes exactly. The solution was left to cool for 3 minutes at (6ºC) in a water bath, kept cold and the absorbance of yellow color was measured within 20 minutes in quartz cuvettes at 600 nm by using spectrophotometer (Cary model 100 conc.).

The amount of reducing sugars was determined from a standard curve using five concentrations of anhydrous glucose (0.04, 0.08, 0.12, 0.16, 0.2%), and the calculated equation:

(Y = 5.6441 X + 0.0102. R^2 = 0.9963), where Y is the sugar concentration and X is the absorbance and R^2 is the regression coefficient.

d- Lycopene content of the fruit juice was determined using the modified reduced volume lycopene assay described by Perkins –Veazie *et al.* (2006): Half g samples of watermelon juice were weighed into amber glass bottles. Solvents were added in a ratio 2:2:1 hexane, ethanol and acetone (10ml : 10ml : 5ml). Bottles were tightly sealed and placed on orbital shaker for 15 min at 200 rpm. 3ml of distilled water were added to each sample ,bottles were shaken again for 10 min. and left to stand for 15 min to develop the solvents phase separation. The absorbance readings were taken by using spectrophotometer (Cary model 100 conc.) at 503 nm wavelength. Lycopene content was then calculated by using the formula of Fish *et al.* (2002):

$$\text{Lycopene (mg/kg)} = \frac{\text{absorbance} \times 31.2}{\text{g tissue}}$$

3.4.3 Vegetative growth:

3.4.3.1 Dry weight: Vegetative part of five intact plants from each replicate was taken, dried to a constant weight at 70°C using oven (Memmert model UL 50) and the dry weight was then calculated.

3.4.3.2 Number of branches and number of nodes in each branch were counted for 5 plants in each replicate.

3.4.4 Sex expression: Total numbers of male and female flowers were counted in five plants from each replicate.

3.4.5 Compatibility test

3.4.5.1 Hypocotyl diameters of rootstocks and scion were measured by using hand caliber for each grafting stage.

3.4.5.2 Surviving grafted seedlings were counted for each rootstock in the compatibility study and the survival % was determined.

4. RESULTS

4.1. Jordan Valley (Balawneh) experiment:

4.1.1 Vegetative growth

In Balawneh, grafting "Samara" watermelon on Azman rootstock gave significantly the highest number of leaves (363 per plant) (Table 7), while "Samara" grafted on the remaining *Cucurbita* rootstocks produced more or less similar leaf numbers, which were significantly higher than those of "Samara" on *Lagenaria* rootstocks and the controls. Grafting on Bottle gourd landrace rootstock resulted in lowest number of leaves (223 per plant) which was significantly similar to number of leaves of "Samara" when grafted on the rest of the *Lagenaria* rootstocks and the controls.

Table 7: Effect of rootstock on number of leaves, number of branches, number of nodes per branch and dry matter of "Samara" watermelon in Balawneh (for each parameter, columns having different letters are significantly different according to DMRT at 0.05 level).

Treatment		Number of leaves/plant	Number of branches/plant	Number of nodes/branch	Dry matter g /plant
***Cucurbita* rootstocks**	**Tetsukabuto**	**319 b**	**17 bc**	**18.1 a**	**110 b**
	PT 1313	**329 b**	**17 bc**	**19.2 a**	**113 b**
	Shintoza sup.	**321 b**	**18 b**	**18.1 a**	**115 b**
	Azman	**363 a**	**19 a**	**18.7 a**	**145 a**
***Lagenaria* rootstocks**	**Emphasis**	**253 c**	**17 bc**	**15.0 c**	**66 c**
	FR strong	**226 c**	**15 d**	**15.0 c**	**57 c**
	Bottle gourd	**223 c**	**15 d**	**15.2 bc**	**60 c**
	64-15 RZ	**257 c**	**16 cd**	**16.3 b**	**69 c**
Control (Samara)	**Intact**	**234 c**	**15 d**	**15.4 bc**	**64 c**
	Self grafted	**245 c**	**17 bc**	**14.7 c**	**65 c**

"Samara" on Azman rootstock gave the highest number of branches (19 per plant) (Table 7). However, when grafted on the other *Cucurbita* rootstocks, Emphasis (*Lagenaria*) or self grafted control the number of branches per plant was similar. Furthermore, "Samara" on FR strong and Bottle gourd rootstocks gave the lowest numbers of branches (15 per plant) which were similar to those on the other *Lagenaria* rootstocks (except Emphasis) and the intact control.

Grafted "Samara" on *Cucurbita* rootstocks showed higher numbers of nodes per branch than when grafted on *Lagenaria* rootstocks and without grafting (control). The highest number of nodes (19.2 per branch) (Table 7) was given by "Samara" grafted on PT 1313 which was similar to those of the same scion on the remaining *Cucurbita* rootstocks. Self grafting, however, resulted in the lowest number of nodes (14.7 per branch), but this was similar to number of nodes produced by "Samara" when grafted on *Lagenaria* rootstocks (except 64-15 RZ) beside those of the intact control.

Dry matter content of "Samara" watermelon varied considerably with the rootstock (Table 7). Heaviest (145 g/plant) and lightest (57 g/plant) dry weights were observed when "Samara" was grafted on Azman and FR Strong rootstocks, respectively. Otherwise, the graft combinations with the *Cucurbita* rootstocks gave similar dry weights and were higher than those of "Samara" combinations with the *Lagenaria* rootstocks and the two controls.

4.1.2 Sex expression

"Samara" on Azman rootstock gave the highest significant number of male flowers (343 per plant); when grafted on the other *Cucurbita* rootstocks numbers of male flowers were similar but significantly lower (Table 8). "Samara" on *Lagenaria* rootstocks and the controls gave significantly lower number of male flowers per plant. Grafting on FR Strong rootstock gave the lowest number of male flowers (211 per plant).

The highest significant number of female flowers was given by grafting "Samara" on Azman rootstock (9.6 per plant) which was similar to the effect

Table 8: Effect of rootstock on male, female flowers and male/female ratio of "Samara" watermelon in Balawneh (for each parameter, ,columns having different letters are significantly different according to DMRT at 0.05 level

Treatment		Male flower/plant	Female flower/plant	Male/female flower ratio
***Cucurbita* rootstocks**	**Tetsukabuto**	**292 b**	**8.2 bc**	**35.7 :1 a**
	PT 1313	**310 b**	**8.5 b**	**36.7 :1 a**
	Shintoza sup.	**304 b**	**8.7 ab**	**35.2 :1 a**
	Azman	**343 a**	**9.6 a**	**35.8 :1 a**
***Lagenaria* rootstocks**	**Emphasis**	**236 c**	**6.9 d**	**34.4 :1 a**
	FR strong	**211 c**	**6.4 d**	**33.0 :1 a**
	Bottle gourd	**208 c**	**6.7 d**	**31.3 :1 a**
	64-15 RZ	**241 c**	**7.3 bc**	**33.2 :1 a**
Control (Samara)	**Intact**	**219 c**	**6.5 d**	**33.5 :1 a**
	Self grafting	**229 c**	**6.7 d**	**33.9 :1 a**

of Shintoza supreme rootstock. "Samara" scion on the other *Cucurbita* rootstocks gave significantly higher female flowers than the combinations with *Lagenaria* rootstocks and the control (Except for 64-15 RZ rootstock).

Grafted "Samara" on all rootstocks and the controls gave similar male : female flower ratios (Table 8). The highest ratio (36.7 : 1) and the lowest ratio (31.3 : 1) were given when PT 1313 and Bottle gourd landrace rootstocks were used, respectively.

4.1.3 Yield and yield components

4.1.3.1 Yield

"Samara" yields varied considerably with the rootstocks used (Fig. 7). The highest significant marketable yield (8.45 ton/du) was obtained from "Samara" when grafted on Azman rootstock. Grafting on the other *Cucurbita* rootstocks, resulted in significantly higher marketable yields than grafting on *Lagenaria* rootstocks and the intact control. The self grafted control, however, produced the lowest marketable yield

(2.85 ton/du) and was significantly similar to yields of "Samara" on all *Lagenaria* rootstocks and the intact control.

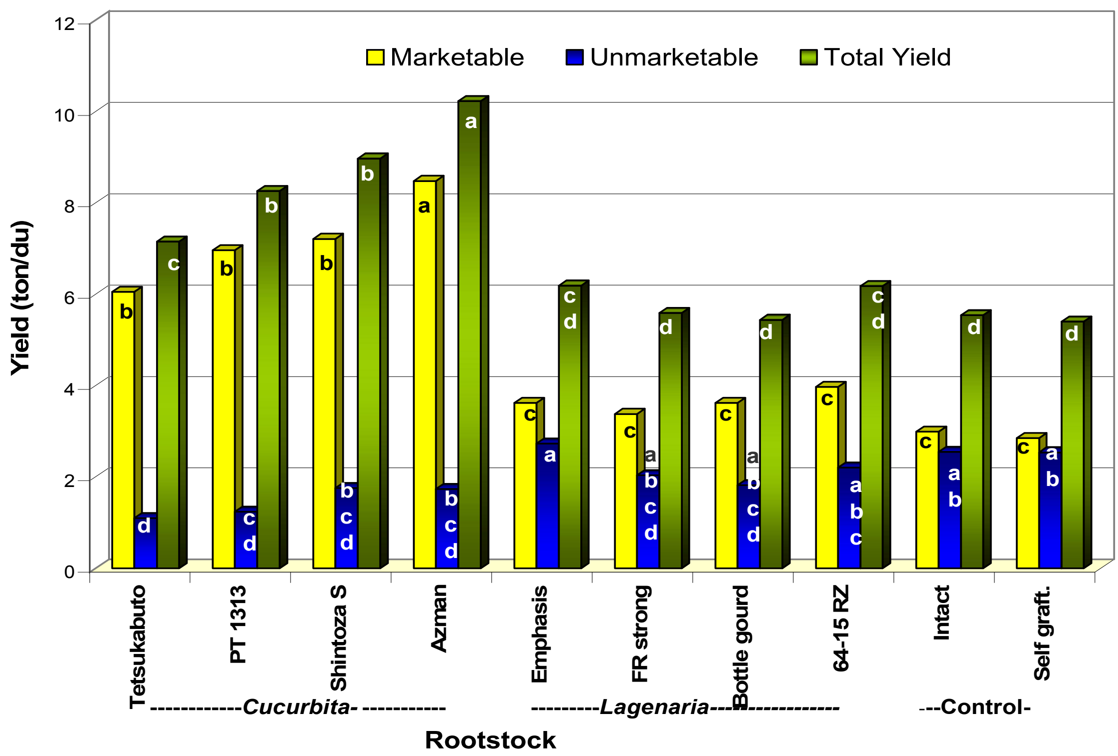

Figure 7: Effect of rootstock on marketable, unmarketable and total yields of "Samara" watermelon in Balawneh (for each parameter, columns having different letters are significantly different according to DMRT at 0.05 level).

Grafting "Samara" watermelon on Emphasis rootstock gave significantly the highest unmarketable yield (2.73 ton/du) which was similar to yields of "Samara" on the remaining *Lagenaria* rootstocks and to the control. The lowest unmarketable yield was induced by grafting on Tetsukabuto rootstock (1.1 ton/du); similar effects of the other *Cucurbita* rootstocks, FR Strong rootstock and Bottle gourd rootstock, were observed.

Grafting "Samara" on Azman rootstock gave significantly the highest total yield (10.23 ton/du) (Fig. 7). "Samara" grfted on Shintoza supreme and PT 1313 rootstocks, gave higher total yield than when grafted on *Lagenaria* rootstocks and than the control. The lowest total yield was given by the self grafted control (5.4 ton/du), which was similar to yield of the intact control and those of the scion on all *Lagenaria* rootstocks. "Samara" grafted on Tetsukabuto rootstock produced higher total yield than when grafted on FR Strong and Bottle gourd rootstocks and the control, but total yields were similar to yields of the scion combinations with Emphasis and 64-15 RZ rootstocks.

4.1.3.2 Average fruit weight

Average fruit weight of grafted "Samara" watermelon was influenced by rootstock to variable extents (Fig. 8). The highest average marketable fruit weight (5.85 kg/fruit) was given by "Samara" grafted on Tetsukabuto rootstock and was significantly similar to average marketable fruit weight by grafting on Azman and Shintoza supreme rootstocks. "Samara" on these two rootstocks gave heavier fruits than the control and when grafted on *Lagenaria* rootstocks. The scion on Bottle gourd rootstock and the self grafted control produced the lowest average marketable fruit weights (4.52 kg/fruit) which were significantly similar to the intact control and "Samara" grafted on *Lagenaria* rootstocks.

Grafting on FR Strong and Shintoza supreme rootstocks gave significantly the lowest (2.81 kg/fruit) and highest (3.48 kg/fruit) unmarketable average fruit weights, respectively (Fig. 8). Otherwise, grafting on the other rootstocks and the controls resulted in significantly similar unmarketable average fruit weights.

Tetsukabuto rootstock induced, on total yield basis, "Samara" scion to give the highest average fruit weight (5.24 kg/fruit), whose effect was significantly similar to the effects of Azman and Shintoza supreme rootstocks. When grafted

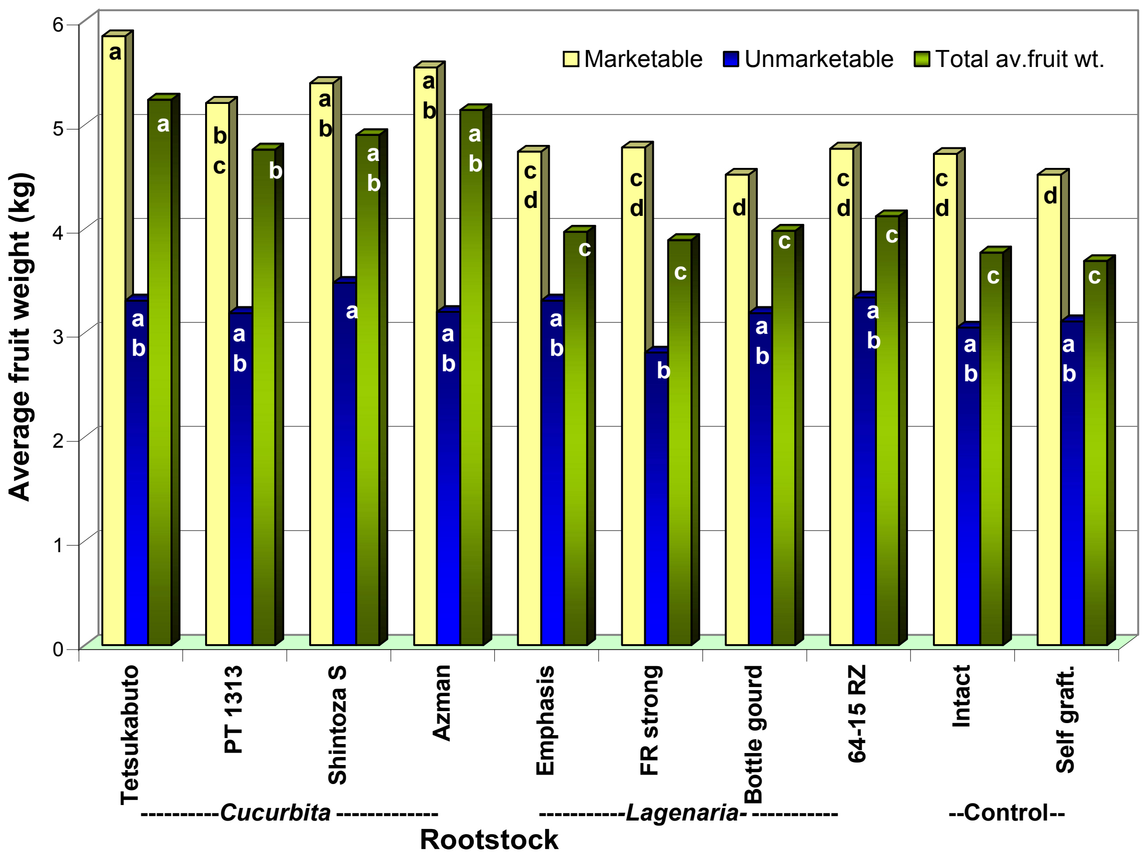

Figure 8: Effect of rootstock on average fruit weight for marketable, unmarketable and total yields of "Samara" watermelon in Balawneh (for each parameter, columns having different letters are significantly different according to DMRT at 0.05 level).

on *Cucurbita* rootstocks, "Samara" gave higher average fruit weight than when grafted on *Lagenaria* rootstocks and than the control (Fig. 8). The self grafted control gave the lightest average fruit weight, but average fruit weight, on total yield basis, was similar to those of the intact control and of "Samara" grafted on all *Lagenaria* rootstocks.

