Journal of the American Pomological Society 69(4): 186-200 2015

Apple genetic resources in Israel

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Additional index words: *Malus,* germplasm collection, low chilling requirements

Abstract

Although the origin of apple (*Malus domestica*) is not considered to be from the Mediterranean, its culture in Israel has been known for centuries. It was suggested that apple culture in the area began through the transfer of plants from the region of Armenia thousands of years ago. In an effort to preserve and explore the genetic and breeding potential of the Israeli varieties, a plot was allotted to an apple germplasm collection at the Newe Ya'ar Research Center (elevation about 100 m, lat. 32°42'N, long. 35°11'E). The collection includes 33 accessions from different parts of the country, including the Judea Mountains, the Samaria Mountains, the Coastal Plain and Galilee. Although the number of old apple varieties in Israel is very small compared to other collections in the world, it is of high importance as it represents accessions that are adapted to regions with hot summer soil temperatures and mild winter conditions. The cultivar Anna, which is especially adapted to low chilling requirements and grown worldwide, originated from a cross between a local cultivar and a Western cultivar. A population originating from this cultivar was also used for the first QTL mapping of chilling requirements in apple. In view of the rising interest in varieties that are better adapted to global climate change, the Israeli collection is of high importance for future studies of adaptation to hot climate, tolerance to diseases and insects, and for breeding.

Source and history of apples in Israel

The origin of the *Malus* genus is considered to be south east to central Asia (Goor et al., 1962; Robinson et al., 2001). *Malus sieversii* (Ledeb.) M. Roem was identified as the progenitor of the cultivated apple (Janick et al., 1996; Velasco et al., 2010). A wild species of *M. sieversii* is found in the mountains of Central Asia, a region characterized by very cold winters with precipitation falling mainly in winter and spring (100 to 1,500 mm a year). The time and place of apple domestication have not yet been established, and it is estimated that domestication occurred in more than one place over a long period of time (Cornille et al., 2012). The exact era of *Malus* emergence in the near east and Israel region is not known. Possibly, it was transferred from the Armenian-Iranian region 4,000-5,000 years ago (Goor et al., 1962). There are no wild *Malus* species reported in the Flora of Israel (Holland et al., 2006).

Evidence of apple culture in Israel has been found in historical documents since the Common Era (Goor et al., 1962). Apples were grown mainly at higher elevations, where conditions are sufficient for the production of good quality fruit. Reports on apple growing along the Mediterranean coast, especially in its southern part, near Jaffa, Ashkelon and Gaza (Fig. 1) are available. Thomson (1880) describes: "… the whole area is planted over with orchards of the various kinds of fruit which flourish in this region. It is especially celebrated for its apples, which are the largest and best I have seen in Palestine". The Mediterranean coast region is characterized by a relatively warm climate, with a small amount of cold units accumulated during winter. Therefore, reports on apple varieties that grow in warm regions dating back to the 16th century (Belon, 1553; Goor et al., 1962) imply that apple varieties with a low chilling requirement already existed centuries ago.

The *Malus* genus includes about thirty

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primary species (the number differs among botanists) and many more synonyms, not truly wild species, sub-species and interspecific crosses, constituting a widely diverse genus (Dzhagaliev, 2003; Forsline et al., 2003; Janick et al., 1996; Robinson et al., 2001; Way et al., 1990). While *Malus* is very diverse genetically, modern cultivated apple varieties have a rather narrow genetic base, leaning on two cultivars, 'Delicious' and 'Golden Delicious' (Janick et al., 1996; Way et al., 1990). Nearly all of the world's most important commercially produced apples belong to the species *Malus domestica* Borkh. (Way et al., 1990), formerly known as *M. communis*, *M. pumila* (not *M. pumila* Mill.) or *M. sylvestris* (not *M. sylvestris* (L.) Mill.) (GRIN, 2014). Other *Malus* species have a small part in the origin of commercial apple (Goor et al., 1962; Way et al., 1990).

Malus species are also utilized as rootstocks, pollinators and ornamental plants. The Israeli local edible varieties and apple rootstocks were classified as *M. domestica* Borkh. (Goor et al., 1962). Pollinating and ornamental crab apples of other *Malus* species are scarcely used in Israel and none of these is an old or local species.

In early documents (up to the beginning of the 20th century) reporting on apples in Israel, there is no reference to any variety name or detailed description of specific apples except for description of color, taste or other general statements (e.g. Le Strange, 1890; Thomson, 1880). Variety names have been documented since the thirties of the 20th century (Goor and Rapaport, 1949; Goor et al., 1962; Grasowsky and Weitz, 1933).

Local apple germplasm

All over the world new cultivars are substituting old ones continuously, and gradually hundreds of important previously-grown commercial cultivars are being lost (Way et al., 1990). In Israel, a rapidly developing country, such a process is also taking place, and old local varieties are being neglected and eventually lost because many of them have relatively poor fruit quality and are less attractive to growers and to consumers. Although these varieties are considered inferior, there are indications that they may have beneficial qualities reflected in their ability to grow in the Israeli climate and soil conditions of a semi-wild environment. Most superior cultivars require medium to high chilling to flourish, but in Israel most growing regions provide insufficient chilling. Most of the old local traditional and the locally bred varieties have low chilling requirements. Low chilling requirements are the most important trait which characterizes Israeli accessions. This trait of the Israeli varieties has, in fact, been used for breeding (Haugge, 2010; Hauagge and Cummins, 2000; Pommer and Barbosa, 2009; Oppenheimer and Slor, 1968; Rumayor et al., 2001; Sherman and Lyrene, 2003) and for genetic mapping (Van Dyk et al., 2010). The importance of Israeli originated cultivars is now realized and recognized internationally. Other groups also used low chill requiring varieties for mapping genes involved in low chill requirements (Celton et al., 2011; Revers et al., 2013).

