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Preliminary Compatibility between Some Table-Grapevine Scion and Phylloxera-Resistant Rootstock Cultivars

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ABSTRACT

A trial of seven scion grape cultivars (Beiroti, Dapogi, Fhesi, Hamadani-Baladi, Jandali, White-Romi and Zeiny) and five phylloxera resistant rootstock cultivars (Richter-110, Paulsen-1103, Ruggeri-140, B 41 and 216/3), in addition to own rooted vines were undertaken to asses preliminary compatibility.

The results indicated that 'Fhesi' and the combinations of Jandali/Richter-110, White-Romi/Ruggeri-140, White-Romi/216/3 and White-Romi/B 41 were highly compatible. Positive correlations between callus development, root development and successful grafts were also observed. However, 'Hamadani-Baladi' and 'Zeiny' were significantly incompatible with less than 50% of graft-success. Time needed for buds-burst in the grafted combination was significantly less (33- 48 days) than that of the own rooted plant (60-66 days). Further research is needed for the prolonged compatibility effect on yield and quality.

Keywords: Grapevine-phylloxera, rootstocks, scions, graft-compatibility.

INTRODUCTION

The grape phylloxera, *Daktulosphaira vitifoliae* (Fitch) [Phylloxeridae: Homoptera] is one of the worst threats to modern viticulture world-wide (Read and Gu, 2003). This aphid-like parasite pest attacks vine roots, damages thereby the root galls and gradually destroys the whole rooting system of European grape *Vitis vinifera* L. (Granett *et al.,* 2001; Al-Mommany and Al-Antary, 2008). Indeed, the infested plants die within three to five years from infestation (Forneck *et al*., 2001; Kellow *et al.*, 2004).

In Palestine, phylloxera problem was first observed at the beginning of 1980 in Bethlehem district and extended to Hebron area, causing more than 50% yield loss (Basheer-Salimia and Hamdan, 2009, a, b).

In regions where phylloxera occurs, grafting is generally essential, wherein the scion is a cultivar of *V. vinifera* and the rootstock is either a North American *Vitis* species or an inter-specific *Vitis* hybrid (Weaver, 1976). Even where phylloxera is not present, serious consideration should be given to using phylloxera resistant rootstocks (Jackson, 2008). Nowadays, grape culture would be impossible without using grafted grapevines.

In choosing a given rootstock, ranking property is necessary as each rootstock has its benefits and deficits. The choice should be taken seriously as once a rootstock has been considered; it remains a permanent component of the vineyard life until replanting (Jackson, 2008). The most basic criterion for any rootstock cultivar choice is its compatibility with the scion cultivar.

Compatibility refers to the ability of the scion and the rootstock to form a functional long-term graft union

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(Hartmann *et al.,* 2002). Complete fusion of the adjoining cambial tissues is critical to effective translocation of water, nutrients and growth regulators. Areas that do not join shortly after grafting never fuse and such gaps leave weak points that provide sites for invasion by various pests and disease-causing agents (Jackson, 2008). Therefore, early and accurate prediction of graft compatibility in nursery has great importance (Petkou *et al*., 2004).

The main goal of this study was to assess in nursery the preliminary compatibility between seven Palestinian local table-grapevine (*V. vinifera*) and five grapevine phylloxera resistant rootstock cultivars.

MATERIAL AND METHODS

1. Plant Material

a) Rootstock

Cuttings of 30-40 cm in length with 3 nodes of the following grapevine rootstock cultivars known to be resistant to phylloxera; namely: Richter-110, Paulsen-1103, Ruggeri-140, B 41 and 216/3 were obtained from the Holly Land Nursery officially licensed for grapevine rootstock production in Palestine at Sa'er-Hebron.

The cuttings were tested against grapevine leaf roll associated viruses, Fanleaf and Corkey-Bark using ELISA technique (Al-Moudallal *et al.*, 1984; Boscia *et al*., 1992). The tests were conducted at the biotechnology laboratory of Bethlehem University.

The cuttings for grafting were disbudded using a sharp sterilized knife while for those to grow on their own roots, one lateral bud in the uppermost or distal portion of the cutting was left. For rooting enhancement of all cuttings, 2cm vertical cuts were made at the basis of each cutting. The cuttings were soaked for 30 minutes in a Disinfectant Aqueous Solution (DAS) containing 2 gm/L Bavestin (Carbendazim 50% W.P.), 2 gm/L Merpan (Captan 50% W.P.), 2 ml/L Roger (Dimethoate 40% E.C.) and 1 ml/L Confidor (Imidapride 35% E.C.). Then, the cuttings were left to dry and placed into wood-meal that was treated also with the DAS.

b) Scion

Twelve to fifteen cm long healthy hardwood cuttings (node + internode) of seven Palestinian local table-grapevine cultivars; namely: Beiroti, Dapogi, Fhesi, Hamadani-Baladi, Jandali, White-Romi and Zeiny were obtained from Al-Arroub Agricultural Experimental Station. The cuttings were disinfected with the DSA as mentioned earlier.