4.1.3.3 Average fruit number per plant

Azman, Shintoza supreme and PT 1313 rootstocks were significantly effective in increasing the marketable average fruit number per plant of "Samara" scion over the control and the *Lagenaria* rootstocks. The control gave the lowest number of fruits per plant (Fig. 9). "Samara" scion on

Tetsukabuto rootstock gave the lowest fruit number per plant among the *Cucurbita* rootstocks.

The controls and "Samara" grafted on the *Lagenaria* rootstocks gave similar unmarketable fruit numbers per plant but "Samara" on Emphasis rootstock tended to give higher unmarketable fruit numbers. The lowest unmar-

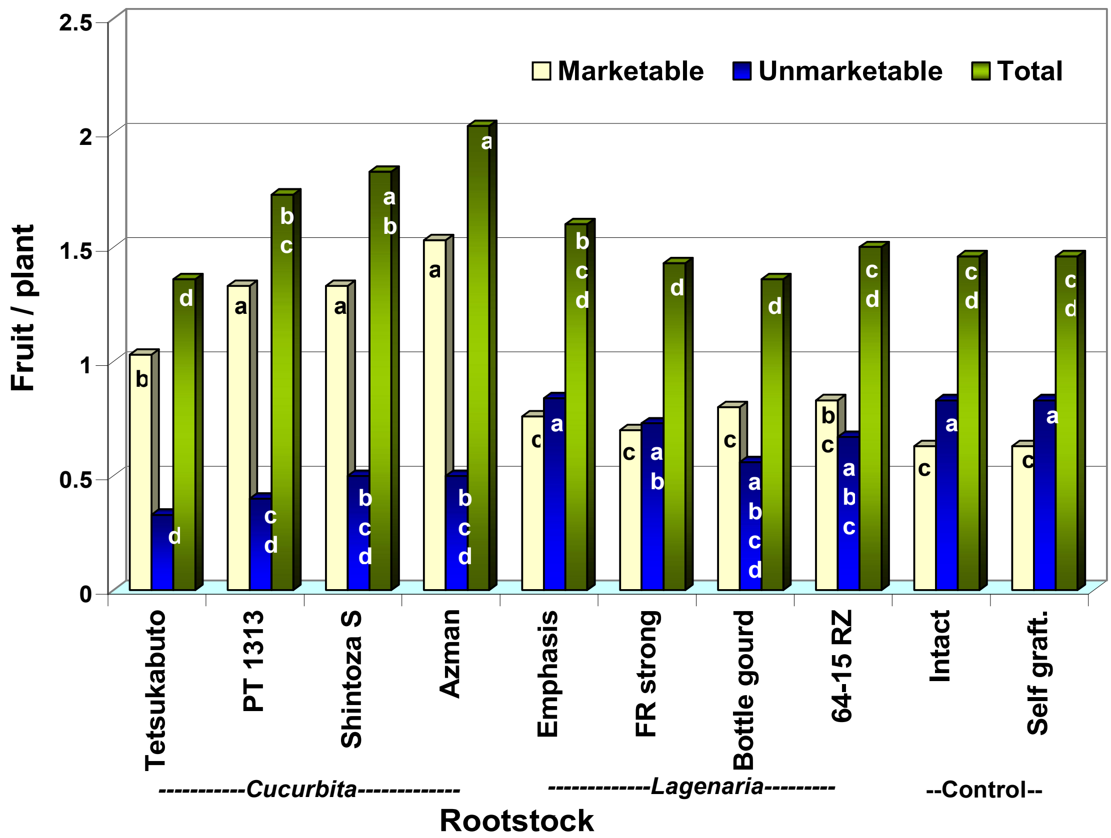

Figure 9: Effect of rootstock on marketable, unmarketable and total fruit numbers per plant of "Samara" watermelon in Balawneh (for each parameter, columns having different letters are significantly different according to DMRT at 0.05 level).

ketable number was obtained by grafting on Tetsukabuto rootstock, which was similar to those of the graft combinations with the other *Cucurbita* and Bottle gourd rootstocks (Fig. 9).

Azman and Shintoza supreme rootstocks combined with “Samara” scion gave the highest total fruit number per plant (2.03 and 1.83 fruits, respectively). On the other hand, the lowest number was given by grafting on Tetsukabuto and Bottle gourd rootstocks (1.36 fruits), which were significantly similar to the control and all grafted *Lagenaria* rootstocks. Grafting “Samara” on PT 1313, Shintoza supreme and Emphasis rootstocks gave similar total fruit numbers (Fig. 9).

4.1.4 Fruit quality

4.1.4.1 Physical properties

When “Samara” watermelon was grafted on *Cucurbita* rootstocks, fruit indices were significantly higher than those of the controls and of “Samara” grafted on *Lagenaria* rootstocks (Table 9). The highest (1.26) and lowest (1.15) fruit indices were achieved by grafting on Tetsukabuto rootstock and the self grafted control, respectively. Grafting on the latter gave significantly similar indices to those of “Samara” on the other *Lagenaria* rootstocks which were similar to the control.

Thickness of fruit rind varied with the rootstock. The thickest (1.12 cm) and thinnest (0.96 cm) fruit rinds were obtained by grafting “Samara” on 64-15 RZ and “PT 1313 and Azman” rootstocks, respectively (Table 9). The induced rind thickness by the two *Cucurbita* rootstocks was similar to that of the self grafted control. The remaining five rootstocks (Tetsukabuto, Shintoza supreme, Emphasis, FR Strong, and Bottle gourd landrace) induced fruit rind thickness similar to that of the intact “Samara” control.

Table 9: Effect of rootstock on fruit index, rind thickness and flesh firmness of "Samara" watermelon fruit in Balawneh (for each parameter, columns having different letters are significantly different according to DMRT at 0.05 level).

Treatment		Fruit Index	Rind thickness(cm)	Flesh firmness kg-force
Cucurbita rootstocks	Tetsukabuto	1.26 a	1.03 bc	1.88 ab
	PT 1313	1.22 b	0.96 d	1.94 a
	Shintoza sup.	1.24 b	1.04 bc	1.78 abc
	Azman	1.24 b	0.96 d	1.78 abc
Lagenaria rootstocks	Emphasis	1.16 cd	1.05 bc	1.59 c
	FR strong	1.17 cd	1.01 c	1.69 bc
	Bottle gourd	1.16 cd	1.07 b	1.56 c
	64-15 RZ	1.18 c	1.12 a	1.67 bc
Control (Samara)	Intact	1.16 cd	1.02 bc	1.61 c
	Self grafted	1.15 d	1.00 cd	1.61 c

Though significantly firmest (1.94 kg-force) fruit flesh was associated with grafting "Samara" on PT 1313 rootstock, flesh firmness was statistically similar when "Samara" was grafted on all *Cucurbita* rootstocks. Grafting on Bottle gourd landrace and Emphasis roostocks gave the softest flesh of "Samara" fruits. Similar flesh firmness was also observed for the control and by grafting on the remaining *Lagenaria* rootstocks (Table 9).

4.1.4.2 Chemical properties

"Samara" watermelon grafted on *Lagenaria* rootstocks (Emphasis and Bottle gourd) and the two controls gave significantly highest total soluble solids (Table 10). TSS % of "Samara" fruits was significantly reduced by grafting on the other rootstocks.

Total sugar content was significantly higher in fruits of the self grafted control, compared with those from scions grafted on *Cucurbita* rootstocks except for Azman rootstock. Otherwise, each of the two categories gave similar total sugar contents to those of scions grafted on the remaining rootstocks (Table 10).

Reducing sugar contents were significantly similar in "Samara" fruits when "Samara" was grafted on the *Cucurbita* and *Lagenaria* rootstocks including the controls. However, grafting on Tetsukabuto and Azman rootstocks tended to give the highest (6.46%) and the lowest (5.90%) reducing sugar content, respectively (Table 10).

Table 10: Effect of rootstock on total soluble solids, total sugars, reducing sugars and lycopene content of "Samara" watermelon fruits in Balawneh (for each parameter, columns having different letters are significantly different according to DMRT at 0.05 level**).**

Treatment		TSS %	Total sugars %	Reducing sugars %	Lycopene mg / kg
Cucurbita rootstocks	Tetsukabuto	9.44 c	8.73 b	6.46 a	28.69 a
	PT 1313	9.46 c	8.05 b	6.25 a	26.58 abc
	Shintoza sup.	9.62 bc	8.42 b	5.97 a	28.26 ab
	Azman	9.46 c	8.87 ab	5.90 a	25.39 c
Lagenaria rootstocks	Emphasis	10.20 a	9.00 ab	6.15 a	25.73 c
	FR strong	9.44 c	8.98 ab	6.68 a	25.21 c
	Bottle gourd	10.12 a	9.24 ab	6.33 a	26.68 bc
	64-15 RZ	9.47 c	8.28 b	6.09 a	24.90 c
Control (Samara)	Intact	10.01 ab	8.88 ab	6.51 a	25.17 c
	Self grafted	10.14 a	10.38 a	6.93 a	25.66 c

Lycopene contents were significantly higher (28.69 mg/kg) than those of all treatments when "Samara" was grafted on Tetsukabuto rootstock except for grafting on PT 1313 and Shintoza supreme rootstocks. Lowest lycopene contents (24.9 mg/kg) were induced by grafting on 64-15 RZ rootstock. However, the two controls and grafting on all *Lagenaria* and PT 1313 rootstocks gave similar results (Table 10).

4.2 Highland (Jerash) experiment

4.2.1 Vegetative growth

Grafting "Samara" watermelon on *Cucurbita* rootstocks gave significantly highest number of leaves per plant compared with the two controls and "Samara" grafted on *Lagenaria* rootstocks (Table 11). The highest number of leaves was given by grafting on Azman rootstock (389 leaf/plant) while the lowest number of leaves was obtained from grafting on Bottle gourd landrace rootstock (250 leaf/plant), which was significantly similar to the remaining *Lagenaria* rootstocks and the control.

Table 11: Effect of rootstock on number of leaves, number of branches, number of nodes per branch and dry weight of "Samara" watermelon plant in Jerash (for each parameter, columns having different letters are significantly different according to DMRT at 0.05 level).

Treatment		Number of leaves/plant	Number of branches/plant	Number of nodes/branch	Dry matter g /plant
Cucurbita rootstocks	Tetsukabuto	355 a	17.5 bc	20.2 a	142 a
	PT 1313	349 a	17.9 bc	19.5 ab	145 a
	Shintoza sup.	368 a	17.5 bc	21.0 a	130 a
	Azman	389 a	19.3 a	20.4 a	151 a
Lagenaria rootstocks	Emphasis	274 b	16.9 bc	16.7 c	90 b
	FR strong	255 b	15.9 c	16.0 c	86 b
	Bottle gourd	250 b	16.5 bc	16.9 bc	90 b
	64-15 RZ	273 b	17.1 bc	15.9 c	83 b
Control (Samara)	Samara	251 b	15.9 c	15.7 c	78 b
	Self grafted	275 b	17.1 bc	16.1 c	76 b

Significantly highest number of branches (19.3 branch/plant) was produced by "Samara" when grafted on Azman rootstock. On the other hand, the intact control and "Samara" grafted on FR strong rootstock gave the lowest number of branches (15.86 branch/plant) (Table 11), which were significantly similar to those of grafted "Samara" on the other rootstocks and self grafted control.

In general, Grafting “Samara” on *Cucurbita* rootstocks gave significantly higher number of nodes per branch compared with the two controls and those grafted on *Lagenaria* rootstocks which were also similar in number of nodes per branch (Table 11).

To similar extents, *Cucurbita* rootstocks caused significant enhancement in the dry weight of “Samara” plants. In contrast, *Lagenaria* rootstocks failed to increase plant dry weight being almost similar in effect to the controls (Table11).

4.2.2 Sex expression

Sex expression was greatly affected by grafting “Samara” on different rootstocks (Table 12). Significantly highest numbers of male and female flowers per plant were produced by “Samara” when grafted on *Cucurbita* rootstocks. “Samara” grafted on *Lagenaria* rootstocks and both of the controls gave similar numbers of male and female flowers. However, within

Table 12: Effect of rootstock on male, female flowers and male : female flower ratio of “Samara” watermelon plant in Jerash (for each parameter, columns having different letters are significantly different according to DMRT at 0.05 level).

Treatment		Male flower/plant	Female flower/plant	Male/female flower ratio
***Cucurbita* rootstocks**	**Tetsukabuto**	**337 a**	**9.9 a**	**33.9:1 a**
	PT 1313	**332 a**	**9.9 a**	**34.1:1 a**
	Shintoza sup.	**350 a**	**10.3 a**	**34.1:1 a**
	Azman	**369 a**	**10.7 a**	**34.4:1 a**
***Lagenaria* rootstocks**	**Emphasis**	**257 b**	**8.0 b**	**32.2:1 abc**
	FR strong	**239 b**	**7.9 b**	**30.3:1 bcd**
	Bottle gourd	**277 b**	**8.3 b**	**33.2:1 ab**
	64-15 RZ	**256 b**	**8.5 b**	**30.0:1 dc**
Control (Samara)	**Intact**	**250 b**	**8.1 b**	**29.1:1 d**
	Self grafted	**258 b**	**8.5 b**	**30.2:1 bcd**

“*Cucurbita* rootstocks” and “*Lagenaria* rootstocks and the controls” responses of “Samara” scions were similar in terms of male and female flowers produced. The highest male : female flower ratio was given by grafting on Azman

(34.4 :1) which was significantly similar to that obtained by grafting on the other *Cucurbita* rootstocks, Emphasis and Bottle gourd landrace (Table 12).

The intact control gave the lowest male : female ratio (29.1 : 1) and the ratio was significantly similar to those of the self grafted control and “Samara” grafted on 64-15 RZ and FR Strong rootstocks.