Early documentation of Israeli local apple varieties is poor and only very few varieties or landraces were specified (Table 1). The most frequently mentioned variety is 'Hashabi' (sometimes mentioned as 'Khashabi') which was also commonly used as a local apple rootstock. Although various 'Hashabi' accessions have inferior fruits, which are used for cooking, the plant adapts well to growth in warm winters and high soil temperatures in summer. The earliest record of 'Hashabi' was documented by Grasowsky and Weitz (1933).

Following the literature over the years reveals that some varieties had probably been lost before this project was initiated. Such are, for example, the varieties 'Safiti' and 'Shaashayi' mentioned by Grasowsky and Weitz in 1933 and not mentioned by the same author in 1962 (Goor et al.; Goor formerly Grasowski).

Grasowsky and Weitz (1933) reviewed the

Table 1. Local apple varieties (by alphabetical order) documented before the germplasm collecting project was initiated, their passport and characteristic data and current status (Goor and Rapaport, 1949; Goor et al., 1962; Grasowsky and Weitz, 1933; Gur-Arieh, 1995).

Variety name	Etymology	Synonym	Assumed origin	Growing region	Picking period	Fruit qualities	Local usage	Current status[z]
Adasiya	Village name العدسية	None	Not available	Jordan Valley	July	Light yellow with red blush, pinkish flesh, sweet-sour, juicy	Eating	Lost
Adasiya Adom	Red from Adasiya	Hadasia Adom	Local or Damascus	Not available	June	Small-medium size, pinkish flesh, sweet	Eating	Lost
Biari	Unknown	Hilou	Local	All regions, best in the Southern Coastal Plain	June	Small-medium size, not regular, yellow with red blush, whitish fresh, wine like flavor	Eating	Lost
Hashabi	Woody	Hamod (Etym. sour), Dubi, Fathmeh	Local	All regions	July	Medium-large size, green-yellow, greenish cream flesh, low sweetness and some bitterness	Cooking, rootstock	Exist
Huzeri	Unknown	None	Not available	Jerusalem	August	Roundish, small size, red or partly red, greenish flesh, sour-sweet, not juicy	Not available	Lost
Salfiti	Unknown	None	Not available	Not available	June	Very small, light green, whitish flesh, flat taste	Not available	Lost
Shami	From Damascus	Koudsi	Damascus	Ramallah and Southern Coastal Plain	July	Elongated small size, greenish with pink or red blush, whitish flesh, sour-sweet	Eating, Cooking	Exist
Shami Kuz Saber	From Damascus	None	Damascus	Jerusalem	July	Oblong, greenish, creamy cheeks, whitish flesh, sour-sweet	Eating	Lost
Shami Sefi	From Damascus	None	Damascus	Jerusalem	July	Roundish small-medium size, yellowish green, creamy flesh, sour-sweet	Eating	Lost
Shaashayi	Unknown	None	Not available	Not available	Not available	Small, irregular, greenish yellow, white flesh, tasteless	Rootstock	Lost
Succari	Sugar	Karkeshani (Etym. crunchy)	Local	Mountains, Nazareth and Jerusalem	June	Small-medium size, green-yellow with or without red blush, creamy flesh, sour-sweet, juicy	Eating, rootstock	Exist
Zbidani	Unknown	None	Not available	Not available	Early	Yellow	Not available	Lost

[z] An accession that exists in the collection under the same local name and can be identical or a landrace or a homonym.

apple growing in mandatory Palestine and described the following varieties: 'Succari' (syn. 'Karkeshani'), 'Hashabi' (syn. 'Hamod', 'Dubi', 'Fatmeh'), 'Biari' (syn. 'Hilou'), 'Shami' ('Shami – Kuz Saber', 'Shami – Sefi'), 'Huzeri', 'Safiti' and 'Shaashayi' (Table 1). Goor and Rapaport (1949) mention the varieties (arranged by planted areas) 'Hashabi' (syn. 'Hamod'), 'Succari', 'Biari', 'Shami' and 'Huzeri' (Table 1). Goor et al. (1962) described five local varieties: 'Adasiya Adom' ('Red Adasiya'), 'Succari' (syn. 'Karkeshani'), 'Biari', 'Hashabi' and 'Adasiya' (Table 1). Among the locally bred cultivars they indicate 'Vered', which was bred by Oppenheimer. 'Vered' was selected in 1947 from the cross 'Calville Saint Sauveur' x Unnamed local seedling from Damascus made in 1939 (Goor et al., 1962; Greene, 1997; Oppenheimer and Slor, 1968).

Oppenheimer and Slor (1968) report on their breeding program that was aimed to combine low chilling requirement with the highest obtainable fruit quality. Breeding started in 1939 and a number of local varieties with low chilling requirements and very low fruit quality were used as parents together with some exported varieties. Five cultivars were released. 'Yael', 'Naomi', 'Tamar' and 'Vered' were derived from the cross 'Calville Saint Sauveur' x Unnamed local seedling (Damascus). The selection 'Rachel' was derived from the cross 'Biari' x 'White Astrachan' (Greene, 1997; Oppenheimer and Slor, 1968). Further breeding yielded three varieties selected in 1967: 'Shlomit', 'Maayan' and 'Michal', which are the descendants of the F1cross ['Calville Saint Sauveur' x Unnamed local seedling (Damascus)] x 'Delicious' (Greene, 1997, Oppenheimer and Slor, 1968). 'Vered' was the only cultivar that was commercialized, but unfortunately it was lost in Israel.

