Hebron University Research Journal-A (Natural Sciences) - (مجلة جامعة الخليل للبحوث- أ (العلوم الطبيعيه)

Volume 9 | Issue 1 Article 2

2020

Breeding rootstocks for fruit trees in Palestine: Status and prospective toward future climate change scenarios

Rezq Basheer
Hebron University, rezqbasheer@hebron.edu

Fatina Hawamdeh
Hebron University, HawamdehFatina@hebron.edu

abdul jalil Hamdan
Hebron university, ajhamdan@hebron.edu

Hebron University Research Journal(A)
Vol.(9), pp.(11-28), 2020

H.U.R.J. is available online at
http://www.hebron.edu/journal

Breeding rootstocks for fruit trees in Palestine: Status and prospective toward future climate change scenarios

[*]Basheer-Salimia Rezq, [1]Hawamdeh Fatina, [1]Hamdan Abdul-Jalil and [2]Al-salimieya Mohamad

[1*]Department of Plant Production and Protection, Faculty of Agriculture,

Hebron University, Hebron, Palestine.

Corresponding author: rezqbasheer@hebron.edu

[2]Land Research Center, Palestine.

Received: (27/4/2020), Accepted: (26/7/2020)

Abstract:

This review characterizes, identifies and presents remarks of breeding rootstocks in Palestine. It's based upon a survey of the rootstocks that have been used along decades of breeding and grafting of local and introduced cultivars. All for acclimatization for hard conditions that confront fruit trees. It also proposes some expected promising rootstocks that might suit the climate change and whatever affected by it of biotic and abiotic stresses in the area. Obviously, this review discusses the advantages of the current confirmed rootstocks that are compatible with most of the species of the popular trees. It also pointed out to inadequate rootstocks that have been used before. In fact, many of these rootstocks still exist, however the elimination of the other rootstocks refers to different reasons either to the environmental conditions or the incompatibility with the preferred cultivars.

Key words: Fruit crops, rootstocks, grafting, scion, climate change.

الملخص:

هذه الدّراسة المرجعيّة تشخص وتوضح، وكذلك تقدّم رؤية واضحة عن أصول أشجار الفاكهه في فلسطين، وتستند- في كتابتها- إلى مسح معلوماتي شامل لأصول أشجار الفاكهة المستخدمة في عمليّة التطعيم منذ استحداثه- بإعتباره وسيلة ناجعةً وناجحةً- لإكثار الأصناف المختلفة من الأشجار المحلية، أوالتي تم إدخالها إلى المنطقة خلال العقود المنصرمة؛ حيث أنّ دراسة هذه الأصناف المختلفة تهدف- بالأساس- إلى إيجاد طريقة ملائمة للتأقلم الأمثل، وتعزيز إمكانية التعايش مع التقلبات البيئية المختلفة التي تعترض نمو أشجار الفاكهة. وتقدّم الدراسة أيضاً آراء ومقترحات للأصول الواعدة التي قد تتناسب مع التغير المناخيّ وجميع المؤثرات الحيوية وغير الحيوية في المنطقة. وتبيّن هذه المراجعة العلمية إيجابيات الأصول المستخدمة التي تتوافق مع معظم أصناف الفاكهه المزروعة حاليّاً، كما أنها تشير إلى الأصول غير الملائمة التي تم استخدامها سابقاً، وكذلك تشير الى تلك التي تم إقصاؤها بسبب عوامل مختلفة تتعلق، إما بالظروف البيئيّة، أو بعدم التوافق بين الأصول والطعوم.

الكلمات المفتاحية: أشجار الفاكهه، أصول، التطعيم ، التغير المناخيّ.

Introduction:

Fruit trees constitute the bulk portion of the Palestinian agriculture in terms of area covered and economical returns. The total agricultural area is about 1,2 million dunum; of which 60% are cultivated with fruit trees (PCBS, 2018). Although Palestine is a small country, it has a wide range of agro-ecological concerns and hosts a large variety of plants (Ighbareyeh et al., 2014; ARIJ, 2015), including fruit trees. This variation is mainly related to its location between the continents Asia, Europe, and Africa, and between the eastern Mediterranean Sea, Red Sea, Dead Sea, and Jordan River. In addition, to its geographical location and the wide range of its elevations which range between 430 m below the sea level up to 1100 above the sea level. Such situation allowed the Palestinian farmers to grow varied-range of fruit crops; in which temperate, sub-tropical and tropical fruit trees exist.