2. Grafting

Indoor tongue grafting technique was performed for each rootstock and scion cultivars during February 2006. For comparison, the cuttings with a single bud were left to grow on their own roots. The grafted areas were covered (rolled and tied) with special plastic parafilm and dipped for 10 seconds into hot grafting-wax (Paraffin wax 5%). Then, the lower parts of the rootstocks (grafted or on their own roots) were dipped for 5 seconds into 4000ppm Indole-3-Butyric Acid.

Each scion/rootstock combination and the own-rooted cuttings were replicated 20 times.

3. Incubation Room

The grafted plants and the own-rooted cuttings were placed in plastic boxes filled with the treated wood-meal and incubated for 10 weeks in an incubation room under 25 ± 5^{o}C, 95% RH and 80% darkness (Todic *et al.*, 2005).

4. Nursery

The successful grafted combinations and the own-rooted transplants were transferred into 2 liter black plastic bags filled with sand and compost (1:1) and watered with the DSA. The grown scions were pruned to two nodes for hardiness, then transferred to the nursery, distributed into a Completely Randomized Design (CRD) and kept for the whole summer before transplanting into the open field for further investigation.

During this period, all the transplants were watered daily and treated against insect pests and diseases when needed.

Measurements

The following parameters were recorded according to (Celik, 2000; Celik *et al.*, 2003):

- Grades of callus development at the grafting union after ten weeks in the incubation room were grouped upon to the visible observations according to (Celik, 2000; Celik *et al.*, 2003), a scale of 1 to 4 was used, where: 1=no callus, 2=low, 3=intermediate and 4=high callus formation on graft union surface.

- Grades of rooting system development after ten weeks in the incubation room were grouped upon to the visible observations according to (Celik, 2000; Celik *et al.*, 2003), a scale of 1 to 4 was used, where: 1=no roots, 2=low, 3=medium and 4=high.

- Days required to scion bud-burst.

- Percentage (%) of survival of the grafted plants, where plants had a vegetative growth and the graft union was lignified after five-months in the nursery.

- Average length (cm) of the main shoot after five-months in nursery.

Data Analysis

The data were statistically analyzed using the one-way analysis of variance (ANOVA) and means were separated using the Tukey's pairwise comparisons at a significance level of $p \leq 0.05$ using the MINITAB package system.

RESULTS AND DISCUSSION

Table (1) shows significantly high grades of callus development among the combinations of Fhesi cultivar with all examined rootstocks as well as the combinations of Jandali/Richter-110, White-Romi/Ruggeri-140, White-Romi/216/3 and White-Romi/B41. In contrast, Hamadani-Baladi and Zeiny cultivars showed the significant least grades.

Table 1: Grade means of callus development on graft union surfaces in different scion/rootstock combinations after ten weeks of graft establishment.

Local Cultivars	Grade of grapevine rootstocks ± SE				
	Richter 110	**Paulsen 1103**	**Ruggeri 140**	**B41**	**216/3**
Beiroti	1.1^{b}±.07	1.4^{b} ±.11	1.55^{b} ±.11	2.2^{a} ±.16	1.5^{b} ±.12
Dabogi	2.05^{b}±.14	1.4^{c}±.11	1.45^{c}±.11	3.3^{a}±.13	1.45^{c}±.11
Fhesi	3.9^{a}±.07	3.8^{a} 5±.08	3.95^{a} ±.05	3.9^{a} ±.07	3.95^{a} ±.05
Hamdani-Baladi	1.15^{b}±.08	1.45^{b}±.11	3.25^{a}±.16	1.1^{b}±.07	1.4^{b}±.11
Jandali	3.85^{a} ±.08	1.2^{c}±.09	1.5^{c}±.12	2.5^{b}±.14	1.4^{c}±.11
White-Romi	3.25^{b}±.14	1.45^{c}±.11	3.9^{a}±.07	3.95^{a}±.05	3.8^{a}±.09
Zeiny	1.45^{b}±.11	1.05^{b}±.05	1.05^{b}±.05	1.4^{b}±.11	3.3^{a}±.15

Means within rows followed by different letters are significantly different at $p \leq 0.05$.