Stein's cultivars 'Anna', 'Ein Shemer', '27' and '28' are crosses made in 1954, between modern varieties as the pollen donors and local varieties. 'Anna' was derived from the cross between 'Golden Delicious' and 'Red Hadasia', and 'Ein Shemer' was derived from the cross of 'Golden Delicious' and 'Zbidani' (Greene, 1997; Gur-Arieh, 1995). In the following years Stein created

F2 crosses between modern cultivars and his F1 crosses. From this project he selected five more cultivars: 'Tomer', 'Or' ('27' x 'Red Delicious'), 'Amihai' ('28' x 'Orleans', 'Amir' (Local seedling 14 x 'Jonathan') and 'Noam' ('Anna' x 'Delicious') (Gur-Arieh, 1995). Most of these cultivars are included in the Israeli collection.

Throughout history, apples were a minor orchard tree crop in Israel. This situation was changed during the last century when new apple cultivars were introduced from abroad, and nowadays, Israeli-grown high quality apple fruits are a popular commodity in the markets. In addition to low chilling requirements, apple varieties of Israeli origin could have other important traits such as higher tolerance to local diseases and pests, better adaptability to soil and radiation, and a higher content of attractive volatiles in the fruit. In order to preserve and better characterize the genetic material of Israeli apples, local accessions were collected from all over the country and grown under identical environmental conditions and agricultural practices at Newe Ya'ar. This living local apple germplasm is grafted on a local Hashabi M.H.13-4 rootstock. The germplasm is primarily used for the preservation of various local apple accessions and for continuous monitoring of their characteristics.

Material and Methods

Plant material

Exploring and collecting local apple accessions, among other deciduous fruit trees, began in 1987 and continues today (Holland et al., 2006). The definition of *local* in this context refers to apples that were known or in use by local farmers during the British Mandate period or before. Local apple varieties are still grown in Israel in small plots or backyards, but these trees are becoming scarcer due to rapid urban and agricultural development. Thus, some documented varieties were not located and have probably been lost. Systematic surveys and explorations that followed the foretold information were conducted during the project period. Newly discovered accessions are collected by their original name and tagged by a special code number. Each newly found accession is individually evaluated and compared to other accessions. Once tagged as a unique accession, it is reproduced vegetatively. Budwood from the originally discovered tree is taken and grafted on the local rootstock Hashabi M.H.13-4. At least two replicates for each accession are planted in the apple orchard. This is an ongoing project and the trees are not at the same age at any point in time. Once in about ten years the orchard is renewed by grafting and planting new trees to ensure the viability of the collection. The trees are trained in a vase shape and treated according to customary apple agrotechniques. 'Golden Delicious', mentioned in this article as a reference accession, is planted with 55 introduced varieties in the same plot. The location of the preservation site is at Newe Ya'ar Research Center in the western Yizre'el Valley, lat. 32°42'N, long. 35°11'E. The orchard is planted on clay grumusol (vertisol) soil at an elevation of about 100 m above sea level. Yizre'el Valley is characterized by a Mediterranean subtropical climate, with an average annual rainfall of about 580 mm concentrated from November through March. The mean diurnal minimum temperature in January is 6°C (43°F), and the mean diurnal maximum temperature in July is 33°C (91°F).

Documentation

The list of accessions present in the collection and their identity cards are documented in the Israel Plant Gene Bank (IGB) at The Volcani Center of the Agricultural Research Organization (http://igb.agri.gov.il/main/index.pl?page=22).

Local accessions were included in the general list of the Israel apple germplasm collection updated to 1985 (curator: Dr. Raphael Assaf), which was published in the European Apple Inventory of the IBPGR/EUCARPIA project (Watkins, 1985).

A report on the status of the collection was presented at the European Cooperative Programme for Plant Genetic Resources (ECPGR) Working Group on *Malus/Pyrus* Fourth Meeting held on 7-9 March 2012 in Weggis, Switzerland (Lateur et al., 2013).

Characterization

All accessions, identified by their code number, are characterized in the orchard.

Flowering. Flowering phenology was recorded in the orchard during the years 1997 to 2013. For each accession, the dates of the first flower, 10% flowering, 80% flowering and end of flowering were documented at least over five years. The dates presented are an average of the recorded data. Flower color description and general estimation of blooming intensity were also documented.

Fruit characteristics. Fruits were characterized for at least four years. Given that the accessions were not collected at the same time, the recording time spanned over different periods that do not necessarily coincide. Fruits were picked when they reached their best eating quality, which was before getting their maximum color and flesh decay that usually comes when the fruit is overripe. When an accession tended to drop its fruit before ripening, the fruits were collected for assessment immediately after dropping started. Ten to twenty fruits from both trees, collected from different positions throughout the tree, were taken for phenotyping. The data recorded included: picking date, fruit size, fruit shape, fruit attractiveness, peel texture, description of peel ground and cover colors, flesh texture and color description, taste description, total soluble solids (% TSS) concentration, aroma and odor assessment, seed color, stalk (pedicel) and calyx description, and noted deficiencies (russet, scratches, bitter pit, flesh browning etc.). Not all of these data are presented in this paper. For the presented data: fruit size, expressed as fruit diameter at the widest circumference, was measured using a manual fruit sorting apparatus; TSS was measured by a hand refractometer (ATC-1, Atago, Tokyo, Japan); fruit shape was determined according to IBPGR apple descriptor (Watkins and Smith, 1982); peel and flesh colors, and taste were described literally; aroma was assessed according to a scale ascending from "none" to "much"; and eating quality was scaled from "very poor" to "good".

Pictures of the fruits were taken during the years 2012-2013 according to the instructions of the ECPGR Working Group on *Malus/Pyrus* Fourth Meeting.