Until 1970th, the majority of fruit trees were vegetatively propagated and trees were grown on their own roots. However, due to different biotic and abiotic factors, there were necessities to introduce new approach of breeding depending on using rootstocks that adapted to non-suitable factor for the scion cultivation. The partners (scion and rootstock) in the new combination must have some degree of botanical relationship, the closer is the better (McMahon et al., 2007). Though, choosing the proper and most compatible rootstocks will give the scion the best chance to survive, produce good economical yields, and guarantee sustainable orchards.

Generally, rootstocks are used to modify form or stature, adapt to a variety of soil, fit in an incompatible climate, impart or resist disease to the scion, increase production, hasten maturity of crop, change the colour of the fruit, affect the flavour of the fruit, shorten life of the tree, increase the size of the fruit, develop vigour, effect salt tolerance and influence storage capacity (Usha et al., 2015). However, during the last decades, drought as a direct result of global and regional climate change (Basheer-Salimia and Sayara, 2017), seems to be the most devastating stress affecting the overall Palestinian agriculture including fruit trees with no exception. In fact, detectable climate change has been observed as lower average precipitation rate, more marked changes in the distribution of precipitation from one year to the next, with winter getting shorter and extensive (Basheer-Salimia and Ward, 2014). Unfortunately, a worst climate change scenario is expected to get more pronounced in the future. According to a realistic emissions scenario for the region, the Intergovernmental Panel on Climate Change (IPCC) predicts that warming over the 21st century will be larger than global annual mean warming – ranging between 2.2-5.1ºC (Collins, et al., 2013). Furthermore, annual precipitation rates are expected to decrease by 10% by 2020, and are expected to decline by 20% by 2050 – with an increased risk of summer droughts in the region.

To cope with such change, breeding rootstocks for fruit trees might be one of the main options toward overcoming the current as well as the future forecast harsh drought conditions.

Despite the economic, nutrition and social importance of fruit trees sector in Palestine, there has been little courtesy and studies for breeding fruit trees rootstocks. This review screens, identifies and presents remarks of the current used rootstocks of fruit trees (including olive, grape, cherry, peach and nectarine, apricot, plum, almond, apple, pear, and citrus), as well as propose some promising rootstocks that might suit the future climate change scenarios in Palestine.

1. Olive rootstocks:

Olive (Olea europea L.) is the main horticulture crop in Palestine compromising about 60% from the total area's devoted to fruit trees (PCBS, 2013). In the past, plants were vegetatively propagated using cuttings or suckers. Lately, the method of grafting seedlings was introduced and this technique is still used for olive propagation. Commercially, the interested scion is grafted on one to two year's old seedlings obtained from wild-olive stones or from stones of local cultivars (mainly from Roomi, Nabali and Souri cultivars). Indeed, these rootstocks found to improve the tolerance of the resulting plant to adverse environmental conditions (Hussain et al., 2016), via enhancing different defense adaptation strategies including plant-water relations, nutrient uptake, carbon assimilation, canopy dimension, oxidative pathways, phenology and reproduction processes (Bacelar et al., 2006; Bacelar et al., 2007; Farooq et al., 2009; Petridis et al., 2012; Stocker et al., 2013; Brito et al., 2018; and IOC 2019). Therefore, developing grafting approach technique for olive tree varieties is highly important to withstand these stresses (severe summer conditions, excessive heat load, high daily irradiance, and low winter rainfall and precipitations), that characterize the Mediterranean region in the latest decades (Brito et al., 2019) including Palestine with no exception. Such condition is leading to higher evaporative demand and decreased soil water availability affecting thereby the overall olive cultivation, yield and quality.

2. Grape rootstocks:

Grape (Vitis vinifera L.) is the second most important fruit crop in terms of both area covered as well as economical returns (Basheer-Salimia and Hamdan 2009a). Until 1980, Palestinian grapes were clonally propagated on their own roots mainly by cutting. Due to phylloxera infestation Daktulosphaira vitifoliae, and its severe damage on grapevines; five American rootstocks resistant to grape phylloxera were chosen and accordingly introduced including Rugerri-140, Paulsen-1103, Richter-110, 216/3, and B41 (Table 1).

Table 1. Main characteristics of the current grapevine rootstocks in Palestine.