4.2.3 Yield and yield components

4.2.3.1 Yield

“Samara” watermelon grafted on Azman rootstock gave the highest marketable yield (11.36 ton/du), but produced significantly similar yields when grafted on Shintoza supreme rootstock which induced marketable yields similar to those induced by the remaining *Cucurbita* rootstocks. “Samara” marketable yields were significantly higher than the controls and when grafted on *Cucurbita* rather than on *Lagenaria* rootstocks (Fig. 10). The lowest marketable yield was produced by grafting on FR Strong (5.05 ton/du), which was significantly similar to marketable yield of the self grafted control and “Samara” grafted on the remaining *Lagenaria* rootstocks (except for Bottle gourd landrace) (Fig. 10).

The intact control gave the highest unmarketable yield (2.19 ton/du). Though grafting on Azman rootstock resulted in the lowest unmarketable yield (0.85 ton/du) no significant differences were detected among all treatments including grafting on *Cucurbita* and *Lagenaria* rootstocks and the self grafted control.

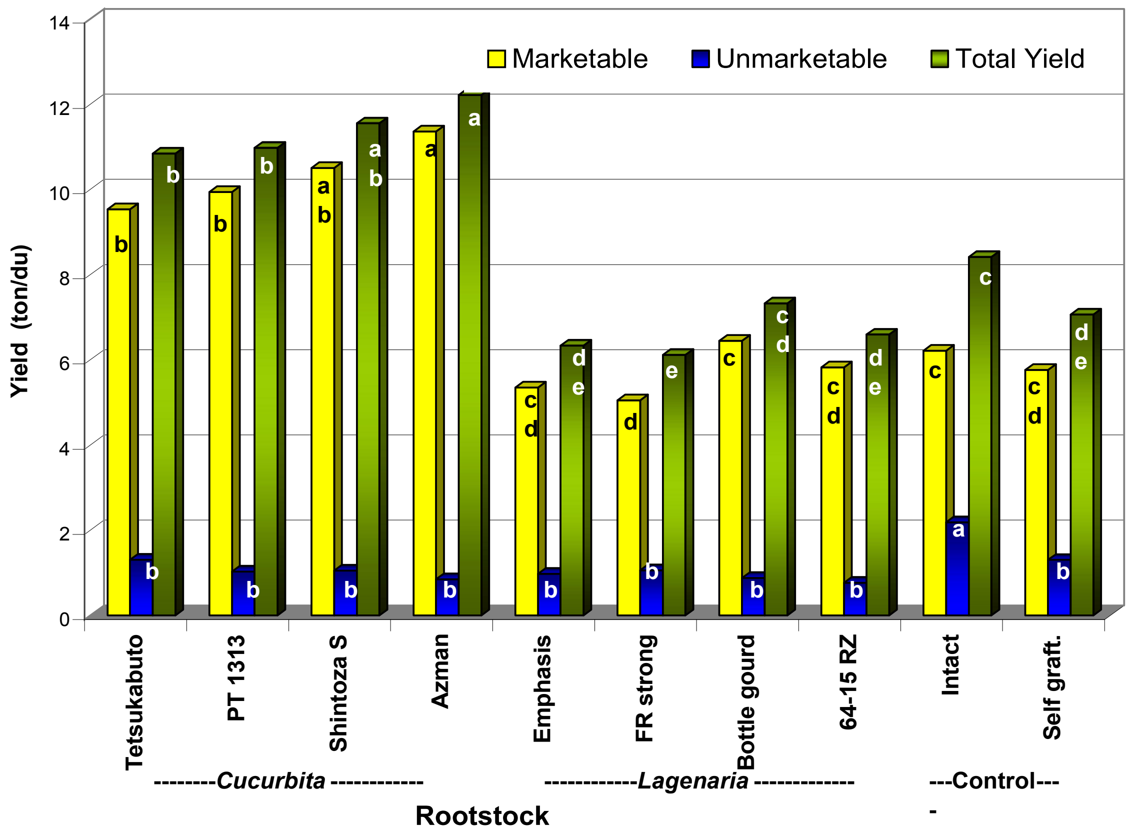

Figure 10: Effect of rootstock on marketable, unmarketable and total yield of "Samara" watermelon in Jerash (for each parameter, columns having different letters are significantly different according to DMRT at 0.05 level)

The highest total yield was produced by "Samara" grafted on Azman and Shintoza supreme rootstocks (12.21, 11.55 ton/du, respectively); the latter was significantly similar to total yield of the same scion when grafted on the other *Cucurbita* rootstocks, which gave higher total yields than those of the grafted *Lagenaria* rootstocks. Grafting FR strong rootstock resulted in the lowest total yield (6.11 ton/du) and was significantly similar to total yields of "Samara" grafted on Emphasis and 64-15 RZ rootstocks and those of the self grafted control.

4.2.3.2 Average fruit weight

Grafting "Samara" watermelon on different rootstocks had considerable effect on average fruit weight. "Samara" Shintoza supreme combination gave the highest marketable average fruit weight (7.2 Kg), which was significantly similar to that of "Samara" grafted on Azman rootstock (Fig. 11). Grafting on Tetsukabuto, PT 1313 and *Lagenaria* (except for 64-15 RZ) rootstocks as well as the controls produced fruits of similar weight. However, grafting on 64-15 RZ gave the lowest marketable fruit weight (5.14 kg) but was similar to fruit weight from the control and grafted *Lagenaria* rootstocks.

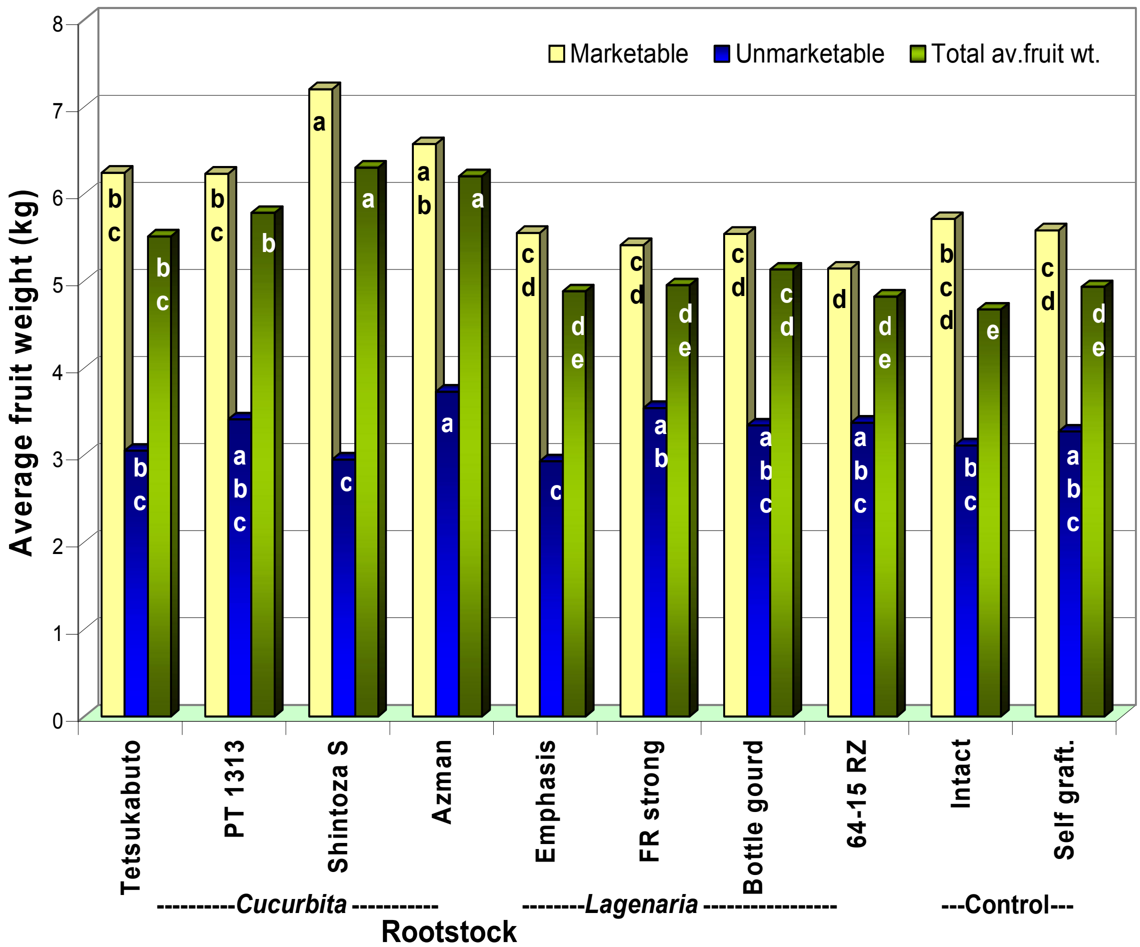

Figure 11: Effect of rootstock on average fruit weight of marketable, unmarketable and total yield of "Samara" watermelon in Jerash (for each parameter, columns having different letters are significantly different according to DMRT at 0.05 level).

By Grafting on Azman rootstock, the highest unmarketable average fruit weight (3.73 kg) was obtained but the self grafted control and grafting on *Lagenaria* (except Emphasis) and PT 1313 rootstocks gave similar unmarketable fruit weights (Fig. 11). In contrast, "Samara" grafted on

Emphasis and Shintoza supreme rootstocks gave the lowest unmarketable fruit weights (2.93, 2.95 kg/fruit) respectively; those rootstock effects were significantly similar to those of all treatments except when Azman and FR strong were used as rootstocks.

4.2.3.3 Average fruit number per plant

"Samara" scion grafted on *Cucurbita* rootstocks gave higher marketable fruit number per plant than when grafted on *Lagenaria* rootstocks and than the control. Grafting "Samara" on Azman rootstock resulted in highest fruit number which was significantly similar to those produced by grafting on the other *Cucurbita* rootstocks (Fig. 12). FR Strong rootstock induced the lowest

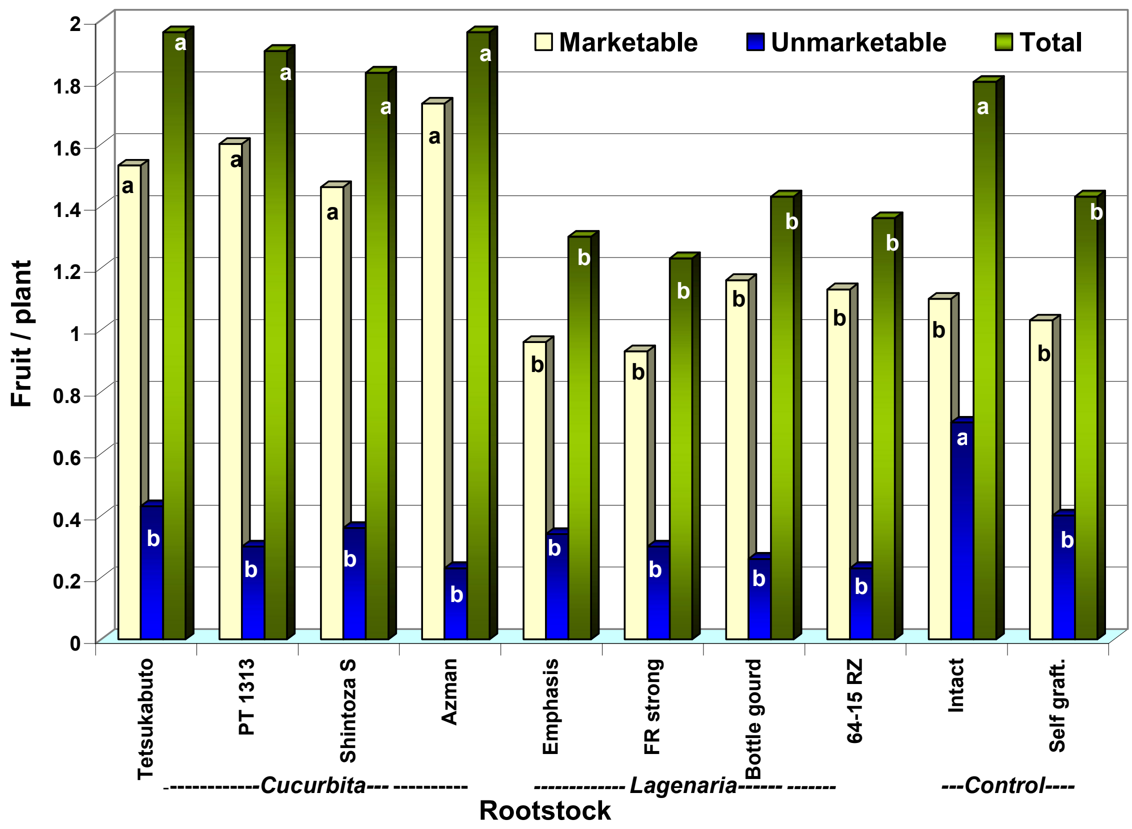

Figure 12: Effect of rootstock on marketable, unmarketable and total fruit number of "Samara" watermelon in Jerash (for each parameter, columns having different letters are significantly different according to DMRT at 0.05 level)

marketable fruit number (0.93) but the other Lagenaraia rootstocks and the control had similar effects . The intact control gave the highest unmarketable fruit number per plant (0.70). The remaining treatments had significantly similar unmarketable fruit numbers, but lowest number (0.23) was given by “Samara” grafted on Azman and 64-15 RZ rootstocks.

“Samara” grafted on *Cucurbita* rootstocks besides the intact control, gave higher total fruit number per plant than when grafted on *Lagenaria* rootstocks or self grafted (Fig. 12). The highest number of fruits per plant was obtained by grafting “Samara” scion on Tetsukabuto and Azman rootstocks (1.96), whereas the lowest number of fruits was given by grafting on FR strong rootstock (1.23).

4.2.4 Fruit quality

4.2.4.1 Physical properties

Though “Samara” scion on Shintoza supreme gave the highest fruit index (1.3), this value was significantly similar to those obtained by grafting on the other *Cucurbita* rootstocks and the control(Table 13). Grafting on 64-15RZ rootstock gave the lowest fruit index value, but similar fruit indices were observed when “Samara” was grafted on the other *Lagenaria* rootstocks, except Bottle gourd landrace. Grafting on this landrace, Emphasis, FR Strong, Tetsukabuto and PT 1313 rootstocks besides the intact control, gave significantly similar fruit indices. “Samara” on *Cucurbita* rootstocks gave higher fruit indices than on *Lagenaria*-type rootstocks.

While the lowest rind thickness was induced by grafting on PT 1313 rootstock, significantly similar effects were induced by all treatments including the control, except for Bottle gourd landrace and 64-15 RZ rootstocks which gave the thickest rind values (1.07, 1.06 cm, respectively) (Table 13).Rind thickness of “Samara” fruits induced by those two rootstocks, was significantly similar to effects of Emphasis, Shintoza supreme rootstocks and the intact control treatments.

Table 13: Effect of rootstock on fruit index ,rind thickness and flesh firmness of "Samara" watermelon fruit in Jerash (for each parameter, columns having different letters are significantly different according to DMRT at 0.05 level).