Plant characteristics. Some tree traits were recorded, including tree shape (upright or spreading), a description of tree height, width and vigor, growth intensity, trunk growth, productivity, and leaf morphology. Pictures of leaves were taken during 2014. Chilling requirement assessment was done by integrating vegetative and reproductive bud break and leaf cover observations with some data obtained from molecular work.

Trunk circumference. This growth indicator was measured once a year, every year, during autumn. The trunks were measured with a measuring tape circling them about 10 cm above the graft union, below the branching point. Since the accessions were not all planted at the same time, the comparison was of the same point in the accession's lifetime, i.e., five years from planting.

Based on the documented data and the data collected at Newe Ya'ar, identification and classification of the accessions in the collection were carried out, i.e. homonyms, landraces, new phenotypes.

Statistical analyses.

The results presented are a multiannual average. Since only two replicates for each accession are planted, the planting year is different and annual changes in weather and other environmental conditions can affect phenotyping of the accessions, a standard error was calculated among annual results. This way the year effect was taken into account.

Results and Discussion

The apple accessions planted in the Israeli living germplasm collection and their passport data are shown in Table 2 and the geographical regions from which the apple germplasm was collected are indicated on Fig. 1. More than 50% of the land in Israel is arid. Apples are grown today and were grown in the past only in the non-desert parts of the country. Cultivars with medium and high chilling requirements are grown in the mountainous parts, while apple cultivars with low chilling requirements are grown along the Coastal Plain and in low altitude valleys.

Fig. 2 shows the dates and durations of flowering of local apple accessions compared to the reference cultivar 'Golden Delicious' at Newe Ya'ar. It can be clearly seen that local apple accessions are prominently early flowering and precede the flowering of 'Golden Delicious', which does not have sufficient chilling at this location. Furthermore, the blooming of local apple accessions is much more abundant than that of 'Golden Delicious', which bears only a handful of flowers after hot winters (less than 100 hours below 7ºC). 'Golden Delicious' is considered by the IGPGR apple descriptor to be an intermediate-late flowering cultivar.

Some fruit characteristics are described in Table 3 and fruit photos are shown in Fig. 3. Fruit color and to some extent fruit shape are influenced by environmental conditions. The data presented are recorded over several years, whereas the pictures were taken in 2013, after a warm winter. This can explain the slight discrepancies found amongst the presented data and also the differences between Fig. 3 and photos from the literature that were taken in regions with sufficient chilling (Gur-Arieh, 1995). The data reveal phenotypic diversity among the accessions, especially in fruit size, peel color and eating quality.

Plant characteristics are detailed in Table 4 and photographs of leaves from the accessions are shown in Fig. 4. It is important to note that the displayed traits were described for apples grown under the Newe Ya'ar's Mediterranean climate, in heavy and not well drained soil, which is not optimal for apples. The data reveal variability among the accessions. Prominent variability can be seen clearly in leaf size and shape and in tree vigor.

The names of the Israeli local accessions are mostly popular names in the Arabic language and are associative, reflecting their place of origin, color, taste or other fruit or

Fig. 1: Geographic regions corresponding to sites where apple germplasm was collected. Only the names of the regions where apples were collected are indicated on the map. The black point shows the location of the Newe Ya'ar Research Center, grey points show the location of the main cities (north to south): Haifa, Tel-Aviv-Jaffa, Jerusalem and Beer-Sheba.

Table 2. List of accessions in the Israeli apple germplasm living collection, their parentage and corresponding place and time of collection. Based on the list that was deposited in IGB (http://igb.agri.gov.il/main/index.pl?page=22).

Accession name	Parentage	Accession code	Collecting site	Collecting year
Baladi	Unknown	Ma. 500-1	Ein El-Assad, Upper Galilee	1990
Soukraji	Unknown	Ma. 502-3	Ein Sartaba, Bet Jann, Upper Galilee	1990
Succari	Unknown	Ma. 503-4	Ein Sartaba, Bet Jann, Upper Galilee	1990
Shami	Unknown	Ma. 533-34	Nd[z]	nd
Lahwani	Unknown	Ma. 596-97	Beit Lahia, Southern Coastal Plain	nd
Karkashani	Unknown	Ma. 624-125	Sheikh Dannon, Akko Plain	1989
Fassuta Hashabi	Unknown	Ma. 634-135	Fassuta, Upper Galilee	1990
Anonymous	Unknown	Ma. 682-183	Meron Mountain, Upper Galilee	1991
Anonymous 1	Unknown	Ma. 684-185	Meron Mountain, Upper Galilee	1991
Gush Halav Succari	Unknown	Ma. 753-254	Gush Halav, Upper Galilee	1993
Ein ElAssad Karkashani	Unknown	Ma. 773-274	Ein El-Assad, Upper Galilee	2004
Smia	Unknown	Ma. 795-296	Kfar Smia, Upper Galilee	2005
Noam, 3/11	Anna x Delicuous	Ma. 823-324	Ein Shemer, Menashe Hills	1982
Amihai, 52-A	28 x Orleans	Ma. 824-325	Ein Shemer, Menashe Hills	1982
Amir, 60-A	14 x Jonathan	Ma. 825-326	Ein Shemer, Menashe Hills	1985
7/11	Unknown	Ma. 826-327	Ein Shemer, Menashe Hills	1987
Anna	Golden Delicious x Red Hadasia	Ma. 827-328	Ein Shemer, Menashe Hills	nd
Or, 10/12-B	27 x Red Delicious	Ma. 828-329	Ein Shemer, Menashe Hills	1985
Tomer, 5/I	Unknown	Ma. 829-330	Ein Shemer, Menashe Hills	1982
Ein Shemer	Golden Delicious x Zbidani	Ma.870-371	Giv'at Ada, Samaria Mountains	2013
Hashabi 10-1	Unknown	M.H. 10-1	Ayyelet HaShahar, Hula Valley	1968
Hashabi 11-2	Unknown	M.H. 11-2	Shamir, Hula Valley	1968
Hashabi 12-3	Unknown	M.H. 12-3	Amir, Hula Valley	1968
Hashabi 13-4	Unknown	M.H. 13-4	near Jenin, Samaria Mountain	1968
Hashabi 14-5	Unknown	M.H. 14-5	Samaria, Samaria Mountains	1968
Hashabi 15-6	Unknown	M.H. 15-6	nd	1968
Hashabi 16-7	Unknown	M.H. 16-7	Hula Research Station, Hula Valley	1968
Hashabi 17-8	Unknown	M.H. 17-8	Sede Nehemia, Hula Valley	1968
Hashabi 18-9	Unknown	M.H. 18-9	nd	1968
Doucin 30-1	Unknown	M.I. 30-1	Amir, Hula Valley	1968
Doucin 31-2	Unknown	M.I. 31-2	Sede Nehemia, Hula Valley	1968
Doucin 32-3	Unknown	M.I. 32-3	Farod, Upper Galilee	1968
Doucin 33-4	Unknown	M.I. 33-4	nd	1968
Zova	unknown	M.TI. 10	Zova, Judean Mountains	1968