Rootstocks\ Characters	Drought Resistance	Phylloxera Resistance	Salinity Resistance
Ruggeri-140	High	High	Med.-High
Paulsen-1103	High	High	Med.
Richter-110	Very High	High	Med.
B41	Med.-High	Susceptible	High
216/3	Med.-High	High	Med.

However, choosing the right scion/rootstock combination is the main challenge due to numerous available local cultivars and the introduced rootstocks, especially in predicting how the scion and the rootstock genotype will interact in the future (Cus, 2004; Serra et al., 2014). Based on the results accomplished lately (Basheer-Salimia and Hamdan 2009a,b; Hamdan and Basheer-Salimia 2010), the best combinations (scions * rootstocks) were presented (Table 2), in which those revealed high successful percentage are considered as a compatible grafting. In fact, further research is needed for more information about the effect of compatibility on yield and quality.

Table 2: Successful percentage of grafted plants after five months in nursery.

Local Cultivars	American Rootstocks				
	Richter-110	**Paulsen-1103**	**Ruggery-140**	**B-41**	**216/3**
Halawani	100%	95%	85%	80%	85%
Halawani-Baladi	79%	60%	79%	60%	80%
Red-Romi	25%	20%	10%	45%	5%
Beitoni	45%	55%	45%	35%	50%
Darawishi	30%	20%	30%	90%	5%
Hamadani-Faranse	45%	60%	0%	5%	40%
Masri	100%	100%	95%	95%	80%
Shami	100%	90%	85%	90%	90%
Beiroti	45%	25%	60%	70%	30%
Dabogi	50%	25%	35%	65%	20%
Fhesi	100%	80%	80%	90%	80%
Hamdani-Baladi	20%	35%	45%	40%	35%
Jandali	100%	20%	50%	65%	45%
White-Romi	55%	20%	85%	80%	85%
Zeiny	35%	40%	40%	35%	45%

In addition to phylloxera problem, and in light of the unpromising future climate changes scenarios, it is crucial to introduce drought-tolerant grapevine cultivars in which grafting is an interesting approach. Based on the literature, it is recommended to use Richter-110 as a promising rootstock for grape-vine cultivation in Palestine since it reveals very-high resistance to drought in similar climate (Yıldırım et al., 2018). Indeed, over many other rootstocks, this rootstock imposed different adaptation mechanisms to drought stress including enforce alteration of root system architecture, enhance root relative water content, improve total carbohydrate and nitrogen content, and finally induct sugar and protein transporters genes (SWEET and NRT1/PTR) in the roots of Richter-110 to facilitate carbohydrate and nitrogen accumulation (Comas et al., 2013; Barrios-Masias et al., 2015; Yıldırım, 2017; Yıldırım et al., 2018). This phenotypic and genotypic information's might explain the superiority of Richter-110 as a promising drought resistance rootstock.

3. Stone-fruit rootstocks:

Stone fruits namely stone because the seed is protected by a rigid stone called the endocarp. The stone fruit is a species that belongs to the genus Prunus and it commonly includes cherry, peach and nectarine, apricot, plum and almond.

3.1. Cherry rootstocks:

Cultivation and production of cherry (Prunus avium L), is still restricted to the southern region of West-Bank, especially Hebron and Bethlehem areas mainly due the available chilling requirements. To date, mahaleb, mazzard, and bitter almond seedlings are used as rootstocks for both sweet and sour cherry (Table 3), in which bitter almond is extensively used over the others. Based on the Palestinian farmers and nurseries experiences (Al-Wadi and Al-sabe'h, 2017; Personal communication), better almond is highly recommended probably due to its high compatibility for most of cherries cultivars, tolerant to lime soils, and tolerant to drought. Another rootstock namely colt also existed, but it dis-appeared mostly due to its high susceptibility to drought.

Table 3. Main characteristics of cherry rootstocks in Palestine.

Rootstocks	Main Characteristics
Mahaleb	More drought tolerant than mazzard, slightly dwarfing, induces early and heavy bearing, not tolerant of wet soils, resists crown gall, bacterial canker, and some nematodes.
Mazzard	Medium drought tolerant, vigorous, does well in a wide range of soils, more tolerant in wet soils than mahaleb (but good drainage still required), resists root-knot nematode, moderately resistant to oak root fungus, susceptible to crown gall, bacterial canker and root-lesion nematode.
Bitter Almond (seed)	Drought tolerant, lime tolerant, available and cheap, susceptible to nematode, grown gall and phytophtora.
Colt (cutting)	Not available, susceptible to drought and crown gall, resistant to phytophtora, resistant to bacterial cankers, and resistant to cherry stem-pitting.