A positive correlation between successful grafts (Table 2) and callus development (Table 1) had been registered ($R^2 = 0.7433$). A similar relationship between root development (Table 3) and mean grade of callus development (Table 1) was also observed ($R^2 = 0.7527$). These results led us to conclude that high grade of callus and subsequently root development might be needed for good compatibility.

Table 2: Successful percentage of grafted and own-rooted plants after five months in the nursery.

Local cultivars	% of own roots (control)	% of grapevine rootstocks ± SE				
		Richter 110	Paulsen 1103	Ruggeri 140	B41	216/3
Beiroti	90^{a}±6.88	45^{bc}±11.4	25^{c}±9.93	60^{ab}±11.2	70^{ab}±10.5	30^{c}±10.5
Dabogi	70^{a}±10.5	50^{ab}±11.5	25^{b}±9.93	35^{ab}±10.9	65^{a}±10.9	20^{b}±9.18
Fhesi	95^{a}±5	100^{a}±0.0	80^{a}±9.18	80^{a}±9.18	90^{a}±6.88	80^{a}±9.18
Hamdani-Baladi	40^{a}±11.2	20^{a}±9.18	35^{a}±10.9	45^{a}±11.4	40^{a}±11.2	35^{a}±10.9
Jandali	100^{a}±0.0	100^{a}±0.0	20^{c}±9.18	50^{bc}±11.5	65^{b}±10.9	45^{bc}±11.4
White-Romi	60^{ab}±11.2	55^{ab}±11.4	20^{b}±9.18	85^{a}±8.19	80^{a}±9.18	85^{a}±8.19
Zeiny	65^{a}±10.9	35^{a}±10.9	40^{a}±11.2	40^{a}±11.2	35^{a}±10.9	45^{a}±11.4

Means within rows followed by different letters are significantly different at $p \leq 0.05$.

Our findings agree with the results reported by Celik (2000) who stated that the grade of callus formation at the grafting union was the main factor for good compatibility between stock and scion. The rootstock genotype might increase the free proline content and/or prevent Indole Acetic Acid conversion to the scion, which will promote rooting and thereby result in the grafting success (Durand and Nitsch, 1977; Bautista and El-Injerto, 1985; Celik *et al.*, 1992).

Table (2) shows high graft-compatibility in Fhesi cultivar among all tested rootstocks in addition to high successful grafts from the combinations of Jandali/Richter-110 (100%), White-Romi/Ruggeri-140 (85%), White-Romi/216/3 (85%) and White-Romi/B41 (80%). The compatible grafts could be attributed to the structural, physiological and/or biochemical events that might occur in the graft union. Indeed, the formation of the callus tissues at the graft interface is the first response to grafting (Pina and Errea, 2005).

Once the graft partners are in contact, the cambial region capable of meristematic activity produces parenchymatic cells and callus tissue that fills the space between the two components (Errea *et al.*, 1994; Wang and Kollmann, 1996; Hartmann *et al.,* 2002), thus leading to high lignifications of cells in the site of scion (Hossein *et al.,* 2008). Several researchers (Yeoman *et al*., 1978; Yeoman, 1984) considered this step the basic requirement for the development of vascular connections between rootstock and the scion leading thereby to successful grafts. When the functional vascular connections are established, translocation of signaling molecules, such as polypeptides in the phloem, could be significant in cell recognition and compatibility between the graft partners (Hartmann *et al*., 2002). Moreover, the highly dynamic structural plasmodesmata offer a pathway for symplastic cell communication and constitute a potential pathway among cells in the graft bridge (Lucas *et al*., 1993; Schulz, 1999). Consequently, this requires leaching or diffusion of some compounds from both sides of the union to the other diffusing into the cell wall, in order to achieve a firm cohesion between rootstock and scion (Yeoman and Brown, 1976; Kollmann and Glockmann, 1985; Kollmann *et al*., 1985).

In comparison with the grafted plants, the own-rooted ones 'Jandali', 'Beiroti' and 'Fhesi' resulted in a highly successful rate of 100%, 95% and 90%, respectively (Table 2). Dapogi, Zeiny and White-Romi, however, showed intermediate success, whereas,

Hamadani-Baladi cultivar presented lower success of 40% (Table 2). Moreover, a similar pattern of root development was also observed in own-rooted cultivars (Table 3). These results agreed with those of (Manuel, 1948; Bouqet, 1980; Sarooshi *et al*., 1982), who tested a number of phylloxera-resistant rootstocks and found that local cultivars perform best on their own roots.

Table 3: Grade means of root development of own-rooted as well as grafted plants after ten weeks of graft establishment.