[z] nd – not definite.

tree characters, as was pointed out at the site of collection. Therefore, synonyms, homonyms and different Hebrew or English spellings for the same variety are known. In this paper one chosen spelling is followed systematically (e.g. 'Succari', not 'Sukkari'). In the past propagation was carried out either by grafting or by seeds. The latter explains the differences in phenotypic descriptions available for the same name (in addition to homonyms) and the appearance of landraces.

Following the characterization of the accessions in this collection, some understanding can be gained as to the nature of the material in this collection:

'Baladi' (Ma.500-1) and 'Soukraji' (Ma.502-3). 'Baladi' (Ma.500-1) and 'Soukraji' (Ma.502-3) are probably synonyms and landraces of the same local variety. Both originated from relatively close sites and show similar phenotypes. They bear small fruits (51.0 mm and 52.6 mm, respectively, as compared to 62.7 mm for 'Golden Delicious'), have red stripes on light green to yellow ground color, are slightly sour to sweet in taste and have a fair eating quality (Table 3). Their tree is upright, vigorous, intensely growing, the white petals are colored

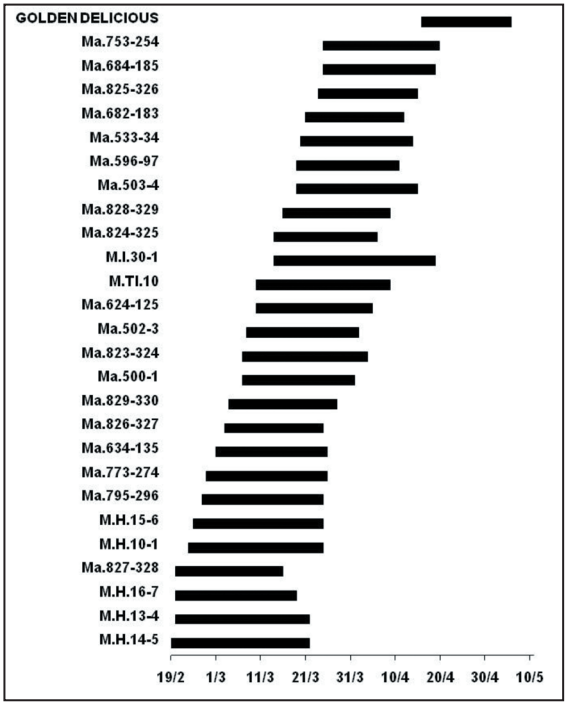

Fig. 2: Flowering period of the accessions in the Israeli apple germplasm living collection at Newe Ya'ar. 'Golden Delicious' grown in the same orchard serves as a reference cultivar. Diagram is sorted by first date. The dates are an average of first flower and end of bloom dates of the data recorded.

with a little pink and both have low chilling requirements (Table 4). They do not show resemblance to any of the past documented varieties.

'Succari' (Ma.503-4). 'Succari' (Ma.503-4) is probably a landrace of the same variety that was reported in the literature. It has small fruits (43.8 mm), which are light green to yellow with little or no red blush and which have a sour-sweet taste (Table 3), while the reported variety is described as being small-medium size, green-yellow with or without red blush, creamy flesh, and sour-sweet (Table 3). The accession in the collection seems to have inferior eating quality compared with the reported variety.

'Karkeshani' (Ma.624-125) and 'Ein El-Assad Karkeshani' (Ma.773-274). 'Karkeshani' (Ma.624-125) and 'Ein ElAssad Karkeshani' (Ma.773-274) are homonyms (*Ein ElAssad* was added to the original name for distinction) and are different from 'Succari', although these names were known to be synonyms in the past. The three accessions (Ma.503-4, Ma.624-125, and Ma.773-274) have different phenotypes (Tables 3 and 4). Moreover, 'Succari' has medium-high chilling requirements, while both 'Karkeshani' accessions have low chilling requirements (Table 4). The two 'Karkeshani' accessions differ from each other in their fruit shape and colors (flat-globuse, red blush and white flesh versus oblong-conical, red stripes and greenish yellowish blush, respectively, Table 3). The tree vigor, growth intensity and petal color are different as well (Table 4). 'Ein El-Assad Karkeshani' (Ma.773-274) has small fruits (49.7 mm) but it is attractive and tasty.

'Gush Halav Succari' (Ma.753-254). 'Gush Halav Succari' (Ma.753-254) (*Gush*

Table 3: Fruit characteristics of the accessions in the Israeli apple germplasm living collection.