3.2. Peach and nectarine rootstocks:

Peaches and nectarines (Prunus persica L.) are principally produced by grafting the selected varieties onto rootstocks. These rootstocks are generally divided into three groups including wild types peach and nectarines (most common), seedlings, and rootstocks bred for rootstock purposes (Layne, 1987; Zheng et al., 2014). A major problem with wild peaches to be used as rootstocks is their high genetic variability and lack of uniformity in the nursery as well as in the field (Rakonjac et al, 2016). Lately, large numbers of rootstocks were used (GF677, barrier, nemaguard, M29, bitter almond, etc), which have shown a wide range of resistance to pests and diseases, tolerance to different edaphic conditions and to their influence on tree physiology (Malcom, 2004; Yagci et al., 2019). Among all these rootstocks, bitter almonds is dominant and outstanding and still the only used rootstock in Palestine probably due to its availability, low price, and its resistance to drought which characterize the region lately.

3.3. Apricot rootstocks:

Comparing with other stone-fruits, apricot (Prunus armeniaca) cultivation and production is cruelly restricted by climatic conditions (Faust et al., 2011); accordingly their rootstocks are also differing in their response to ecological conditions. For instance' Prunus domestica and Prunus cerasifera are the best options for cold areas, whereas Myrobalan rootstock is highly adapted to extreme soil pH. In addition, they differ in their response to pests and disease such as phytophthora, crown gall and oak fruit fungus (Rom, 1991). Today, most apricots cultivars are grafted on bitter almond, local apricot (Prunus armeniaca), Mahaleb, and Myrobalan-GF81 (Table 4).

Table 4: Summery of the main characteristics of some stone-fruit rootstocks in Palestine.

Crop	**Rootstocks**	**Rootstock Characteristics**				
		Availability	**Response to pests**	**Response to stress**	**Propagation method**	**Special characteri stics**
Apricot	Bitter almond	Available	S to root knot nematode, crown gall and phytophthora.	T to drought T to lime.	seeds	Incompatib le with Mestikawi cv. Compatible

						with *Prunus armeniaca*.
	Local apricot *(Prunus armeniaca)*	Available			Seeds	Highly compatible with most of apricot cultivars especially Mestikawi. Early bearing of grafted cultivars. Strong vigor.
	Mahaleb	Not Available	R to root knot nematode	R to drought	Propagated by seed. Low suckers productivity.	Low compatibili ty with local apricot cultivars.
	Myrobalan GF81	Not Available	R to bacterial cankers. Moderately R to crown gall. Very S to phytophthora S to oak fruit fungus.	T to lime. T to drought.	Propagated by seed. High suckers productivity.	-
Plum	Bitter almond	Available	S to root knot nematode, crown gall and phytophthora.	T to calcareous soil. S to wet soil.	seed	T to drought. Late fruit bearing.
	Myrobalan GF31 *Prunus cerasifera*	Available	R to root knot nematode			R to drought.
Almond	Bitter almond	Available	S to root knot nematode, crown gall and phytophthora.	T to calcareous soil. S to wet soil.		T to drought. Late fruit bearing
	GF677	Available	R to root knot nematode. S to ring nematode and bacterial canker.	S to Calcareous soil. S to wet soil.		Propagated by seed. T to drought Early fruit bearing

R: Resistant; S: Susceptible, and T: Tolerant.

However, the main concern is the grafting incompatibility which clearly appeared with apricot. In fact, observations showed difficulty in full growth and stability of the local apricot trees that is grafted on the un-local species. For example, Mestikawi as one of the highly desired apricot cultivar in Palestine is not compatible with bitter almond; however other cultivars are highly unified with it. Based on these observations, bitter almond is used as a successful rootstock for all local apricot cultivars except mestikawi which grafted on local apricot seedlings. Meanwhile, Myrobalan and Mahaleb failed to resume their availability since they are neither compatible nor suits our environment.

3.4. Plum rootstocks:

European plum (Prunus domestica) is known as the main local plum cultivar; however the leading available rootstocks are bitter almond and Myrobalan (GF31). These two rootstocks found to be feasible with the local plum cultivar since they revealed somehow a wide range of adaptability, tolerate the hard growth conditions, and are tolerant to a wide range of soil types. Other rootstocks were also introduced such as Mariana, Okinawa, and GF-677; but they soon disappeared due to incompatibility and un-acclimatization reasons. Due to drought conditions and lack of winter chilling to break dormancy in warm years, bitter almond might be the proper rootstock for breeding plums in Palestine.