Scions (local cultivars)	Grade of own roots (control) ± SE	Grade of rootstocks ± SE				
		Richter 110	Paulsen 1103	Ruggeri 140	B41	216/3
Beiroti	3.85^{a}±.08	1.65^{d}±.11	1.45^{de}±.11	$2.4±^{c}$.13	3.3^{b}±.15	1.05^{e}±.05
Dabogi	3^{a}±.21	2.05^{b}±.14	1^{c}±0.0	1.05^{c}±.05	2.5^{b}±.14	1.1^{c}±.07
Fhesi	3.65^{a}±.11	$3.9±^{a}$.07	3.85^{a}±.08	3.65^{a}±.15	3.85^{a}±.08	3.95^{a}±.05
Hamdani-Baladi	1.9^{a}±.18	1.05^{b}±.05	1.1^{b}±.07	1.2^{b}±.09	1.1^{b}±.07	1.3^{b}±.11
Jandali	3.35^{b}±.15	3.9^{a}±.07	1.1^{e}±.07	1.55^{d}±.11	2.55^{c}±.15	1.55^{d}±.11
White-Romi	2.95^{bc}±.15	2.55^{c}±.14	1.5^{d}±.12	3.9^{a}±.07	3.35^{b}±.15	3.85^{a}±.08
Zeiny	2.3^{a}±.13	1.1^{b}±.07	1.3^{b}±.21	1^{b}±0.0	1.25^{b}±.10	1.4^{b}±.11

Means within rows followed by different letters are significantly different at $p \leq 0.05$.

Table (2) also shows highly significant incompatibility between 'Hamadani-Baladi' and 'Zeiny' (less than 50% of graft-success) among all tested rootstocks. As the same environmental conditions to which grafts were subjected did not result in losses in the other tested cultivars such as Fhesi and since no pest or pathogen infection was noticed during the experimental period, graft incompatibility was likely to cause the unsuccessful grafts (Golino, 1993; Celik, 2000).

Table (4) shows no significant differences in shoot length among own-rooted vines as well as the combinations of Fhesi, Hamadani-Baladi, Jandali, White-Romi and Zeiny. However, Beiroti and Dapogi cultivars showed variable results.

Table 4: Means of shoot lengths (cm) of own-rooted as well as grafted plants after five months in nursery.

Local cultivars	Shoot lengths of own roots (control) (cm) ± S.E	Shoot lengths of grapevine rootstocks (cm) ± S.E				
		Richter 110	Paulsen 1103	Ruggeri 140	B41	216/3
Beiroti	83.78^{a}±4.3	53.11^{b}±6.16	56.4^{b}±8.58	61.58^{b}±7.4	84.93^{a}±5.55	66^{ab}±10.3
Dabogi	63.43^{a}±4.73	46.7^{ab}±5.85	30.4^{b}±3.97	41.43^{ab}±4.69	48.08^{ab}±3.69	44^{ab}±6.65
Fhesi	79.26^{a}±4.38	92.65^{a}±3.78	97.38^{a}±8.26	95.19^{a}±7.63	92.89^{a}±4.13	102.9^{a}±8.42
Hamdani-Baladi	52.25^{a}±3.49	42.25^{a}±5.59	48.57^{a}±3.98	50.67^{a}±4.62	46.63^{a}±4.65	45.29^{a}±5.69
Jandali	83.15^{a}±3.94	84.8^{a}±3.97	68.5^{a}±3.28	66.6^{a}±15.6	77.69^{a}±6.79	62.78^{a}±6.08
White-Romi	70.75^{a}±4.79	61.11^{a}±4.43	49.5^{a}±5.20	72.53^{a}±4.69	70.06^{a}±5.18	73.47^{a}±6.01
Zeiny	71.69^{a}±5.58	58.57^{a}±4.58	64.62^{a}±6.99	61.25^{a}±4.94	55.86^{a}±7.39	63.56^{a}±6.50

Means within rows followed by different letters are significantly different at $p \leq 0.05$.

Buds of the grafted plants occurred within 33 to 48 days after grafting, whereas, the own-rooted cuttings took place within 60-66 days (Table 5). These differences in duration might be possibly due to the high concentration of cytokinins and gibberellins resulting from "blinding" rootstock nodes. These PGRs probably moved down to the base and resulted in initiating root premordium formation and thus earlier bud burst (Hackett *et al*., 1997; Lund *et al.*, 1997).

Table 5: Mean number of days required for bud burst of own-rooted as well as grafted plants.