Accession code	Ripening date	Fruit diameter (mm)	TSS (%)	Aroma	Fruit shape	Peel ground color	Red blush cover	Flesh color	Taste	Eating quality
Ma.500-1	24/6	51.0±4.1	12.7±0.7	medium	flat-globose	light green to yellow	stripes up to 60%	white	slightly sour to sweet	fairly good
Ma.502-3	24/6	52.6±1.0	11.9±0.0	slight	flat	light green to yellow	stripes up to 30%	white	slightly sour to sweet	fairly good
Ma.503-4	23/7	43.8±3.9	13.1±0.6	medium	oblong	light green to yellow	little or none	white	sour sweet	poor
Ma.533-34	22/8	55.6±4.3	14.3±0.9	medium	flat-globose	light green to green	very little or none	greenish	sweetish	medium
Ma.596-97	26/8	55.1±1.4	15.4±1.5	none	globose-conical	light green	none	greenish	sweet	medium
Ma.624-125	1/7	48.1±2.9	12.8±1.0	medium	flat-globose	light green to yellow	scattered up to 60%	white	slightly sour to sweet	fairly good
Ma.634-135	28/6	55.0±0.3	12.1±0.4	none	globose	light green to yellow	very little or none	white	sour astringent	very poor
Ma.682-183	25/8	65.3±4.2	13.5±0.6	slight	flat	light green	light stripes up to 50%	greenish	some sweetness	medium
Ma.684-185	27/8	59.9±2.2	14.3±0.5	slight	globose	light green	none	white greenish	little tasteless	medium
Ma.753-254	2/8	60.1±3.0	13.6±0.6	medium	globose	light green	none	white	sour sweet	medium
Ma.773-274	3/6	49.7±2.1	11.5±0.6	little	oblong-conical	light green to yellow	stripes 50-100%	greenish yellowish	slightly sour	good
Ma.795-296	2/7	53.0±2.5	12.7±0.9	none	flat	light green to yellow	none	white greenish	little tasteless and astringent	very poor
MTI 10	14/7	58.0±1.2	13.2±0.5	none	globose	light green	usually none	white	astringent	very poor
MI.32-3	2/8	47.3±4.8	13.3±0.3	slight	globose	light green	usually none	white	slightly sour	poor
M.H.10-1	7/6	49.5±10.7	12.3±0.8	none	globose	light green to yellow	usually none	greenish	sour astringent	very poor
M.H.13-4	5/6	50.9±1.4	11.7±0.5	none	globose	light green to yellow	usually none	white greenish	sour astringent	very poor
M.H.14-5	6/6	51.0±3.5	11.3±0.5	none	globose	light green to yellow	usually none	greenish yellowish	sour astringent	very poor
M.H.15-6	9/6	52.2±2.3	11.5±0.4	negligibl	globose	light green to yellow	none	white greenish	sour astringent	very poor
M.H.16-7	12/6	51.0±1.9	11.8±0.2	negligibl	globose	light green to yellow	usually none	greenish yellowish	sour astringent	very poor
Noam	6/7	71.9±6.0	12.2±0.6	medium	flat-globose	light green	stripes up to 50%	white yellowish	little tasteless	medium
Amihai	25/7	69.9±2.2	12.2±0.5	much	flat-globose	light green	stripes 30-100%	white yellowish	sweet	medium
Amir	16/7	66.2±1.7	12.0±0.3	medium	flat-globose	light green	stripes up to 50%	white yellowish	unpleasant	poor
7/11	10/7	71.2±1.7	11.7±0.4	much	oblong-conical	light green	stripes up to 70%	white yellowish	little tasteless to sweet	fairly good
Anna	9/7	62.6±1.8	12.3±0.7	much	oblong-conical	light green to yellow	stripes up to 50%	white yellowish	sweet	good
Or	12/8	74.8±1.2	12.1±0.1	much	oblong-conical	light green	stripes up to 50%	white yellowish	slightly sour	good
Tomer	23/7	65.4±1.1	13.2±1.1	much	oblong-conical	light green	stripes up to 30%	white yelowish	sweet	good
Golden Delicious	3/9	62.7±2.6	12.4±0.4	medium	globose-conical	yelllow	none	White yelowish	sweet	good

Halav was added to the original name for distinction) is different from 'Succari' (Ma.503-4) and is most likely a homonym, as it is also different from the variety mentioned in the literature. 'Gush Halav Succari' (Ma.753-254) has a totally different tree in comparison to 'Succari' (Ma.503-4) (Table 4). Ma.753-254 fruit is larger (60.1 mm and 43.8 mm, respectively), different in shape (globose and not oblong) and its eating quality is better (Table 3).

'Shami' (Ma.533-34). 'Shami' (Ma.533-

34) implies that the origin is Syria and more specifically Damascus (in Arabic "al Sham"). Since Syria has favorable conditions for growing apples, good varieties were transferred to Israel through history as mentioned in old written sources. This accession may be

Table 4: Plant characteristics and chilling requirement assessment of the accessions in the Israeli apple germplasm living collection.