Treatment		Fruit Index	Rind thickness (cm)	Flesh firmness (kg-force)
***Cucurbita* rootstocks**	**Tetsukabuto**	**1.29 ab**	**1.02 bc**	**1.67 abcd**
	PT 1313	**1.28 ab**	**1.00 c**	**1.76 abc**
	Shintoza sup.	**1.30 a**	**1.04 abc**	**1.83 a**
	Azman	**1.30 a**	**1.01 bc**	**1.78 ab**
***Lagenaria* rootstocks**	**Emphasis**	**1.24 de**	**1.04 abc**	**1.57 d**
	FR strong	**1.25 cde**	**1.01 bc**	**1.63 bcd**
	Bottle gourd	**1.26 bcd**	**1.07 a**	**1.58 d**
	64-15 RZ	**1.23 e**	**1.06 ab**	**1.64 bcd**
Control (Samara)	**Intact**	**1.27 abc**	**1.03 abc**	**1.64 bcd**
	Self grafted	**1.30 a**	**1.01 c**	**1.60 cd**

In general, treatments of *Cucurbita* rootstocks gave higher fruit flesh firmness values than *Lagenaria* rootstocks (Table 13). All rootstock treatments gave significantly similar flesh firmness values to the intact control except for Shintoza supreme rootstock which induced significantly highest flesh firmness values (1.83 kg-force). Lowest firmness values, however, were observed when "Samara" was grafted on Emphasis and Bottle gourd (1.57, 1.58 kg-force, respectively).

4.2.4.2 Chemical properties

All grafting treatments and the controls showed no significant differences in total soluble solids, total sugars and reducing sugars of "Samara" scion fruits. However, grafting on *Cucurbita* rootstocks tended to give lower total soluble solids than grafting on *Lagenaria* rootstocks, except for bottle gourd (*Lagenaria* landrace). Similarly, grafting on *Cucurbita* rootstocks gave lower values for total sugars, except for PT 1313 (*Cucurbita* hyprid) and higher values for reducing sugars (Table 14). "Samara" watermelon, as an intact control, gave the

Table 14: Effect of rootstock on total soluble solids, total sugars, reducing sugars and lycopene contents of "Samara" watermelon fruits in Jerash (for each parameter, columns having different letters are significantly different according to DMRT at 0.05 level).

Treatment		TSS %	Total sugars %	Reducing sugars %	Lycopene mg/kg
Cucurbita rootstocks	Tetsukabuto	9.9 a	9.9 a	6.6 a	28.9 a
	PT 1313	9.8 a	10.3 a	6.5 a	26.6 d
	Shintoza sup.	9.9 a	9.6 a	6.5 a	27.0 bcd
	Azman	9.8 a	9.8 a	6.3 a	26.6 d
Lagenaria rootstocks	Emphasis	10.1 a	10.3 a	6.4 a	26.9 cd
	FR strong	9.9 a	10.1 a	6.1 a	28.4 ab
	Bottle gourd	9.74 a	10.0 a	6.0 a	26.8 cd
	64-15 RZ	10.1 a	10.5 a	6.2 a	27.6 abcd
Control (Samara)	Intact	10.3 a	9.9 a	6.0 a	27.7 abcd
	Self grafted	10.0 a	9.72 a	6.1 a	28.1 abc

highest TSS% (10.25%), whereas when grafted on 64-15 RZ (*Lagenaria* hybrid rootstock) the highest TSS% and total sugar values (10.1, 10.5%, respectively) were obtained. "Samara" on Tetsukabuto (*Cucurbita* hybrid) rootstock gave the highest reducing sugar value (6.56%).

Significant variations in lycopene contents of "Samara" watermelon fruits were observed (Table 14). Grafting on Tetsukabuto rootstock gave the highest lycopene content (28.9 mg/kg) and was significantly similar to lycopene contents of fruits from grafting on FR strong and 64-15 RZ (*Lagenaria* hybrids) rootstocks and the control. Though grafting on PT 1313 (*Cucurbita* hybrid) gave the lowest lycopene content (26.6 mg/kg), similar lycopene contents were found in "Samara" fruits of all treatments except for grafting on Tetsukabuto and FR Strong rootstocks and the self grafted control.

4.3. Compatibility and survival rate

Seedlings of "Samara" watermelon and "*Cucurbita* and *Lagenaria* rootstocks" were grafted at three stages of growth and development (cotyledon, first true leaf and second true leaf) to study the effect of hypocotyl diameter on scion rootstock compatibility and survival rate at different growth stages.

4.3.1. Compatibility

4.3.1.1. Hypocotyls diameter

The hypocotyl diameters of "Samara" seedlings at the time of grafting showed considerable differences within each growth stage. Hypocotyl diameters of "Samara" seedlings to be grafted on *Cucurbita* rootstocks, bottle gourd and 64-15 RZ (*Lagenaria*) rootstocks were similar at cotyledon growth stage (Table 15). The thinnest hypocotyls were those to be grafted on FRstrong rootstock and were similar in diameter to those for grafting on Bottle gourd and Emphasis rootstocks.

Table 15: Hypocotyl diameter of "Samara" watermelon scion seedlings upon grafting on *Cucurbita* and *Lagenaria* rootstocks at three stages of growth and development (for each parameter, columns having different letters are significantly different according to DMRT at 0.05 level).

Treatment		Hypocotyl diameter (mm)		
		Cotyledon	First true leaf	Second true leaf
Cucurbita rootstocks	Tetsukabuto	2.37 ab	2.52 a	2.42 c
	PT 1313	2.38 a	2.49 a	2.49 ab
	Shintoza sup.	2.36 ab	2.41 c	2.50 a
	Azman	2.38 a	2.42 bc	2.48 ab
Lagenaria rootstocks	Emphasis	2.30 bc	2.48 a	2.47 ab
	FR strong	2.27 c	2.48 a	2.48 ab
	Bottle gourd	2.32 abc	2.51 a	2.45 bc
	64-15 RZ	2.38 a	2.47 ab	2.48 ab

At the first true leaf stage all hypocotyls of "Samara" seedlings used for grafting were thicker than those of Shintoza supreme and Azman rootstocks only; otherwise, seedling hypocotyls of *Cucurbita* and *Lagenaria* rootstocks were similar in diameter (Table 15). At the second true leaf stage scion hypocotyl diameters to be grafted on Shintoza supreme were only thicker than those of Tetsukabuto and the bottle gourd (*Lagenaria*) rootstocks.

At the cotyledon stage, hypocotyls of Tetsukabuto and 64-15 RZ seedlings were the thickest at time of grafting (Table 16); the thinnest were those of PT 1313 and bottle gourd seedlings.

Table 16: Hypocotyl diameter of *Cucurbita* and *Lagenaria* rootstocks used for grafting "Samara" watermelon at three stages of growth and development (for each parameter, columns having different letters are significantly different according to DMRT at 0.05 level).

Treatment		Hypocotyl diameter (mm)		
		Cotyledon	First true leaf	Second true leaf
Cucurbita rootstocks	Tetsukabuto	3.86 a	3.82 cd	3.81 c
	PT 1313	3.14 d	3.48 f	3.57 d
	Shintoza sup.	3.69 b	3.75 de	3.93 ab
	Azman	3.61 bc	3.69 e	3.79 c
Lagenaria rootstocks	Emphasis	3.60 bc	3.94 ab	3.88 b
	FR strong	3.56 c	3.88 bc	3.92 ab
	Bottle gourd	3.18 d	3.83 c	3.90 b
	64-15 RZ	3.79 a	3.98 a	3.98 a

At the first and second true leaf stages, at time of grafting, seedlings of 64-15 RZ (*Lagenaria*) and PT 1313 rootstocks (*Cucurbita*) rootstocks had the thickest and the thinnest hypocotyls, respectively. The hypocotyl diameters of the remaining rootstocks were intermediate in their thickness, but varied considerably (Table 16).

Hypocotyl ratios of "Samara" scion to Shintoza supreme ,Azman ,Emphasis and FR strong rootstocks at time of grafting were similar but lower than those of Tetsukabuto and bottle gourd rootstocks (Table 17); the lowest scion diameter to rootstock diameter ratios were observed in PT 1313 and 64-15 RZ rootstocks at the cotyledon stage. At the first true leaf stage, the highest

Table 17: Hypocotyl diameter ratio of "Samara" watermelon scion to rootstocks upon grafting at three stages of growth and development (for each parameter, columns having different letters are significantly different according to DMRT at 0.05 level).

Treatment		Hypocotyl diameter ratio		
		Cotyledon	First true leaf	Second true leaf
***Cucurbita* rootstocks**	**Tetsukabuto**	**0.76:1 a**	**0.66:1 b**	**0.64:1 c**
	PT 1313	**0.62:1 c**	**0.72:1 a**	**0.72:1 a**
	Shintoza sup.	**0.64:1 bc**	**0.64:1 cd**	**0.64:1 b**
	Azman	**0.66:1 b**	**0.65:1 bc**	**0.65:1 b**
***Lagenaria* rootstocks**	**Emphasis**	**0.64:1 bc**	**0.63:1 de**	**0.63:1 c**
	FR strong	**0.64:1 bc**	**0.64:1 cd**	**0.63:1 c**
	Bottle gourd	**0.73:1 a**	**0.65:1 bc**	**0.63:1 c**
	64-15 RZ	**0.63:1 c**	**0.62:1 d**	**0.63:1 c**

and the lowest diameter ratios, were those of grafted PT 1313 and 64-15 RZ rootstocks respectively; the latter ratio was similar for the remaining combinations of "Samara" and rootstocks, except for Testukabuto, Azman and Bottle gourd. "Samara" : *Lagenaria*, and "Samara" : Tetsukabuto hypocotyl diameters were the lowest, while the highest ratio was for "Samara" : PT 1313 combination at the second true leaf stage (Table 17).

4.3.1.2. Survival rate

Survival rate of the grafted seedlings at the three stages of growth and development was determined when the grafted seedlings were ready for transplanting (Table 18). All growth stages of the grafted seedlings gave significantly similar survival rates (≥ 94.45%) within each stage. In general, the highest survival rates were associated with grafting at first true leaf stage.

Table 18: Survival rate of grafted "Samara" watermelon on *Cucurbita* and *Lagenaria* rootstocks at three stages of growth and development (for each parameter, columns having different letters are significantly different according to DMRT at 0.05 level).

Treatment		Survival rate (%)		
		Cotyledon	First true leaf	Second true leaf
***Cucurbita* rootstocks**	**Tetsukabuto**	**97.23 a**	**100 a**	**97.23 a**
	PT 1313	**94.45 a**	**97.23 a**	**97.23 a**
	Shintoza sup.	**97.23 a**	**97.23 a**	**100 a**
	Azman	**97.23 a**	**100 a**	**100 a**
***Lagenaria* rootstocks**	**Emphasis**	**94.45 a**	**100 a**	**97.23 a**
	FR strong	**97.23 a**	**100 a**	**94.45 a**
	Bottle gourd	**94.45 a**	**97.23 a**	**94.45 a**
	64-15 RZ	**97.23 a**	**100 a**	**100 a**

4.3.1.3. Anatomy of the graft union

Anatomy of the graft union of "Samara" watermelon grafted on *Cucurbita* and *Lagenaria* rootstocks was accomplished cross sections were prepared and photographed (plates 2 and 3).

The developmental stages of graft union are shown: They began with parenchyma cell division that filled the space between the wounded scion and rootstock (plates 2 "C, D" and 3 "C, D"), and made a connecting callus in the line of union. Cell division continued and the new cells differentiated into xylem and phloem cells to connect the vascular bundles of the scion with the rootstock vascular system (plates 2 " E, F" and 3 " E, F").

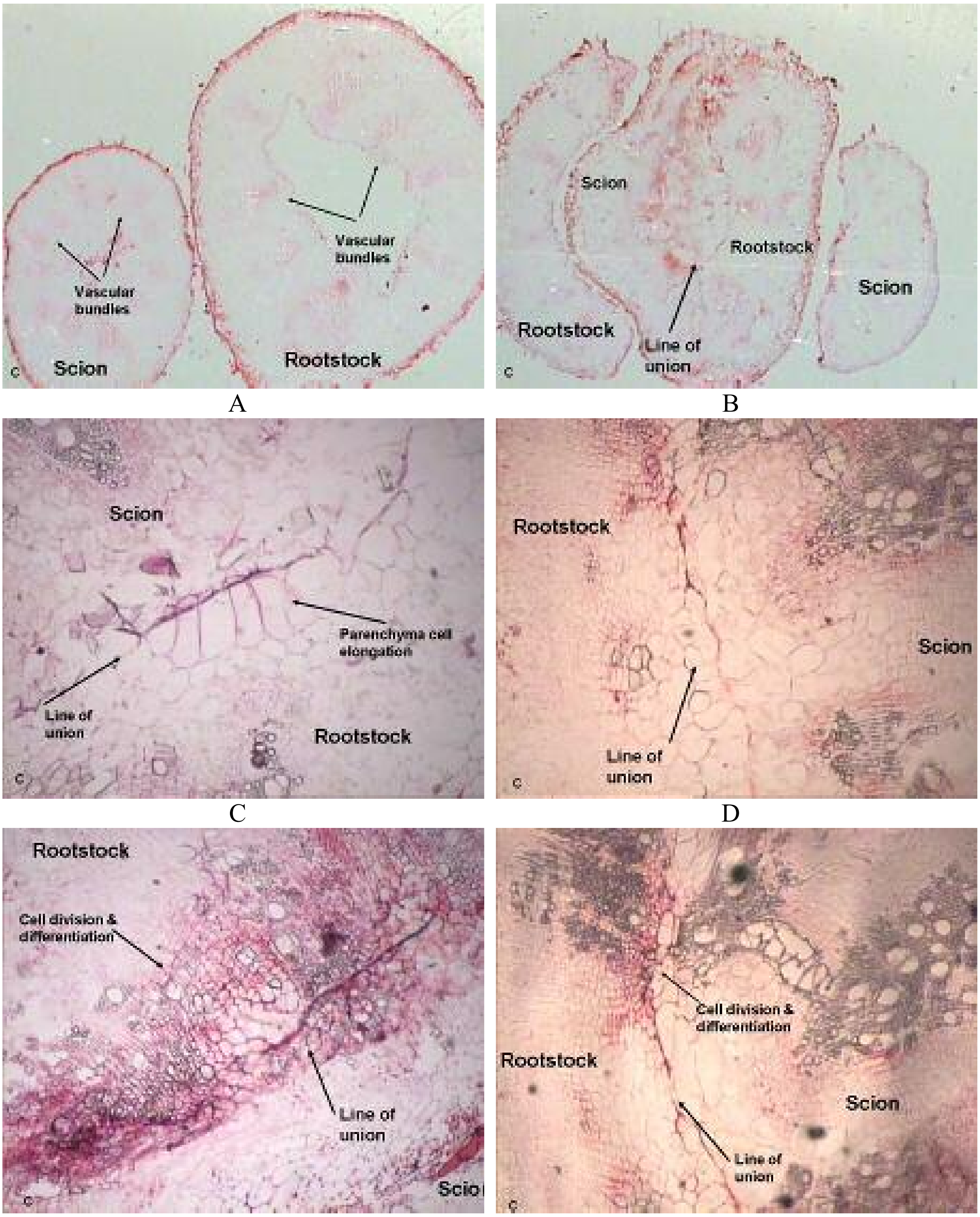

Plate 2. A: Cross section of "Samara" watermelon (left) and Azman (*Cucurbita*) rootstock hypocotyles. B: Cross section of graft union for "Samara" and Azman combina- tion. C & D: Parenchyma cell division and elongation at the line of union. E & F: Cell division and differentiation into xylem and phloem vessels.