Local cultivars	Own roots (control) days ± SE	Grapevine rootstocks (days) ± SE				
		Richter 110	Paulsen 1103	Ruggeri 140	B41	216/3
Beiroti	60^{d}±.43	34.95^{a}±.28	35.2^{a}±.22	38.3^{c}±.25	47.4^{b}±.23	34.75^{a}±.14
Dabogi	60.05^{d}±.41	47.65^{c}±.22	35^{a}±.13	37.75^{b}±.28	34.8^{a}±.16	47.45^{c}±.28
Fhesi	65.7^{b}±.38	33.45^{a}±.17	34.85^{a}±.20	33^{a}±.25	33.45^{a}±.28	33.3^{a}±.26
Hamdani-Baladi	61.45^{c}±.37	47.6^{b}±.22	35.1^{a}±.39	47.85^{b}±.18	47.25^{b}±.22	47.35^{b}±.22
Jandali	66.2^{c}±.34	33.6^{a}±.17	34.8^{a}±.33	47.1^{b}±.16	35^{a}±.26	32.85^{a}±.20
White-Romi	60^{e}±.50	47.7^{d}±.25	34.9^{a}±.19	38^{b}±.30	33.05^{a}±.17	37.85^{b}±.13
Zeiny	59.8^{d}±.53	38.55^{b}±.24	34.9^{a}±.16	47.35^{c}±.32	35.15^{a}±.29	37.8^{b}±.21

Means within rows followed by different letters are significantly different at $p \leq 0.05$.

Several hypotheses have been postulated in an attempt to explain incompatibility. It is suggested that a single factor or a combination of many factors might be the reason for the unsuccessful graft establishment: (1) genetical divergence of the grafted partners (Pina and Errea, 2005); (2) the presence of non-functional plasmodesmata (Schulz, 1999; Martens *et al.,* 2004); (3) abnormal vascular tissue connections (Wang and Kollmann, 1996; Errea, 1998); (4) endogenous plant hormones (Sorce *et al.,* 2002; Mattsson *et al.,* 2003); (5) antioxidant enzymes (Quesada and Macheix, 1984; Pina and Errea, 2005, Gokbayrak *et al.*, 2007); (6) the presence of phenolic compounds (Feucht and Treutter, 1991); (7) phloem-translocation of proteins (Golecki *et al*., 1998; 1999); and (8) long distance translocation of RNA (Gomez and Pallas, 2004; Gomez *et al.,* 2005).

In conclusion, the combinations of Fhesi cultivar and the combinations of Jandali/Richter-110, White-Romi/Ruggeri-140, White-Romi/ 216/3, White-Romi/B41 and Beiroti/B41 were completely compatible and should be strongly considered as suitable local cultivar selection. Further research is needed for more information about the effect of compatibility on yield and quality.

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دراسة التوافق في تطعيم بعض أصناف عنب المائدة على أصول مقاومة لحشرة فيلو كسرا العنب

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ملخـص

تناول هذا البحث دراسة درجات الالتحام والتوافق لسبعة أصناف محلية هي: بيروتي، دابوقي، فحيصي، حمدلني بلدي، جندلي، رومي أبيض، و زيني، مع خمسة أصول مقاومة لحشرة الفيلوكسرا هي: ريختر 110، بولسن 1103، روجري 140، B41، و 3/216، بالإضافة إلى تجذير عقل من الأصناف المحلية بلا تطعيم كشاهد. تم تقويم درجة التوافق وعدم التوافق لكل مجموعة جديدة.

أظهرت نتائج التحليل درجات عالية من التوافق بين الصنف فحيصي وكافة الأصول المستخدمة في التجربة، وكذلك بالنسبة للصنف جندلي مع ريختر، والصنف رومي أبيض المطعم على الأصول روجري 140، 3/216، وB41. كما دلت الدراسة على وجود علاقة طردية بين درجة التكلس ودرجة التجذير ونسبة نجاح الاشتال. في المقابل أظهرت النتائج أن كلاً من الصنف حمدلني بلدي والصنف زيني ذو درجات متدنية من التوافق مع كافة الأصول المستخدمة في التجربة وبنسبة نجاح تقل عن 50%. كما أظهرت النتائج وجود فروق معنوية في تفتح البراعم بين النباتات المطعمة التي تفتحت مبكراً بعد 33-48 يوماً من التطعيم والنباتات غير المطعمة التي تفتحت متأخراً بعد 60-66 يوماً.

وعليه، فإن هناك حاجة لمتابعة أثر التوافق و عدم التوافق في الإنتاج كمياً و نوعياً في الحقل.

الكلمات الدالة: فيلوكسرا العنب، الأصول، المطاعيم، التوافق.

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