Accession code	Tree shape	Tree height	Tree width	Trunk circumference 5th leaf (cm)	Tree vigor	Growth intensity	Petal abaxial surface color	Productivity	Chilling requirement
Ma.500-1	upright	high	medium	23.3	vigorous	intense	a little pink on white	high	low
Ma.502-3	upright	high	medium	24.0	vigorous	intense	a little pink on white	medium	low
Ma.503-4	upright	medium	narrow	16.5	intermediate	weak	white	low	medium-high
Ma.533-34	upright	medium	narrow	16.5	quite vigorous	intermediate	white	low	medium-high
Ma.596-97	upright	high	narrow	19.3	quite vigorous	intermediate	pinkish white	medium	medium-high
Ma.624-125	spreading	high	wide	25.6	vigorous	intense	pinkish white	high	low
Ma.634-135	spreading	high	wide	25.8	vigorous	quite intense	pinkish white	medium	low
Ma.682-183	upright	high	medium	18.9	quite vigorous	quite intense	pinkish white	medium	medium-high
Ma.684-185	upright	high	narrow	21.5	quite vigorous	intense	pinkish white	medium	medium-high
Ma.753-254	spreading	medium	medium	27.6	quite vigorous	intermediate	pinkish	medium	low
Ma.773-274	spreading	medium	wide	-	quite vigorous	quite intense	a little pink on white	high	low
Ma.795-296	spreading	dwarf	wide	-	intermediate	very weak	pinkish white	very low	high
MTI 10	upright	high	narrow	27.1	vigorous	intense	pinkish white	high	medium-high
MI.32-3	upright	medium	wide	21.5	weak	weak	white	medium	medium-high
M.H.10-1	spreading	high	wide	-	quite vigorous	intense	pinkish white	high	low
M.H.13-4	spreading	high	wide	-	vigorous	quite intense	pinkish white	high	low
M.H.14-5	spreading	high	wide	-	vigorous	quite intense	pinkish white	high	low
M.H.15-6	spreading	high	wide	-	quite vigorous	quite intense	pinkish white	high	low
M.H.16-7	spreading	high	wide	-	quite vigorous	quite intense	pinkish white	high	low
Noam	spreading	medium	wide	35.0	intermediate	weak	a little pink on white	high	low
Amihai	spreading	medium	wide	38.7	vigorous	intermediate	pinkish white	high	low
Amir	spreading	medium	wide	42.5	quite vigorous	weak	pinkish white	high	low
7/11	spreading	medium	wide	37.0	quite vigorous	weak	pinkish white	high	low
Anna	upright	medium	medium	38.5	quite vigorous	intense	pinkish white	high	low
Or	spreading	medium	wide	47.7	vigorous	weak	a little pink on white	high	low
Tomer	spreading	medium	wide	42.1	vigorous	intermediate	a little pink on white	high	low
Golden Delicious	upright	high	wide	31.7	vigorous	intermediate	-	medium	medium-high

Fig. 3: Fruits of the various accessions in the living apple germplasm. The picture of each accession was taken at ripening time at Newe Ya'ar (beginning of June to end of August). The fruits are placed on a 1x1 cm grid and displayed according to the guidelines determined by the ECPGR. Browning color of the fruit flesh shown for some of the accessions is due to very rapid oxidation of phenols.

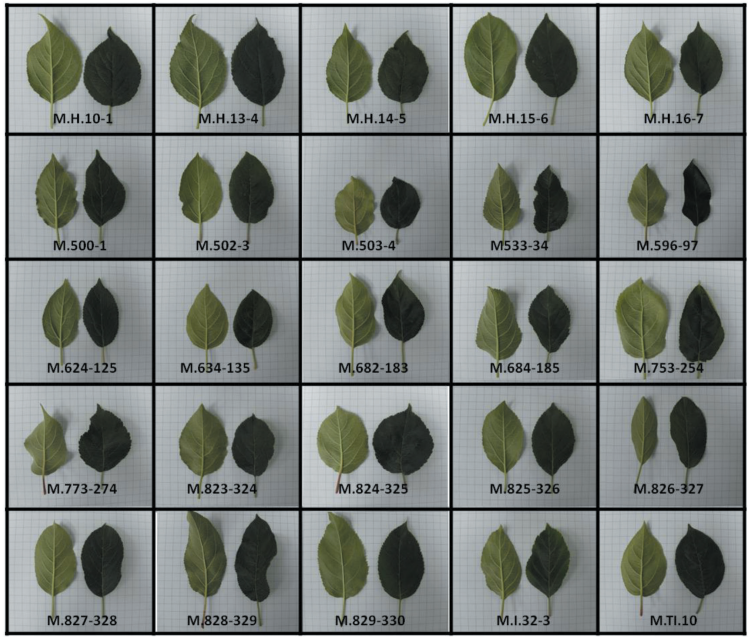

Fig. 4: Leaves of the apple germplasm accessions. Abaxial (left) and adaxial (right) surfaces of fully developed leaves from current year's growth. The leaves are placed on a 1x1 cm grid.

one of them. Indeed, this accession that has medium-high chilling requirements has fair fruit quality, although it can't compete with cultivars like 'Golden Delicious'. Grasowsky and Weitz (1933) wrote that 'Shami' is not a definite type and includes a number of varieties. 'Shami' types which are documented in the old literature seem to differ from this variety (Table 2).

'Lahwani' (Ma.596-97). 'Lahwani' (Ma.596-97), which was collected from Beit Lahia in the southern Coastal Plain is expected to grow well in a warm climate environment. At the beginning of the 20th century the Beit Lahia district was an apple growing region. 'Lahwani' is not mentioned in the literature and its phenotype does not resemble any of the old varieties. The original tree at the collecting site was quite poor, its chilling requirements are assessed as medium-high and its fruit look like poor 'Golden Delicious' fruit. Therefore, it is not considered as valuable as expected for an apple from this region.