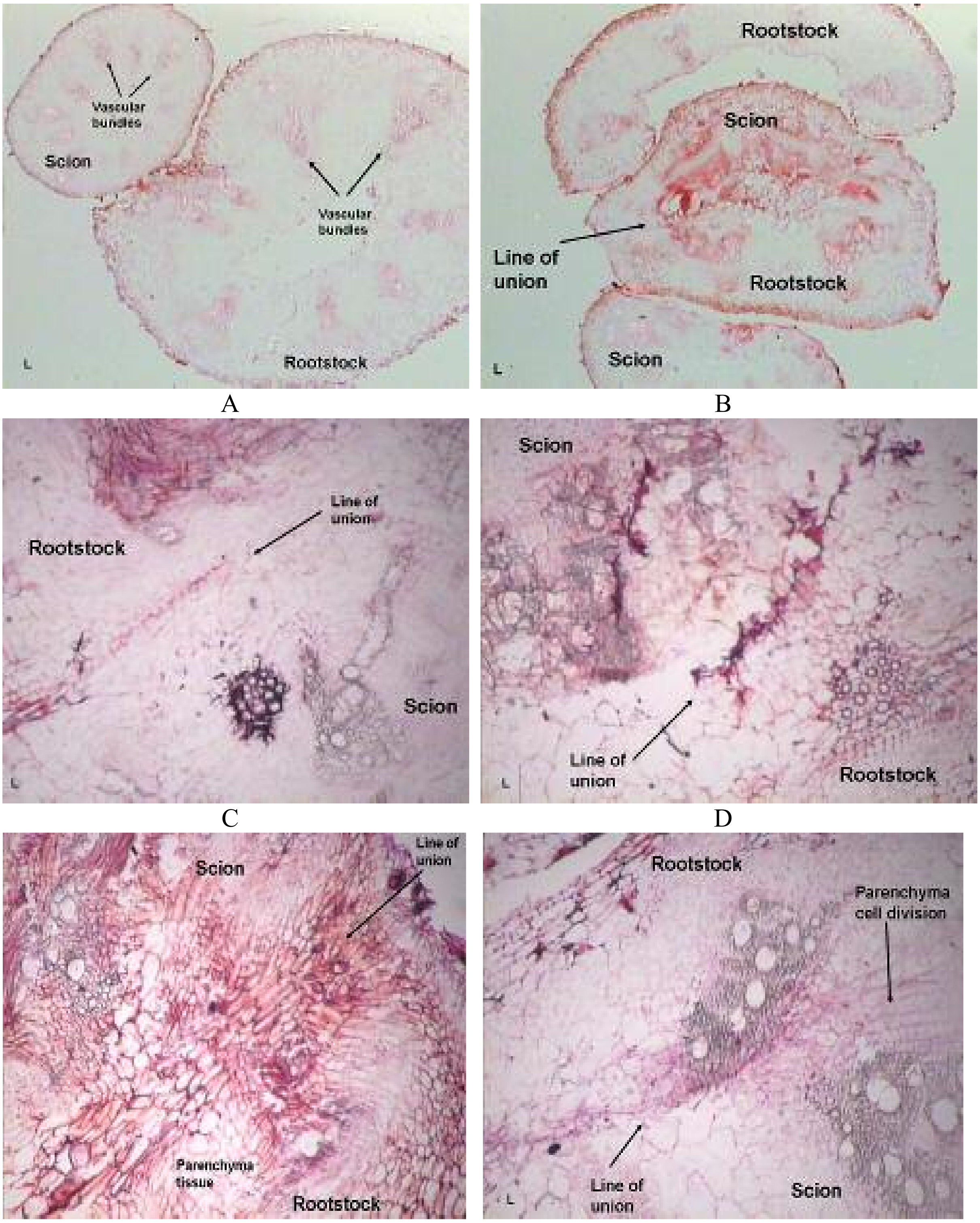

Plate 3. A: Cross section of "Samara" watermelon (left) and Bottle gourd (*Lagenaria*) rootstock hypocotyles. B: Cross section of graft union for "Samara" and Bottle gourd combination. C & D: Parenchyma cell division and elongation at the line of union. E & F: Cell division and differentiation into xylem and phloem vessels.

5. DISCUSSION

5.1 Effect of rootstock on vegetative growth

"Samara" grafted on *Cucurbita* rootstocks was induced to produce significantly higher numbers of leaves per plant (about 40%) than when grafted on *Lagenaria* rootstocks and than the controls in both locations, Balawneh and Jerash (Tables 7 and 11). Using a different watermelon scion, "Crimson Tide", Yetisir and Sari (2003) found that grafting on *Cucurbita* and *Lagenaria* rootstocks gave variable numbers of leaves per plant but were higher than those of the non-grafted control. In another study (Yetisir and Sari, 2004), "Crimson Tide" watermelon grafted on different *Cucurbita* and *Lagenaria* type rootstocks gave significant differences in number of leaves per plant; however, some rootstocks from both types induced similar but higher numbers of leaves per plant of "Crimson Tide" watermelon than the control. Benificial and variable responses were also reported (Pavlou, *et al.*, 2002) in crops other than watermelon, where *Cucurbita maxima* x *Cucurbita moschata* hybrid rootstocks were grafted with " Brunex F_1" cucumber, higher numbers of leaves per plant were observed compared with the control and grafting on the other *Cucurbita* rootstocks used.

"Samara" on Azman rootstock gave the highest number of branches per plant in both experiments of Balawneh & Jerash, while the remaining rootstocks, including Bottle gourd, gave numbers of branches more or less similar to the control (Tables 7 and 11). In contrast, Salam, *et al.* (2002) reported that "Top Yield" watermelon grafted on bottle gourd rootstock gave higher numbers of branches per plant. These discrepancies are likely due to different scions used.

Present results (Tables 7 and 11) also indicated that *Cucurbita* rootstocks were more effective in inducing more nodes per branch (20-27%) than the *Lagenaria* rootstocks and than the two controls suggesting taller branches. Under different conditions, and using melons rather than watermelon, Bletsos (2005) reported that grafting "Galia F_1" melon on Mamouth (*Cucurbita* rootstock) and Nun 9075 RT F1 (*Lagenaria* rootstock) and plants grown in methyl bromide fumigated soil resulted in taller plants than the control.

In general agreement with earlier findings (Chouka and Jebari, 1999 and Yetisir and Sari, 2004), grafting "Samara" watermelon on *Cucurbita* rootstocks, in both locations, produced heavier dry vegetative growth than those grafted on *Lagenaria* rootstocks and than the controls (Tables 7 and 11) with Azman inducing the heaviest plants. That dry matter contents of grafted "Samara" were highly correlated with number of leaves per plant (r = 0.94, 0.93), number of branches (r = 0.82, 0.68) and number of nodes per branch (r = 0.87, 0.88) in Balawneh and Jerash, respectively (Appendix A, tables 24 and 25), suggests that rootstocks were effective in supporting adequate vegetative growth of the scion, especially the leaves, thus enhancing the capacity of the scion to produce more photosynthates required for better growth and development of both scion and rootstock.

According to Chouka and Jebari (1999), the impact of grafting on dry vegetative part of "Sugar baby F_1" watermelon plant was very remarkable specially on RS 841 (*Cucurbita* hybrid) rootstock. Moreover, grafted "Crimson Tide" watermelon, on *Lagenaria* (Four hybrids and one landrace) and *Cucurbita* (Three hybrids and two landraces) rootstocks, produced more fresh and dry vegetative growth than did the control (Yetisir and Sari, 2004). Grafting the same scion on similar group of rootstocks induced 6-136% heavier fresh weight than the control, except for 216 (*Lagenaria* hybrid) rootstock (Yetisir and Sari,2003). Consistent with this finding, *Lagenaria* rootstocks herein failed to induce heavier "Samara" plants (Tables 7 and 11).

That rootstocks improve growth of scions, to variable degrees, is well documented herein (Tables 7 and 11) and elsewhere (Yetisir *et al*., 2006; Cohen, *et al*., 2005; Yetisir and Sari, 2004; Bletsos, 2005 and Lee, 1994).

Ungrafted "Crimson Tide" watermelon showed considerable reductions in fresh and dry weights than when grafted on *Lagenaria siceraria* rootstock under flooding (Yetisir *et al*., 2006). Grafting "Malika F_1" melon on *Cucurbita* TZ-148 rootstock induced more fresh weight than the non-grafted control (Cohen *et al*., 2005). Bletsos (2005) attributed the increased vigor of grafted melon plants to the larger root system of the rootstock. The impact of rootstock on the fresh and the dry weights of the scion was closely related to the root length (Yetisir and Sari, 2004) or the vigorous root system of the rootstock (Lee, 1994, as cited by Pavlou *et al.,* 2002), which supply excess water and plant nutrients to the scion (Lee, 1994; Yetisir and Sari, 2004). Undoubtedly, under the conditions of the present investigation, the rootstocks used especially the *Cucurbita* type produced larger root systems capable of supplying the scion with adequate amounts of water and nutrients as depicted by the superior growth of the "Samara" scion (Tables 7 and 11). Cucurbits usually show a significant amount of xylem sap after vine cut, greatly influenced by rootstock and containing high concentration of minerals and organic substances (Kato and Lou 1989; Masuda and Gomi, 1982 as cited by Pavlou *et al*., 2002) and endogenous plant hormones (cytokinins and gibberellins) (Lee, 1994, as cited by Pavlou *et al*., 2002). Besides the vigorous root growth of the rootstocks, the vascular bundles of the hypocotyls play a key role in providing the essential route for water and nutrients absorbed from the soil and the distribution and allocation of photosynthates and endogenous plant bioregulators.

5.2 Effect of rootstock on sex expression.

Sex expression in Cucurbitaceous crops may be influenced by rootstock (Park, 1987; Takahashi, *et al.,* 1981, as cited by Lee, 1994). In both locations, *Cucurbita* rootstocks, especially Azman were most effective inducers of male and female flowers per plant of "Samara" scion compared with the *Lagenaria* rootstocks and the control where similar effects were observed. This is most likely due to better growth of “Samara” on *Cucurbita* rootstocks (Tables 8 and 12). This is substantiated by the highly significant correlation between the number of male flowers and number of branches (r = 0.89 and 0.73) and number of nodes per branch of watermelon plant (r = 0.92 and 0.86) in Balawneh and Jerash, respectively (Appendix A, tables 24 and 25). However, the effect of rootstock on sex expression is not as significant as changes in other characteristics because the major hormones supplied by rootstock are cytokinins and sex expression in cucurbitaceous crops is mostly controlled by gibberellins and internal ethylene (Ying and Narajanan, 1991 as cited by Lee, 1994).

Male to female flower ratio of "Samara" grafted on *Cucurbita* and *Lagenaria* rootstock did not show significant differences between all treatments in Balawneh. On the other hand, in Jerash, *Cucurbita* rootstocks produced higher male to female flower ratio than some *Lagenaria* rootstocks and the controls. However, we believe that this ratio is unnecessarily high as production of female flowers continued throughout the growing season after the fruit set is complete and during fruit growth and development (Tables 8 and 12). Reducing this ratio by reduction of male flowers, by one mean or the other, will undoubtedly divert the consumed carbohydrates to other plant activities including fruit growth and development, thus boosting watermelon yields and improving fruit quality.

5.3 Effect of rootstock on yield and yield components

5.3.1 Yield

Rootstocks induced pronounced effects on yields of "Samara" watermelon in both locations (Figs. 7 and 10). Azman rootstock induced highest marketable and total yields. "Samara" when grafted on *Cucurbita* rootstocks gave higher marketable and total yields and lower unmarketable yields than those grafted on *Lagenaria* rootstocks and controls, except for Jerash where unmarketable yields were similar in all treatments except for intact control which produced the highest unmarketable yields. In contrast, Yetisir *et al.* (2003) reported that "Crimson Tide" watermelon grafted on *Lagenaria* rootstocks (Four hybrids and one landrace) produced higher total and marketable yields than the control and *Cucurbita* rootstocks (Two hybrids and two landraces).

Such variations are possibly due to scions, rootstocks and grafting techniques used and consequent compatibility problems. This is evident from present results (Figs. 7 and 10) and other findings (Yetisir *et al*., 2003; Chouka and Jebari 1999; Ruiz and Romero, 1999) where variations were clear between types of rootstocks and among rootstocks within the same type grafted with different scions.

The incompatibility observed by Yetisir *et al*. (2003) between the scion and the *Cucurbita* rootstocks they used caused low total and marketable yields, since fruits on "Crimson tide" scion could not attain their original fruit size; rootstocks were grafted using hole insertion technique which was not suitable for *Cucurbita* rootstocks and gave lower survival rate than the *Lagenaria* rootstocks. Results of the present investigation herein, where tongue approach grafting technique revealed very high compatibility for all rootstocks used with consequent higher yields especially for *Cucurbita* rootstocks (Figs. 7 and 10). According to Yetisir and Sari, (2004) tongue approach grafting technique gave higher survival rates than hole insertion, which might illustrate the poor compatibility between watermelon and *Cucurbita* rootstocks in their experiment (Yetisir *et al*., 2003). On the other hand, present results were in agreement with results of Chouka and Jebari (1999), who found that "Sugar Baby F_1" watermelon grafted on RS 841 (*Cucurbita* hybrid) and *Lagenaria* rootstock, doubled the production compared with the control, probably due to more absorption of nutrients carried by vigorous root system of the rootstocks. Present results were also consistent with the findings of Ruiz and Romero (1999); efficiency of grafting was evident from the results of melon fruit yield, which was two times higher in the majority of grafted melon plants than the control when Yuma, Melina and Gallicum melon F_1 hybrid cultivars were grafted on Shintoza, RS 841 and Kamel *Cucurbita* rootstocks.

5.3.2 Average fruit weight

Average fruit weight, for both marketable and total yields, was further enhanced by grafting "Samara" on *Cucurbita* rootstocks in Balawneh and Jerash experiments rather than grafting it on *Lagenaria* rootstocks (17 and 23% respectively) and (19 %) over the control (Figs. 8 and 11). This is consistent with earlier findings of Chouka and Jebari (1999) and Miguel *et al*. (2004).

"Sugar Baby F_1" watermelon grafted on RS 841 *Cucurbita* rootstock had positive effect on average fruit weight (Chouka and Jebari, 1999). However, Shintoza (*Cucurbita* hybrid) rootstock had direct enhancing effect on "Reina de Corazones" watermelon fruit growth and size (Miguel *et al*., 2004). In contrast, Yetisir and Sari (2003) reported that “Crimson Tide” watermelon grafted on *Lagenaria* rootstocks (Four hybrids and one landrace) gave larger fruits than the control and plants grafted on *Cucurbita* rootstocks (Three hybrids and two landraces); Skopje and the Turkish *Cucurbita* landrace rootstocks gave the largest (8.8 Kg) and smallest (2.03 Kg) fruits respectively. That their results were contradictory to present results is due to poor compatibility between watermelon and *Cucurbita* rootstocks when hole insertion grafting technique was used. On the other hand, compatibility between "Samara" scion and *Cucurbita* rootstocks was high in the present investigation as was revealed by the survival rates (Table 18) and histological studies (Plates 2 and 3).