3.5. Almond Rootstocks:

Almond (Prunus amygdalus) is the leading stone-fruits in terms of economical and production areas. Bitter almond and GF677 are the only used rootstocks in Palestine for different almond cultivars (Table 4).

4. Pomes rootstocks:

4.1. Apple (Malus pumila) rootstocks:

Generally, standard apple trees were produced by grafting the desired cultivar on one-two year's apple seedlings that comes from apple seeds (Hamed, et al., 2007; Shatat et al., 2007). Later on, mainly M9 and M27 (dwarfing rootstocks) and MM106 (resistance to woolly apple aphid) were introduced. However due to different biotic and abiotic factors as well as grafting incompatibility with our local apple cultivars, most of these rootstocks were found to be not suitable and thereby dis-appeared. Based on the apple grower's experience, most nurseries were limiting their apple rootstocks to the seedlings of quince and local apple seeds (Table 5) which were found to be soundlessly suitable for our environment, highly compatible with most desired cultivars, and presenting a good vigor.

Table 5: Summery of the main characteristics of pome-fruit rootstocks in Palestine.

Crop	Rootstocks	Main characteristics					
		Availability	**Size of tree**	**Responses to pests and diseases**	**Bearing time**	**Proper soil characters**	**Special Character-ristics**
Apple	Local apple (*Malus sylvestris*)	Available	Standard	S to apple stem borer.	Late	Well drained soil	Strong vigor, high compatibili ty with most of cultivars.
	Quince *(Cydonia oblonga)*	Available	Semi-dwarf	S to fire blight R to crown gall	Early	S to alkaline soil T heavy soils T wet soils	Strong vigor
Pear	Local Quince	Available	Standard	R to crown gall	Early	S to alkalinity T to flooding	Cutting & layering. Large size of fruits.
	European & local pear	Available		S to fire blight		T to drought	Seeds

R: resistant; S: susceptible, and T: tolerant.

4.2. Pear (Pyrus communis) rootstocks:

Similar to apple, local and European pears often grafted only onto quince seedlings rootstock (Table 5). This limited option is mainly due to the failed grafting (incompatibility) with the introduced rootstocks, weak tolerant to lime and alkaline soils, and susceptibility to some major pathogens. Furthermore, quince rootstocks found to be highly acclimatized with the existing harsh ambient climatic conditions.

5. Citrus rootstocks:

Citrus is cultivated among wide range of coastal areas mainly in Tulkarm, Qalqilia and Gaza cities. Due to series of biotic (tristeza, exocortez, root knot nematode, root rot) and abiotic factors (drought, increasing soil lime and salinity, frost), its plantation was significantly deducted (MOA, 2014). Toward this end, different rootstocks were introduced and accordingly evaluated. Only Bitter orange and Volca-meriana rootstocks found to be suitable for our conditions. However, bitter orange is used more than Volca-mariana because of its resistance to frost and salinity (Table 6).

Table 6: Susceptibility of citrus rootstocks to different problems in Palestine.

Rootstock disease resistance level	**Availability of rootstock**	**Root knot Nema-tode**	**Root rot**	**Tristez a virus**	**Exocortez**	**Lime in soil**	**Salinity**	**Frost**
Bitter orange (*Citrus auran-tium*)	Available	S	R	S++	R	R	R	T+
Volkameriana	Available	S	R	R	R	T	S	S

R: resistant; S: susceptible, and T: tolerant.

Conclusions:

To cope with climate change and global warming prediction, the following rootstocks are highly recommended for breeding fruit trees in Palestine: olive seedlings from seeds for olive; Richter-110 from cutting for grapes; bitter almond from seeds for cherry, peach, and nectarine; bitter almond or local apricot from seeds for apricot; and bitter almond or Myrobalan (GF31) from seeds for plum; and bitter almond from seeds for almond. Furthermore, quince and local apple seedlings from seeds could be used for apple as well as quince rootstocks from seeds for pear plants. In addition, bitter orange rootstock from seeds is suitable for orange due to its resistance to drought, frost and salinity. Finally, the reviewed rootstocks in this study may be useful and valuable material for any future breeding programs in Palestine.