'Hashabi'. 'Hashabi' is a local landrace with a long history of usage as an apple rootstock. It was in use all over the country, from Beit Lahia in the Southern Coastal Plain, through Nablus and Hebron in the Judean Mountains, to Adasiya in the Jordan Valley, and up to the Upper Galilee. It showed a wide range of tree behaviors (Ben-Dor, 1939; Barak, 1969, 1970). Selection among 'Hashabi' landraces for clonal apple rootstocks resulted in the development of the M.H. series of 'Hashabi' apple rootstocks (Assaf, 1995a, b; Barak, 1969, 1970; Holland et al., 2006). Data on five of them are presented (Tables 3 and 4). These rootstocks are hardy, highly tolerant to high soil temperatures, and display variable degrees of grafted tree vigor (e.g. a small tree on M.H.10-1 and a vigorous tree on M.H.17-8). It has low chilling requirements. Some selections comprise the main apple rootstocks used in modern Israeli apple orchards. Moreover, the M.H. selections are used currently in Newe Ya'ar as parents for breeding rootstocks specially adapted to hot soil temperatures, low chill and tolerance to woolly aphids.

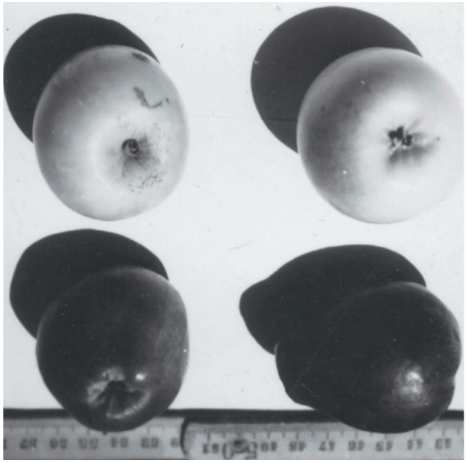

Fig. 5: 'Zbidani' (top) and 'Red Adasiya' (lower) from Mishmar Haemek, Israel. The picture was taken by the late Mr. Dov Barak in 1955 and was donated to the Unit of Deciduous Fruit Tree Sciences at Newe Ya'ar Research Center (originally not colored).

'Fassuta Hashabi' (Ma.634-135). 'Fassuta Hashabi' (Ma.634-135) seems to be another landrace of this variety. The use of this rootstock in Israel is continuous and therefore we are certain of its identification. Although 'Hashabi' is considered a landrace, it is oddly earlier ripening at Newe Ya'ar (June, Table 3) than the 'Hashabi' mentioned in the old literature (July, Table 1).

Scions of the unnamed accessions Ma.682-183 and Ma.684-185 were taken from deserted tree gardens. They are not identified as one of the known old varieties and are regarded as unknown varieties with the possibility of being seedlings of some old introduced variety.

'Zova' (MTI.10). 'Zova' (MTI.10) is a local seedling selected for rootstock usage but is not in any use today. It has medium-high chilling requirements and very poor fruit quality (Tables 3 and 4).

'Doucin' selections. 'Doucin 30-1', 'Doucin 31-2', 'Doucin 32-3' and 'Doucin 33-4' are all selections of an old rootstock that was locally named 'Italian Doucin'. It was

brought to Israel from Italy as 'French Doucin' about 70 years ago and found to be different from the declared rootstock (Bark, 1969, 1970). The rootstock was propagated by both seeds and budwood, and selections were made to find the best clone for growing apples in Israel. Today it is not normally used because it produces a very strong undesired tree.

'Smia' (Ma.795-296). 'Smia' (Ma.795-296), which was collected in a mountainous region, has a very small tree (dwarfed) and unfortunately it did not develop well at Newe Ya'ar. No reference was mentioned in the literature to a dwarf apple in Israel. The owner of the source tree did not know its name and reported that its origin was in Lebanon. 'Smia' seems to have high chilling requirements and is not necessarily local. We still cannot reach conclusions as to its nature.

Although some of the trees in the Israeli collection might have originated from countries surrounding Israel, particularly from Lebanon, Syria and Jordan, we found no accessible literature concerning this issue except for a report on genotyping Syrian local apples using genetic analyses (Muzher et al., 2007).

The current apple germplasm collection and preservation project started only in 1987. At that time some of the few local varieties described in the literature were already lost and unfortunately they are missing from the current living collection. Such varieties include, for example, the 'Red Hadasia' (or 'Red Adasiya' in other references) and 'Zbidani' used by Stein for his breeding program (Gur-Arieh, 1995; Fig. 5, Table 2). For this reason we decided to include in the collection some of the locally bred cultivars (e.g. Ma.823-324, Ma.824-325, Ma.825-326, Ma.826-327, Ma.827-328, Ma.828-329, and Ma.829-330) which are the descendants of old local varieties. The characteristics of these cultivars compared to 'Golden Delicious' are shown in Tables 3 and 4. All of them have low chilling requirements, ripen early (July 6 to August 12), are characterized by red stripes and have high productivity.

Although some local accessions are successfully used as rootstocks, none of them, except for the Stein bred cultivars, can be used as commercial cultivars. The low chilling accessions can be integrated into breeding programs aimed at achieving high quality low chilling new cultivars. No other important characters for breeding utilization are known today.

In conclusion, the Israeli apple collection is unique and most important especially for preserving low chilling requirement accessions. These are intended for breeding towards superior new cultivars and rootstocks adapted to hot climate conditions. Apples are among the most consumed fresh fruits and, in view of global warming and adaptation to climate change, these accessions are of high importance. 'Anna' is an outstanding success of the usage of a local variety, as this cultivar is commercially grown in many warm apple growing regions in the world. More effort should be concentrated on locating unfamiliar or lost types that are not present in the germplasm collection, before they are permanently lost.

Acknowledgments

We thank the Israel Gene Bank for Agricultural Crops at the Agricultural Research Organization in Bet Dagan and the Chief Scientist of the Israeli Ministry of Agriculture and Rural Development for the financial support. We also thank the National Council for Research and Development of the Israel Ministry of Science and Development for financial support in the establishment of the genetic collection.

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