The unmarketable average fruit weight was similar in all treatments in Balawneh except for grafted FR strong which gave the lowest unmarketable average fruit weight (2.81 kg). In Jerash (Figs. 8 and 11), however unmarketable average fruit weight showed significant variation among treatments. The highest unmarketable average fruit weight (3.73 kg) and the lowest (2.93 Kg) were induced by Azman and Emphasis rootstocks, respectively.

5.3.3 Average fruit number

According to findings of Yetisir and Sari (2003), number of fruits per plant was significantly affected by rootstocks. In Balawneh, grafting “Samara” on *Cucurbita* rootstocks produced more (77 and 108%) marketable and total fruit numbers per plant than when grafted on *Lagenaria* rootstocks and than the control, respectively (Fig. 9). In Jerash, this increase was 50% only (Fig. 12). Grafted *Lagenaria* rootstocks and the control gave higher unmarketable fruit number per plant than those on *Cucurbita* rootstocks in Balawneh, while no differences were detected among all treatments of Jerash except for the intact control which gave the highest significant unmarketable fruit number per plant . In contrast, “Crimson Tide” grafted on *Lagenaria* type (Four hybrids and one landrace) rootstocks, and the control had more fruits than those grafted on

Cucurbita type (Three hybrids and two landraces) rootstocks (Yetisir and Sari, 2003). This controversy could be attributed to the incompatibility encountered among the *Cucurbita* rootstocks and "Crimson Tide" scion appearing towards the end of their growing period expressed by wilting of the plants where about 20-80% of grafted *Cucurbita* rootstocks wilted and died before fruits reached its maximum size. When examined, vascular bundles showed that wilting was not due to *Fusarium* in the grafted plants (Yetisir *et al.,* 2003). Grafting "Top yield" watermelon on bottle gourd *Lagenaria* rootstock gave the highest number of fruits per plant (5.25 fruits/plant) (Salam. *et al.,* 2002). Yamasaki (2003) found that ungrafted melon plants were more significantly affected by excessive fruit load than the plants that had been grafted to squash, although the sap flow rate of the plants with single fruit was not affected by rootstock. The roots of squash rootstock have more tolerance to excess loading of fruits because the roots are more vigorous and have stronger ability to absorb nutrients and biosynthesize cytokinin than watermelon scion (Yamasaki *et al*., 1994 as cited by Yamasaki, 2003).

Yetisir and Sari (2004) reported that *Cucurbita* type rootstocks were more tolerant to low soil temperature than other rootstocks. This might explain the results obtained in the present experiments (Figs. 9 and 12), where *Cucurbita* rootstocks in general gave more fruits and consequently higher yields than *Lagenaria* rootstocks (Figs. 9 and 12).

In general the effect of rootstocks on grafted scion might be explained by the interaction of some or all of the following phenomena: increase water and plant nutrient uptake (Kato and Lou, 1989), augmented endogenous hormone production (Zijlstra *et al.,* 1994), tolerance to low soil temperature (Den Nijis and sweets, 1987) and Salanity tolerance (Zerki and persons, 1982; Santa – Cruz *et al.,* 2002 as cited by Yetisir and Sari, 2004).

5.3.4 Effect of rootstock on fruit quality

5.3.4.1 Physical properties

Grafting "Samara" on *Cucurbita* rootstocks gave higher fruit indices than grafting on *Lagenaria* rootstocks and the control in Balwaneh and Jerash (Tables 9 and 13). According to Yetisir *et al.* (2003) fruit indices of "Crimson Tide" watermelon fruits when grafted on *Cucurbita* (Three hybrids and two landraces) and *Lagenaria* (Four hybrids and one landrace), rootstocks were not significantly affected by rootstock. However, Bletsos (2005) indicated that no significant differences were observed in fruit shape, at early and late harvests, between treatments of grafted "Galia" melon on Mamouth F_1 and Nun 9075 RT F_1 (*Cucurbita*) rootstocks.

In general, fruit flesh of "Samara" grafted on *Cucurbita* rootstocks was more firm than that of "Samara" on *Lagenaria* rootstocks and than the control, in both Balawneh and Jerash (Tables 9 and 13). Flesh firmness was significantly affected by rootstock (Yetisir *et al.,* 2003) where two Turkish *Cucurbita* landraces grafted by "Crimson Tide" watermelon induced the greatest firmness compared to the remaining *Cucurbita* and *Lagenaria* rootstocks. These findings were consistent with our results (Tables 9 and 13) where *Cucurbita* rootstocks showed the highest fruit flesh firmness. Christakou *et al.* (2005) found that grafting "Galia" melon on Mamouth and Nun 9075 (*Cucurbita*) rootstocks did not seem to affect fruit flesh firmness, as no significant differences among the treatments were detected.

In general, *Lagenaria* rootstocks induced thicker fruit rinds than *Cucurbita* rootstocks in Balwaneh and Jerash (Tables 9 and 13). Although the difference was not economically important, Yetisir *et al.* (2003) found that *Lagenaria* rootstocks produced thicker fruit rinds which comply with the present results (Tables 9 and 13).

5.3.4.2 Chemical properties

"Samara" grafted on Emphasis and bottle gourd landrace gave the highest total soluble solids which was significantly similar to those of both controls in Balawneh (Table 10), while in Jerash all treatments gave similar total soluble solids (Table 14). Similar to our findings in Jerash, Miguel *et al.* (2004) reported that total soluble solids were identical in grafted and ungafted triploid "Reina de Corazones" watermelon when grafted on nine different *Cucurbita* and *Lagenaria* rootstocks. According to Yetisir et al., (2003), all roostocks gave similar total soluble solids, except for CMO and CMA (Turkish *Cucurbita* landraces) which evinced severe incompatibility with watermelon. Total soluble solids of "Top yield" fruits of watermelon grafted on bottle gourd (*Lagenaria*) rootstock were significantly higher than that of non-grafted (Salam *et al*., 2002).

Grafted rootstocks gave significantly similar total and reducing sugar contents in Balawneh and Jerash experiments (Tables 10 and 14). "Crimson Tide" watermelon fruits when grafted on *Cucurbita* (Three hybrids and two landraces) and *Lagenaria* (Four hybrids and one landrace) rootstocks induced similar reducing and total sugar contents, except CMO and CMA (Turkish *Cucurbita* landraces) which showed poor compatibility with the scion.

Induced lycopene contents by Tetsukabuto rootstock were similar to those induced by PT 1313 and Shintoza supreme rootstocks in Balawneh and similar to those induced by FR strong and 64-15 RZ rootstocks and both controls in Jerash. Otherwise, Tetsukabuto rootstock induced the highest lycopene contents in "Samara" watermelon fruits, in both locations (Tables 10 and 14).

5.3.5. Compatibility and survival rate

5.3.5.1. Survival rate

Significant variations in seedling hypocotyl diameters of scion and rootstock were evident upon grafting at the three stages of growth and development (cotyledon, first true leaf and second true leaf stage) (Tables 15 and 16). "Samara" hypocotyl diameters ranged between 2.27 to 2.52 mm, while *Cucurbita* and *Lagenaria* rootstocks hypocotyl diameters ranged from 3.14 to 3.98 mm. Hypocotyls of PT 1313 were the thinnest and those of 64-15RZ were the thickest.

Although, hypocotyl diameter ratios between scion and rootstocks showed significant differences in the three growth stages upon grafting, the survival rates of grafted seedling were similar within each stage (Tables 17 and 18). This might indicate that the difference in the hypocotyl diameters between “Samara” scion and rootstocks in the ranges observed herein (Tables 15 and 16) had no effect on the survival rate of grafted seedlings at the three growth stages.

It was noticed in this study that the first true leaf growth stage of scion and rootstock seedlings was the most practical in grafting procedure and gave the highest survival rates where tongue approach grafting technique was used. Similar results were obtained by Yetisir and Sari (2004) when "Crimson Tide" watermelon scion was grafted on *Cucurbita* (Two hybrids and two landraces) and *Lagenaria* (Three hybrids and one landrace) rootstocks by using tongue approach technique. On the other hand, *Cucurbita* rootstocks gave survival rates much lower than the *Lagenaria* rootstocks when hole insertion grafting technique was used, which was explained by the larger pith in *Cucurbita* rootstocks seedlings; if the inserted scion loose the contact with cut surface, the scion will die (Yetisir and Sari, 2003).

5.3.5.2. Anatomy of the graft union

Photographed cross sections of the grafted union for "Samara" watermelon on *Cucurbita* and *Lagenaria* rootstocks showed the developmental stages of the formation of successful graft union (plates 2 and 3).

The first stage began with parenchyma cell division of the wounded scion and rootstocks hypocotyls and formed a callus to fill the gap in between; cell division continued in the line of union. In the second stage, newly divided cells started to differentiate to form new xylem and phloem cells to complete the connection between scion and rootstock vascular systems.

In grafted plants, vascular regeneration can re-establish the continuity of the transport system by means of a complex developmental process involving structural and physiological differentiation of parenchyma into xylem and phloem elements (Jefferee and Yeoman, 1983 as cited by Fernandez-Gracia *et al*., 2004). According to Fernandez-Gracia *et al*. (2004), the developmental stages in the formation of graft union in tomato, were recognized; the early stage began by generation of parenchyma wound callus that filled the gap between the two graft components; living cells from the surface quickly began to grow in size (hypertrophic cells) and to divide; after the graft union assemblage between the cells of the rootstock and scion was developed, differentiation of the new vascular system began. Asahina *et al*. (2002) indicated that GA production in the cotyledon was involved in cell division during tissue reunion in the cortex of cucumber and tomato cut hypocotyls.

6. SUMMARY AND CONCLUSION

Two field experiments were conducted, one in Jordan Valley (Balawneh) and the second in the highlands (Jerash), to study the influence of different rootstocks on growth, yield and fruit quality of grafted "Samara" watermelon, using tongue approach grafting technique.

6.1 Vegetative growth:

Cucurbita rootstocks induced higher number of leaves and branches per plant, higher number of nodes per branch and higher dry vegetative plant weights than the *Lagenaria* rootstocks, the intact control and the self grafted control. Azman (*Cucurbita*) rootstock induced best vegetative growth among all rootstocks in the two locations.

6.2 Sex expression:

Male and female flowers per plant were higher when "Samara" was grafted on *Cucurbita* rootstocks than those from *Lagenaria* rootstocks and the control. Male : female flower ratios tended to be similar in all treatments in Balawneh and higher ratios were induced by *Cucurbita* rootstocks in Jerash.

6.3 Yield and yield components:

In both locations "Samara" grafted on *Cucurbita* rootstocks, gave highest marketable and total yields and lowest unmarketable yields than when grafted on *Lagenaria* rootstocks, and than the controls.

Fruit size and number of fruits per plant were the highest when "Samara" was grafted on *Cucurbita* rootstocks in both locations. Though effects of Azman and Shintoza supreme (*Cucurbita*) rootstocks were similar, Azman was the most effective in inducing highest marketable and total yields.

6.4 Fruit quality:

In general fruit indices and flesh firmness of "Samara" fruits were higher when grafted on *Cucurbita* rootstocks, while fruit rind thickness was more or less higher by grafting on *Lagenaria* rootstocks.

Reducing sugars of "Samara" fruits were not affected by rootstock in both locations. Total soluble solids and total sugars were higher by grafting on *Lagenaria* rootstock and in the control in Balawneh, but both total soluble solids and total sugars were not affected by grafting in Jerash. Rootstocks induced lycopene content more or less similar to either intact or self grafted control except for Tetsukabuto (*Cucurbita*) rootstock which was the most effective in raising lycopene content of "Samara" fruits.

In general, *Cucurbita* rootstocks induced remarkable positive effects on vegetative growth, yield, fruit size and fruit flesh firmness of grafted "Samara " watermelon, while the other fruit quality parameters were similar to the controls. Azman and Shintoza supreme showed the best performance among *Cucurbita* rootstocks.

7. REFERENCES

Anonymous . 2006 . Plant grafting as a tool to help reduce the need for soil fumigation with methyl bromide , United States, Environment Protection Agency. **http://www.epa.gov/ozone/mbr/casestudies/ volume3/ graftng3.html**

Anonymous. 2005. Watermelon area, yield and production. General statistics department–Jordan. **http://www.dos.gov.jo/agr/ agr-a/index .htm**

Armengol, J., Jose, C., Moya, M., Sales, R., Vicent, A. and Gracia-Jimenez, J. 2000. *Fusarium solani f. sp. Cucurbita e* race 1, a potential pathogen of grafted watermelon production in Spain**. EPPO Bulletin** 30: 179-183.

Asahina, M., Iwai, H., Kikuchi, A., Yamguchi , S., Kamiya, Y., Kamada, H., and Satoh, S. (2002) . Gibberellin produced in the cotyledon is required for the cell division during tissue reunion in the cortex of cut cucumber and tomato hypocotyls. **Plant physiology** 129: 201- 210 .

Bletsos, F. 2005. Use of grafting and Caclium Cyanamide as alternatives to methyl bromide soil fumigation and their effects on growth, yield, quality and *Fusarium* wilt control in melon**. J. Phytopathology**. 153: 155-161.

Chouka, A.S. and Jebari, H. 1999. Effect of grafting on watermelon on vegetative and root development, production and fruit quality. **Acta Hortic.** 492: 85-93.

Christakou, E., Arvanitoyannis, I., Khah, E. and Bletsos, F. 2005. Effect of grafting and modified atmosphere packaging (MAP) on melon quality parameters during storage. **Journal of Food, Agriculture and Environment**. 3 : 145-152.

Cohen, R., Burger, Y., Horev, C., Porat, A. and Edelstein, M. 2005. Performance of Galia-type melons grafted on to *Cucurbita* rootstock in *Monosporascus cannoballus* infected and non-infecetd soils. **Annals of Applied Biology.** 146: 381-387.

Daykin, M., and Hussey, R., (1985). Staining and histopathological teckniques in nematology. p: 39-48. ***In***, **An advanced treatise on *Meloidogyne*** vol.2, eds. Barker, K., Carter, C., and Sasser, J. A cooperative publication of the department of plant pathology and USAID. North Carolina State University. USA.

Dubois, M., Gilles, K., Hamilton, J., Roberts, P. and Smith, F. 1956. Colorimetric method for determination of sugars and related substances .**Analytical Chemistry**. 28: 350-356.

Edelstein, M., Ben-Hur, M., Cohen, R., Burger, Y. and Ravina, I. 2005. Boron and Salinity effects on grafted and non-grafted melon plants. **Plant and Soil.** 269: 273-284.

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

Fernandez_Garcia, N., Carvajal, M., and Olmos , E. (2004) Graft union formation in tomato plants : peroxidase and catalase involvement . **Annals of botany** 93 : 53 – 60

Fernandez-Garica, N., Martinez, V. and Carvajal, M. 2004. Effect of salinity on growth, mineral composition, and water relations of grafted tomato plants**. J. Plant Nutr.** Soil Sci. 167: 616-622.