REFERENCES:

Al-Wadi and Al-Sabe’h (2017). Personal communication.

ARIJ, (2015). Assessment of food production and consumption to improve sustainable agriculture and food security in the West Bank. *Publication of the Applied Research Institute – Jerusalem*, Palestine.

Bacelar, E.A., Moutinho-Pereira, J.M., Gonçalves, B.C., Ferreira, H.F., and Correia, C.M. (2007). Changes in growth, gas exchange, xylem hydraulic properties and water use efficiency of three olive cultivars under contrasting water availability regimes. *Environ. Exp. Bot.*, 60, 183–192.

Bacelar, E.A., Santos, D.L., Moutinho-Pereira, J.M., Gonçalves, B.C., Ferreira, H.F., and Correia, C.M. (2006). Immediate responses and adaptive strategies of three olive cultivars under contrasting water availability regimes: Changes on structure and chemical composition of foliage and oxidative damage. *Plant Sci.*, 170, 596–605.

Barrios-Masias, F.H., Knipfer, T., and McElrone A.J. (2015) Differential responses of grapevine rootstocks to water stress are associated with adjustments in fine root hydraulic physiology and suberization. *Journal of Experimental Botany*, 66(19), 6069–6078.

Basheer-Salimia, R. and Hamdan, A. (2009a). Assessment of Preliminary Grafting Compatibility-Incompatibility between Local Palestinian Table-Grapevine Cultivars and Different Phylloxera. *An-Najah University Journal for Research (N. Sc.)*, 23, 49-71.

Basheer-Salimia, R. and Hamdan, A. (2009b). Grapevine Scion-Rootstock Combinations of Palestinian Local Cultivars and Rootstocks Resistant to Grape Phylloxera Daktulosphaira vitifoliae (Fitch) [Phylloxeridae: Homoptera]. *Dirasat, Agricultural Sciences*, Volume 36(1), 19-28.

Basheer-Salimia, R. and Sayara, T. (2017). Using Stable Isotope (□13C) and C/N ratio to study the effects of Climate Change on Olive trees. *Arab American University Research Journal*, 3(1), 22-38.

Basheer-Salimia, R. and Ward, J. (2014). Climate change and its effects on olive tree physiology in Palestine. *Review of research journal*, 3(5), 1-7.

Brito, C., Dinis, L. T., Moutinho-Pereira, J., and Correia, C. M. (2019). Drought Stress Effects and Olive Tree Acclimation under a Changing Climate. *Plants*, 8(7), 232.

Brito, C.; Dinis, L.T.; Meijón, M.; Ferreira, H.; Pinto, G., Moutinho-Pereira, J., Correia, C. (2018). Salicylic acid modulates olive tree physiological and growth responses to drought and re-watering events in a dose dependent manner. *J. Plant Physiol.* 230, 21–32.

Collins, M., Knutti, R., Arblaster, J., Dufresne, J.L., Fichefet, T., Friedlingstein, P., Gao, X., Gutowski, W.J., Johns, T., Krinner, G., Shongwe, M., Tebaldi, C., Weaver A.J., and Wehner, M. (2013). Long-term Climate Change: Projections, Commitments and Irreversibility. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Comas, L.H, Becker, S.R, Cruz, V.M, Byrne, P.F and Dierig D,A. (2013). Root traits contributing to plant productivity under drought. *Front. Plant Sci*., 4, article no 442, 1-16.

Cus, F. (2004). The effect of different scion/rootstock combinations on yield properties of cv. `Cabernet Sauvignon`. *Acta agriculturae slovenica,* 83(1), 63-71.

Farooq, M., Wahid, A., Kobayashi, N., Fujita, D., and Basra, S.M. (2009). Plant drought stress: Effects, mechanisms and management. *Agron. Sustain. Dev*., 29, 185–212.

Faust, M., Timon, B., Surányi, D., Nyujtó, F., and Gradziel, T. (2011). Origin and dissemination of prunus crops: Peach, cherry, apricot, plum and almond. *International Journal for Horticultural Science,* 11, 1-241.

Hamdan, A. and Basheer-Salimia, R. (2010). Preliminary Compatibility between Some Table-Grapevine Scion and Phylloxera-Resistant Rootstock Cultivars. *Jordan Journal of Agricultural Sciences*, 6(1), 1-10.