Fernandez-Gracia, N., Martinez, V., Cerd, A. and Carvajal, M. 2002. Water and nutrient uptake of grafted tomato plants grown under saline conditions. **J. Plant Physiol**. 159: 899-905.

Fish, W., Perkins-Veazie, P. and Collins, J. 2002. A quantitative Assay for Lycopene that utilizes reduced volumes of organic solvants**. Journal of Food Composition and Analysis.** 15: 309-317.

Fonseca, I., Klar, A., Goto, R. and Neves, C. 2003. Colored polyethylene soil covers and grafting effects on cucumber flowering and yield. **Scientia Agricola.** 60: 643-649.

Khah, E. 2005. Effect of grafting on growth, performance and yield of aubergine (*Solanam melongena*) in the field and greenhouse. **Journal of food. Agriculture and Development** 3: 92-94.

Kurata, K. 1994. Cultivation of grafted vegetables. II Development of grafting robots in Japan**. Hortscience**. 29: 240-244.

Lee, J. 1994. Cultivation of grafted vegetables. Part I. Current status, grafting methods and benefits. **HortScience**. 29: 235-239.

Lopez-Perez, J., Strange, M., Kaloshian, I. and Ploeg, A. 2006. Differential response of Mi gene – resistant tomato rootstocks to root-knot nematodes (*Meloidogyne incognita*). **Crop Protection**. 25: 382-388.

Miguel, A., Maroto, J., SanBautista, A., Baixauli, C., Cebolla, V., Pascual, Lopez, S. and Guardiola, J. 2004. The grafting of triploid watermelon is an advantages alternative to soil fumigation by methyl bromide for control of Fusarium wilt. **Scientia Horticulture**. 103: 9-17.

Marsic, N., and Osvald, J. (2004). The influence of grafting on yield of two tomato cultivars (*Lycopersicon esculentum Mill*.) grown in a plastic house. **Acta Agriculturae Slovenica**. 83: 243 – 249.

Nisini, P., Colla, G., Granat, E., Temperini, O., Crino, P. and Saccardo, F. 2002. Rootstock resistance to Fusarium wilt and effect on yield quality of two muskmelon cultivars. **Scientia Horticulture**. 93: 281-288.

Oda, M. 2004. Grafting of vegetable, to improve greenhouse production. Food.and.fertilizer.technology.center.**Http://www.agent.org/library/abstract/eb480.html.**

Oka, Y., Offenbach, R. and Pivonia, S. 2004. Pepper rootstock graft compatibility and response to *Meloidogyne javanica* and *M. incognita.* **Journal of Nematology**. 36 : 137-141.

Pavlou, G.,Vakalounakis, D., Ligoxigakis, E. 2002. Control of root and branch rot of cucumber, caused by *Fusarium oxysporum f. sp. radicis – cucumerinum*, by grafting to resistant rootstock. **Plant Disease**. 86 : 379-382 .

Perkins-Veazie, P., Collins, J., Davis, A., Roberts, W. 2006. Carotenoid content of 50 watermelon cultivars. **J. Agric. Food Chem.** 54: 2593-259 .

Rivero, R., Ruiz, J. and Romero, L. 2003. Can grafting in tomato plants strengthen resistance to thermal stress **?**. **J. Sci. Food Agric**. 83: 1315-1319.

Ross, A. 1959. Dinitrophenol method for reducing sugars in: Talburt. W.F (ed.) **Potato processing**. The AV1 publishing co. inc., Westport, CT, USA. pp. 469-470.

Ruiz, J. and Romero, L. 1999. Nitogen efficiency and metabolism in grafted melon plants. **Scientia Horticulturae**. 81: 113-123.

Salam, M., Ghowdhury, S. and Dhar, M. 2002. Growth and yield of watermelon as influenced by grafting. **Outline Journal of Biological Sciences** 2: 298-299.

Siguenza, C., Schochow, M., Turini, T. and Ploeg, A. 2005. Use of *Cucumis metuliferus* as a rootstock for melon to manage *Meloidogyne incognita*. **Journal of Nematology**. 37: 276-280.

Tarka–Mavrona, E., Koutsika–Sotirion, M. and Prista. T. 2000. Response of squash (*Cucurbita* spp.) as rootstock for melon (*Cucumis melo* L.) **Sci. Hort**. 83: 353-362.

Yamasaki, A. 2003. Root-pressure driven xylem sap flow in greenhouse melon (*Cucumis melo* L.): diurnal change and the effects of shading, growth stage, rootstock and fruit number. **Plant and Soil.** 255: 409-412.

Yetisir, H. and Sari, N. 2003. Effect of different rootstocks on plant growth, yield and quality of watermelon. **Aust. J. Exp. Agric**. 43: 1269-1274.

Yetisir, H. and Sari, N. 2004. Effect of Hypocotyl Morphplpgy on survival rate and growth of watermelon seedlings grafted on rootstocks with different emergence performance at various temperatures. **Turk. J. Agric.** 28: 231-237.

Yetisir, H., Sari N. and Yucel, S. 2003. Rootstock resistance to Fusarium wilt and effect on watermelon fruit yield and quality. **Phytoparasitica** 31: 163-169.

Yetisir, H., Calishan, M., Soylu, S. and Sakar, M. 2006. Some physiological and growth responses of watermelon [*Citrullus lanatus Matsum. et Nakai*] grafted onto *Lagenaria siceraria* of flooding. **Environment and experimental Botany**. 58: 1-8.

8. Appendices

8.1 Appendix (A)

Appendix table 1: Analysis of variance for vegetative growth of grafted "Samara" watermelon in Balawneh.

Source	df	Mean square			
		Leaves/plant	Branches/plant	Nodes/branch	Dry matter
Block	2	1.636	0.209	0.157	7.348
Treatment	9	7484.110**	6.238**	9.216**	2940.268**
Error	18	335.765	0.640	0.414	129.299

* Significant at 0.05 level.
** Significant at 0.01 level.

Appendix table 2: Analysis of variance for vegetative growth of grafted "Samara" watermelon in Jerash.

Source	df	Mean square			
		Leaves/plant	Branches/plant	Nodes/branch	Dry matter
Block	2	83.301	1.308	1.819	168.356
Treatment	9	8117.701**	3.126**	13.805**	2847.147**
Error	18	882.596	0.898	2.422	127.767

* Significant at 0.05 level.
** Significant at 0.01 level.

Appendix table 3: Analysis of variance for sex expression of grafted "Samara" watermelon in Balawneh.

Source	df	Mean square		
		Male flower/ plant	Female flower/plant	Male : Female flower ratio
Block	2	2.50	0.177	3.496
Treatment	9	7050.78**	3.650**	7.603
Error	18	322.257	0.302	9.628

* Significant at 0.05 level.
** Significant at 0.01 level.

Appendix table 4 : Analysis of variance for sex expression of grafted "Samara" watermelon in Jerash.

Source	df	Mean square		
		Male flower/ plant	Female flower/plant	Male : Female flower ratio
Block	2	661.25	0.077	0.705
Treatment	9	7173.02**	3.422**	12.644*
Error	18	782.55	0.227	3.088

* Significant at 0.05 level.
** Significant at 0.01 level

Appendix table 5: Analysis of variance for yield of grafted "Samara" watermelon in Balawneh.

Source	df	Mean square		
		Marketable yield	Unmarketable yield	Total yield
Block	2	0.170	0.048	0.156
Treatment	9	12.611**	0.882*	8.966**
Error	18	0.464	0.241	0.328

* Significant at 0.05 level.
** Significant at 0.01 level.

Appendix table 6: Analysis of variance for yield of grafted "Samara" watermelon in Jerash.

Source	df	Mean square		
		Marketable yield	Unmarketable yield	Total yield
Block	2	0.048	0.182	0.255
Treatment	9	17.735**	0.504*	17.192**
Error	18	0.369	0.122	0.407

* Significant at 0.05 level.
** Significant at 0.01 level.

Appendix table 7: Analysis of variance for average fruit weight of grafted "Samara" watermelon in Balawneh.

Source	df	Mean square		
		Marketable average fruit weight	Unmarketable average fruit weight	Total average fruit weight
Block	2	0.170	0.093	0.0002
Treatment	9	0.644**	0.102*	1.066**
Error	18	0.107	0.088	0.055

* Significant at 0.05 level.
** Significant at 0.01 level.

Appendix table 8: Analysis of variance for average fruit weight of grafted "Samara" watermelon in Jerash.

Source	df	Mean square		
		Marketable average fruit weight	Unmarketable average fruit weight	Total average fruit weight
Block	2	0.108	0.211	0.004
Treatment	9	1.191*	0.202*	1.058**
Error	18	0.233	0.081	0.054

* Significant at 0.05 level.
** Significant at 0.01 level.

Appendix table 9 : Analysis of variance for average fruit number of grafted "Samara" watermelon in Balawneh.

Source	df	Mean square		
		Marketable average fruit number	Unmarketable average fruit number	Total average fruit number
Block	2	0.004	0.012	0.016
Treatment	9	0.324**	0.105*	0.146**
Error	18	0.016	0.027	0.021

* Significant at 0.05 level.
** Significant at 0.01 level.

Appendix table 10: Analysis of variance for average fruit number of grafted "Samara" watermelon in Jerash.

Source	df	Mean square		
		Marketable average fruit number	Unmarketable average fruit number	Total average fruit number
Block	2	0.004	0.024	0.009
Treatment	9	0.250**	0.057*	0.261**
Error	18	0.022	0.012	0.016

* Significant at 0.05 level.
** Significant at 0.01 level.

Appendix table 11: Analysis of variance for physical properties of grafted "Samara" watermelon in Balawneh.

Source	df	Mean square		
		Fruit index	Rind thickness	Flesh firmness
Block	2	0.003	0.0004	0.003
Treatment	9	0.005**	0.007**	0.050*
Error	18	0.0001	0.0006	0.013

* Significant at 0.05 level.
** Significant at 0.01 level.

Appendix table 12: Analysis of variance for physical properties of grafted "Samara" watermelon in Jerash.

Source	df	Mean square		
		Fruit index	Rind thickness	Flesh firmness
Block	2	0.0001	0.0003	0.007
Treatment	9	0.002**	0.002	0.240*
Error	18	0.0002	0.0007	0.007

* Significant at 0.05 level.
** Significant at 0.01 level.

Appendix table 13: Analysis of variance for chemical properties of grafted "Samara" watermelon in Balawneh.

Source	df	Mean square			
		Total soluble solids	Total sugars	Reducing sugars	Lycopene content
Block	2	0.386	0.452	0.043	0.477
Treatment	9	0.336**	1.228*	0.313*	5.174*
Error	18	0.065	0.711	0.302	1.511

* Significant at 0.05 level.
** Significant at 0.01 level.

Appendix table 14: Analysis of variance for chemical properties of grafted "Samara" watermelon in Jerash.

Source	df	Mean square			
		Total soluble solids	Total sugars	Reducing sugars	Lycopene content
Block	2	0.305	0.458	0.384	0.485
Treatment	9	0.077	0.258	0.141	1.939*
Error	18	0.209	0.527	0.134	0.576

* Significant at 0.05 level.
** Significant at 0.01 level.

Appendix table 15: Analysis of variance for rootstock hypocotyl diameter upon grafting at three stages of growth.

Source	df	Mean square		
		Cotyledon	First true leaf	Second true leaf
Treatment	7	0.416* *	0.152* *	0.101* *
Error	40	0.006	0.004	0.003

* Significant at 0.05 level.
** Significant at 0.01 level.

Appendix table 16 : Analysis of variance for "Samara" scion hypocotyl diameter upon grafting at three stages of growth.

Source	df	Mean square		
		Cotyledon	**First true leaf**	**Second true leaf**
Treatment	7	0.012*	0.009* *	0.003* *
Error	40	0.004	0.002	0.001

* Significant at 0.05 level
** Significant at 0.01 level.

Appendix table 17: Analysis of variance for hypocotyl diameter ratio of "Samara" scion to rootstock upon grafting at three stages of growth.

Source	df	Mean square		
		Cotyledon	**First true leaf**	**Second true leaf**
Treatment	7	0.016* *	0.005* *	0.003* *
Error	40	0.001	0.001	0.00

* Significant at 0.05 level.
** Significant at 0.01 level.

Appendix table 18: Analysis of variance for survival rate of grafted "Samara" scion on *Cucurbita* and *Lagenaria* root-stocks at three stages of growth.

Source	df	Mean square		
		Cotyledon	**First true leaf**	**Second true leaf**
Treatment	7	6.15	6.15	15.99
Error	16	22.96	8.61	14.35

* Significant at 0.05 level.
** Significant at 0.01 level.

Appendix table 19 : Irrigation and fertilizing schedule in Balawneh and Jerash experiments

Weeks	**Irrigation water** (m^3/du)		**Fertilizer**	
	Balawneh	**Jerash**	**N-P-K**	**Quantity** (kg)
1	35	30	15-30-15	3
2	20	20	15-30-15	3
3	20	20	20-20-20	4
4	25	20	20-20-20	4
5	28	23	20-10-20	4
6	35	30	20-10-20	4
7	27	32	15-15-30	8
8	28	30	15-15-30	8
9	28	30	31- 0- 5	4
10	30	35	31- 0- 5	5
11	30	30		

Appendix table 20 : Pesticides used for controlling different pests in Balawneh and Jerash experiments

Pest	**Pesticide**		
	Trade name	Common name	Rate ml or g/100 lit water
Damping off	Previcur M	Propamocarb	150
White fly and aphids	Mociplan	Acetamiprid	50
Spider mites	Vertimec	Abamectin	40
Powdery mildew	Flint Score	Trifloxystrobin Difenoconazol	25 60

Appendix table 21: C.V, R-square and LSD of parameters determined in Balawneh experiment.

Variable	C.V	R-square	LSD
Number of leaves/plant	6.63	0.917	31.43
Number of branches/plant	4.83	0.83	1.37
Number of nodes/branch	3.88	0.918	1.12
Dry matter	13.15	0.919	19.51
Male flower/plant	6.92	0.92	30.8
Female flower/plant	7.27	0.86	0.94
Male/female flower ratio	9.05	0.32	5.48
Fruit index	1.02	0.95	0.02
Rind thickness	2.52	0.84	0.44
Flesh firmness	6.57	0.66	0.19
TSS	2.61	0.76	0.44
Total sugars	9.48	0.48	1.45
Reducing sugars	8.67	0.35	0.94
Lycopene	4.69	0.64	2.10

Appendix table 22: C.V, R-square and LSD of parameters determined in Jerash experiment.

Variable	C.V	R-square	LSD
Number of leaves/plant	9.68	0.82	50.96
Number of branches/plant	5.52	0.66	1.63
Number of nodes/branch	8.73	0.75	2.66
Dry matter	10.56	0.92	19.4
Male flower/plant	9.56	0.82	47.99
Female flower/plant	5.29	0.88	0.82
Male/female flower ratio	5.46	0.67	3.01
Fruit index	1.23	0.80	0.026
Rind thickness	2.57	0.54	0.045
Flesh firmness	5.15	0.63	0.148
TSS	4.6	0.256	0.79
Total sugars	7.24	0.254	1.25
Reducing sugars	5.83	0.548	0.63
Lycopene	2.76	0.639	

Appendix table 23: C.V, R-square and LSD for hypocotyl diameter of scion and rootstock, hypocotyl diameter ratio of scion and rootstock and survival rate at three stages of growth.

Variable	**Stage**	**C.V**	**R-square**	**LSD**
Scion hypocotyl diameter	Cotyledon stage	2.64	0.35	0.07
	First true leaf stage	1.86	0.44	0.05
	Second true leaf stage	1.24	0.39	0.04
Rootstock hypocotyl diameter	Cotyledon stage	2.2	0.92	0.09
	First true leaf stage	1.64	0.87	0.07
	Second true leaf stage	1.31	0.87	0.06
Hypocotyl diameter ratio of scion and rootstock	Cotyledon stage	3.64	0.83	0.03
	First true leaf stage	2.16	0.82	0.02
	Second true leaf stage	1.49	0.87	0.01
Survival rate	Cotyledon stage	9.98	0.15	8.29
	First true leaf stage	2.96	0.23	5.07
	Second true leaf stage	3.88	0.32	6.55

Appendix table 24 : Correlation Coefficients between vegetative growth, sex expression and yield parameters for Balawneh experiment.

Person Correlation Coefficients, N = 30
Prpb > |r| under H0: Rho=0

	Nodes/ branch	Leaves/ plant	Branches/ plant	Market. fruit wt.	Market. fruit no.	Female flowers	Male flowers	Fruit index	Dry matter	Total fruit wt.	Total fruit no.	Market. yield	Total yield
Nodes/ branch	1.00000	0.918 <.0001	0647 <.0001	0.657 <.0001	0.851 <.0001	0.838 <.0001	0.922 <.0001	0.806 <.0001	0.867 <.0001	-0.038 0.8391	0.543 0.0019	0.828 <.0001	0.802 <.0001
Leaves/ plant	0.918 <.0001	1.00000	0.894 <.0001	0.681 <.0001	0.891 <.0001	0.900 <.0001	0.999 <.0001	0.803 <.0001	0.944 <.0001	-0.089 0.6368	0.688 <.0001	0.851 <.0001	0.901 <.0001
Branches/ plant	0.648 <.0001	0.895 <.0001	1.00000	0.560 <.0001	0.739 <.0001	0.777 <.0001	0.888 <.0001	0.631 0.0002	0.821 <.0001	-0.132 0.4862	0.687 <.0001	0.684 <.0001	0.809 <.0001
Marketable fruit wt.	0.657 <.0001	0.681 <.0001	0.560 <.0001	1.00000	0.637 0.0002	0.650 <.0001	0.681 <.0001	0.891 <.0001	0.743 <.0001	-0.058 0.7607	0.407 <.0001	0.706 <.0001	0.711 <.0001
Marketable fruit no.	0.851 <.0001	0.892 <.0001	0.739 <.0001	0.637 <.0001	1.00000	0.841 <.0001	0.893 <.0001	0.778 <.0001	0.897 <.0001	0.042 0.8233	0.741 <.0001	0.949 <.0001	0.938 <.0001
Female flower/plant	0.839 <.0001	0.900 <.0001	0.777 <.0001	0.650 0.0002	0.841 <.0001	1.00000	0.899 <.0001	0.772 <.0001	0.920 <.0001	-0.183 0.3328	0.713 <.0001	0.806 <.0001	0.888 <.0001
Male flower/plant	0.922 <.0001	0.999 <.0001	0.888 <.0001	0.681 <.0001	0.893 <.0001	0.899 <.0001	1.00000	0.805 <.0001	0.944 <.0001	-0.087 0.6462	0.687 <.0001	0.852 <.0001	0.901 <.0001
Fruit index	0.807 <.0001	0.803 <.0001	0.631 0.0002	0.891 <.0001	0.778 <.0001	0.772 <.0001	0.805 <.0001	1.00000	0.854 <.0001	-0.060 0.7499	0.423 <.0001	0.820 <.0001	0.775 <.0001
Dry matter	0.868 <.0001	0.944 <.0001	0.821 <.0001	0.743 <.0001	0.897 <.0001	0.920 <.0001	0.944 <.0001	0.854 <.0001	1.00000	-0.082 0.6645	0.688 <.0001	0.870 <.0001	0.920 <.0001
Total fruit wt.	-0.039 0.839	-0.089 0.636	-0.132 0.486	-0.058 0.760	0.042 0.823	-0.183 0.332	-0.087 0.646	-0.060 0.749	-0.082 0.664	1.00000	-0.102 0.590	0.003 0.984	-0.096 0.613
Total fruit no.	0.543 0.0019	0.688 <.0001	0.687 <.0001	0.407 <.0001	0.741 <.0001	0.713 <.0001	0.687 <.0001	0.423 <.0001	0.688 <.0001	-0.102 0.5904	1.00000	0.640 <.0001	0.875 <.0001
Marketable yield	0.828 <.0001	0.851 <.0001	0.684 <.0001	0.706 <.0001	0.949 <.0001	0.806 <.0001	0.852 <.0001	0.820 <.0001	0.870 <.0001	0.003 0.9844	0.640 <.0001	1.00000	0.886 <.0001
Total yield	0.803 <.0001	0.901 <.0001	0.809 <.0001	0.711 <.0001	0.938 <.0001	0.888 <.0001	0.901 <.0001	0.775 <.0001	0.920 <.0001	-0.096 0.6138	0.875 <.0001	0.886 <.0001	1.00000

Appendix table 25 : Correlation Coefficients between vegetative growth, sex expression and yield parameters for Jerash experiment.

Person Correlation Coefficients, N = 30
Prpb > |r| under H0: Rho=0

	Nodes/ branch	Leaves/ plant	Branches/ plant	Market. fruit wt.	Market. fruit no.	Female flowers	Male flowers	Fruit index	Dry matter	Total fruit wt.	Total fruit no.	Market. yield	Total yield
Nodes/ branch	1.00000	0.94112 <.0001	0.47897 0.0074	0.74693 <.0001	0.73095 <.0001	0.85371 <.0001	0.85834 <.0001	0.50462 0.0045	0.88133 <.0001	0.86345 <.0001	0.64194 0.0001	0.85175 <.0001	0.81675 <.0001
Leaves/ plant	0.94112 <.0001	1.00000	0.73727 <.0001	0.72447 <.0001	0.81571 <.0001	0.94071 <.0001	0.93830 <.0001	0.57697 0.0008	0.93402 <.0001	0.87100 <.0001	0.70919 <.0001	0.90903 <.0001	0.86865 <.0001
Branches/ plant	0.47897 0.0074	0.73727 <.0001	1.00000	0.43175 0.0172	0.61566 0.0003	0.74171 <.0001	0.73268 <.0001	0.47198 0.0085	0.67529 <.0001	0.54570 0.0018	0.51787 0.0034	0.63836 0.0001	0.59618 0.0005
Marketable fruit wt.	0.74693 <.0001	0.72447 <.0001	0.43175 0.0172	1.00000	0.44903 0.0128	0.75334 <.0001	0.66495 <.0001	0.50885 0.0041	0.70917 <.0001	0.86266 <.0001	0.55835 0.0013	0.72684 <.0001	0.75585 <.0001
Marketable fruit no.	0.73095 <.0001	0.81571 <.0001	0.61566 0.0003	0.44903 0.0128	1.00000	0.82171 <.0001	0.87723 <.0001	0.62338 0.0002	0.84562 <.0001	0.72282 <.0001	0.85459 <.0001	0.93834 <.0001	0.89819 <.0001
Female flower/plant	0.85371 <.0001	0.94071 <.0001	0.74171 <.0001	0.75334 <.0001	0.82171 <.0001	1.00000	0.91951 <.0001	0.62852 0.0002	0.90191 <.0001	0.89395 <.0001	0.72169 <.0001	0.92341 <.0001	0.88487 <.0001
Male flower/plant	0.85834 <.0001	0.93830 <.0001	0.73268 <.0001	0.66495 <.0001	0.87723 <.0001	0.91951 <.0001	1.00000	0.59170 0.0006	0.93328 <.0001	0.85294 <.0001	0.72686 <.0001	0.92530 <.0001	0.86925 <.0001
Fruit index	0.50462 0.0045	0.57697 0.0008	0.47198 0.0085	0.50885 0.0041	0.62338 0.0002	0.62852 0.0002	0.59170 0.0006	1.00000	0.50619 0.0043	0.55901 0.0013	0.68781 <.0001	0.66813 <.0001	0.70086 <.0001
Dry matter	0.88133 <.0001	0.93402 <.0001	0.67529 <.0001	0.70917 <.0001	0.84562 <.0001	0.90191 <.0001	0.93328 <.0001	0.50619 0.0043	1.00000	0.85397 <.0001	0.75218 <.0001	0.92206 <.0001	0.89041 <.0001
Total fruit wt.	0.86345 <.0001	0.87100 <.0001	0.54570 0.0018	0.86266 <.0001	0.72282 <.0001	0.89395 <.0001	0.85294 <.0001	0.55901 0.0013	0.85397 <.0001	1.00000	0.59245 0.0006	0.89429 <.0001	0.84622 <.0001
Total fruit no.	0.64194 0.0001	0.70919 <.0001	0.51787 0.0034	0.55835 0.0013	0.85459 <.0001	0.72169 <.0001	0.72686 <.0001	0.68781 <.0001	0.75218 <.0001	0.59245 0.0006	1.00000	0.86068 <.0001	0.92906 <.0001
Marketable yield	0.85175 <.0001	0.90903 <.0001	0.63836 <.0001	0.72684 <.0001	0.93834 <.0001	0.92341 <.0001	0.92530 <.0001	0.66813 <.0001	0.92206 <.0001	0.89429 <.0001	0.86068 <.0001	1.00000	0.97832 <.0001
Total yield	0.81675 <.0001	0.86865 <.0001	0.59618 0.0005	0.75585 <.0001	0.89819 <.0001	0.86925 <.0001	0.86925 <.0001	0.70086 <.0001	0.89041 <.0001	0.84622 <.0001	0.92906 <.0001	0.97832 <.0001	1.00000

8.2 Appendix (B)

List of abbreviations

Abbreviation	Word or sentence
°C	Degree Celsius
cm	Centimeter
C.V	Coefficient of variation
df	Degree of freedom
DMRT	Duncan Multiple Range Test
du	Dunum
et al	And others
FAA	Formalin aceto –alcohol
F1	First generation hybrid
Fig.	Figure
g	Gram
GA	Gibbrellic acid
hr	Hour
kg	Kilogram
L	Liter
LSD	Least significant difference
m	Meter
m^2	Square meter
m^3	Cubic meter
mg	Milligram
min	Minute
ml	Milliliter
mm	Millimeter
ppm	Part per million

Abbreviation	Word or sentence
r	Correlation coefficient
rpm	Revolution per minute
SAS	Statistical analysis software
Sec	Second
TBA	Tertiary butyl alcohol
TSS	Total soluble solids
/	Per
%	Percent

نمو وإنتاج وجودة ثمار البطيخ المطعم على أصول مختلفة تحت ظروف الزراعة المكشوفة في وادي الاردن والمرتفعات

إعداد

فؤاد احمد سلامة سليمان

المشرف

الاستاذ الدكتور محمد احمد صوان

ملخــص

أجريت تجربتان حقليتان في وادي الأردن (البلاونة) والمرتفعات (جرش) لدراسة تأثير التطعيم على نمو وإنتاج وجودة المحصول لصنف البطيخ "سمارا". تم التطعيم على ثمانية أصول: أربعة منها من مجموعة كيوكيربتا (تيتسوكابوتو، بي تي 1313، شنتوزا سوبريم وأزمان) والأربعة الاخرى من مجموعة لاجيناريا (إمفاسيز، اف آر سترونج، يقطين محلي و 64-15 آر زد) وشاهد غير مطعم وآخر مطعم ذاتيا.

أدى تطعيم الصنف "سمارا" على الأصل أزمان (من مجموعة كيوكيربتا) في الموقعين، الى زيادة معنوية في "عدد الأوراق والوزن الجاف وعدد الأزهار المذكرة والمؤنثة" للنبات الواحد. وتشابهت هذه الصفات عند التطعيم على أصول مجموعة كيوكيربتا وكانت هذه الصفات بشكل عام، أعلى منها عند التطعيم على أصول لاجيناريا والشاهدين. وبينما كانت نسبة الأزهار المذكرة الى الازهار المؤنثة متشابهة لجميع معاملات التطعيم والشاهدين في البلاونة، كانت هذه النسبة بشكل عام، أعلى في مجموعة كيوكيربتا عنها في مجموعة لاجيناريا والشاهدين في جرش.

وتفوق الإنتاج المسوق والكلي وعدد الثمار المسوق والكلي عند تطعيم "سمارا" على الأصل أزمان في الموقعين. وبشكل عام، كانت أصول مجموعة كيوكيربتا أكثر تأثيرا في هذه الصفات من مجموعة لاجيناريا. أما الإنتاج غير المسوق، فقد كان أقله عند التطعيم على أصول كيوكيربتا وأعلاه عند التطعيم على أصول لاجيناريا وفي الشاهدين في البلاونة. أما في جرش، فقد كان الإنتاج غير المسوق متشابها في جميع المعاملات عدا الشاهد غير المطعم الذي أعطى أعلى إنتاج غير مسوق، وبدرجة معنوية. وتفوّق معدل

وزن الثمرة المسوقة عند التطعيم على أصول كيوكيربتا في الموقعين وخاصة عند استعمال الأصلين تيتسوكابوتو وأزمان من مجموعة كيوكيربتا في البلاونة.

هذا وقد أثر التطعيم على صفات ثمار البطيخ الكيميائية بدرجات متفاوتة. فتشابه محتوى الثمار من السكّريات المختزلة في جميع المعاملات في كلّ من الموقعين. أما السكّريات الكلّية، فقد كانت أعلى بدرجة معنوية في ثمار الشاهد المطعّم وأقل عند التطعيم على 64-15 آر زِد (من مجموعة لاجيناريا)، وفيما عدا ذلك تشابهت السكّريات الكلّية في باقي المعاملات في البلاونة، بينما تشابهت الثمار في محتواها من هذه السكّريات والمواد الصلبة الذائبة في جميع المعاملات في جرش. أما في البلاونة فقد ارتفعت المواد الصلبة الذائبة بدرجة معنوية، عند التطعيم على الأصلين إمفاسيز واليقطين المحلي (من مجموعة لاجيناريا) وفي الشاهدين.

وزاد الليكوبين بدرجة معنوية عند تطعيم "سمارا" على الأصل تيتسوكابوتو عنه عند تطعيمه على الأصل أزمان (من مجموعة كيوكيربتا) وعلى أصول مجموعة لاجيناريا والشاهدين. أما في جرش فقد كان محتوى الثمار من الليكوبين مرتفعا بدرجة معنوية عند التطعيم على الأصل تيتسوكابوتو عنه في باقي أصول مجموعة كيوكيربتا والأصلين اليقطين المحلي وإمفاسيز (من مجموعة لاجيناريا).

وبناءً عليه نوصي أن يستعمل المزارعون في وادي الأردن (البلاونة) والمرتفعات (جرش) صنف البطيخ "سمارا" مطعّماً على أصول من مجموعة كيوكيربتا وخاصة أزمان وشنتوزا سوبريم.