Hamed, F., Aisi, I., and Batha, M. (2007). Fruit production. *Damascus University Press*. University of Damascus, Syria.

Hussain, I., Naeem, N., Jan, A., Rehman, H., and Ali, S. (2016). Performance of different olive cultivars under time of grafting. *Pure and Applied Biology*, 5, 1.

Ighbareyeh, J., Cano-Ortiz, A., Suliemieh, A., Ighbareyeh, M., and Cano, E. (2014). Phytosociology with Other Characteristic Biologically and Ecologically of Plant in Palestine. *American Journal of Plant Sciences*, 5, 3104-3118.

IOC, (2019). The yearly publication of the International Olive Council.

Lyane, REC. (1987). Rootstocks for fruit crops. Rom, R.C. and Carlson R.F. (eds.). *John Wiley and Sons*, New York, 185-216.

Malcom, P. (2004). Effects of root temperatures and genotype on the growth of peach rootstocks and their scions. *Publication of the Centre for Horticulture and Plant Science, University of Western Sydney, Richmond, Australia.*

McMahon M.J., Kofranek A.M., and Rubatzky V.E. (2007). Hartmann's Plant Science "growth, development, and utilization of cultivated plants". Prentice-Hall, Inc., Upper Saddle River, New Jersey, USA.

MOA, (2014). Assets of citrus and their specifications. *Publication of the Palestinian Ministry of Agriculture*, Ramallah, Palestine.

PCBS, (2013). Assessment of the Palestinian Plant and Animal Production. *Palestinian Central Bureau of Statistics*, Ramallah, Palestine.

PCBS, (2018). Assessment of the Palestinian Plant and Animal Production. *Palestinian Central Bureau of Statistics*, Ramallah, Palestine.

Petridis, A., Therios, I., Samouris, G., Koundouras, S., and Giannakoula, A. (2012). Effect of water deficit on leaf phenolic composition, gas exchange, oxidative damage and antioxidant activity of four Greek olive (*Olea europaea* L.) cultivars. *Plant Physiol. Biochem.*, 60, 1–11.

Rakonjac, V., Nikolić, D., Fotirić-Akšić, M., & Čolić, S. (2016). Rootstock and inter-stock influence on vigor, fruit and leaf properties of sour cherry cultivars. *Acta Horticulturae*, 1139, 231–236.

Rom, R.C. (1991). Apricot rootstocks: perspective, utilization and outlook. *Acta Horticulturae*, 293, 345-354.

Serra, I., Strever, A., Myburgh, P., and Deloire, A. (2014). Review: The interaction between rootstocks and cultivars (*Vitis vinifera* L.) to enhance drought tolerance in grapevine. *Australian Journal of Grape and Wine Research*, 20(1), 1-14.

Shatat, A., Qronfula, M., and Ateyyah, A. (2007). Principles of fruit trees production. *The University of Jordan Press*, Amman, Jordan.

Stocker, T.F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S. K., Boschung, J., Nauels, A., Xia, Y., Bex, V., and Midgley, P.M. (2013). Climate Change: The Physical Science Basis: Contribution of Working Group I to the Fifth. Assessment Report of the Intergovernmental Panel on Climate Change 2013; *Cambridge University Press*, NewYork, NY, USA.

Usha, K., Thakre, M., Goswami A.K., and Deepak, G (2015). Fundamental of fruit production. *Publication of Division of Fruits and Horticultural Technology, Indian Agricultural Research Institute, New Delhi.*

Yağci, M., Kaşkavalcı, G., and Devran, Z. (2019). Reaction of peach and nectarine rootstocks to different populations of root-knot nematode species, Meloidogyne incognita (Kofoid & White, 1919) and Meloidogyne javanica (Treub, 1885). *Turkish Journal of Entomology*, 43(2), 171-178.

Yıldırım K., Yağcı A, Sucu S., and Tunç S. (2018). Responses of grapevine rootstocks to drought through altered root system architecture and root transcriptomic regulations. *Plant Physiology and Biochemistry*, 127, 256-268.

Yıldırım, K. (2017). Utilization of selection indexes for adaptive responses of black poplar (populous nigra L.) to drought stress. *J. New Res. Sci.* 2(6), 1-16.

Zheng, Y., Crawford, G.W., Chen, X. (2014). Archaeological Evidence for Peach (Prunus persica) Cultivation and Domestication in China. *PLoS ONE*, 9(9), 1-9.