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Pistachio production and industry in Turkey: current status and future perspective

B.E. Ak^{1,*}, S. Karadag² and E. Sakar¹

¹University of Harran, Faculty of Agriculture, Department of Horticulture, Sanliurfa (Turkey)

²Pistachio Research Station, Gaziantep (Turkey)

*e-mail: beak@harran.edu.tr

Abstract. The pistachio nut belongs to the genus *Pistacia* of the family Anacardiaceae. *Pistacia* genus have 11 species. Some of the species play an important role in vegetation at the Mediterranean and Asian regions and most of them have proved successful as rootstocks for top working the cultivated pistachio nut. Except *Pistacia vera* the other species have no economical significance. They are called wild pistachios. In Afganistan, Iran, Pakistan, Turkey and all the Mediterranean countries there are millions of wild pistachio trees or bushes which belong to different *Pistacia* species. *Pistacia* species are grown in 30°-40° latitude and are suited for different climate areas in the world. In Turkey, during last decades new plantations are being established and pistachio farmers conscious of the importance of male tree and irrigation. Nowadays due to governmental support the farmers are applying good agricultural practices rules for their orchards

Keywords. Pistachio – Rootstock – Cultivar – Irrigation – Fertilization.

Production et industrie des pistaches en Turquie : situation actuelle et perspectives futures

Résumé. Les pistaches appartiennent au genre *Pistacia* de la famille Anacardiaceae. Le genre *Pistacia* possède 11 espèces. Certaines espèces jouent un rôle important pour la végétation dans les régions méditerranéenne et asiatique et la plupart se sont avérées performantes comme porte-greffes pour les pistaches cultivées. Excepté *Pistacia vera*, les autres espèces sont économiquement insignifiantes. Elles sont dénommées pistachiers sauvages. En Afghanistan, Iran, Pakistan, Turquie et dans tous les pays méditerranéens, il y a des millions de pistachiers sauvages, arbres ou buissons, qui appartiennent aux différentes espèces de *Pistacia*. Les espèces de *Pistacia* grandissent à une latitude de 30°-40° et sont adaptées aux différentes zones climatiques du monde. En Turquie, durant les dernières décennies, de nouvelles plantations sont mises en place et les cultivateurs de pistaches sont conscients de l'importance de l'arbre mâle et de l'irrigation. De nos jours, en raison de l'appui du gouvernement, les producteurs appliquent les principes des bonnes pratiques agricoles dans leurs vergers.

Mots-clés. Pistachier – Porte-greffe – Cultivar – Irrigation – Fertilisation.

I – Introduction

The pistachio nut belongs to the genus *Pistacia* of the family Anacardiaceae. The *Pistacia* genus has 11 species. The edible pistachio for commerce is the species *Pistacia vera* L. In addition to many named cultivars, significant populations of wild germplasm exist, primarily in central Asia, from Turkey to Afghanistan.

Pistacia vera is grown at 30°-40° latitude and suited for different climate areas in the world. The area of pistachio plantation in the last 11 years has increased from 407,900 ha in 1994, to 526,600 ha in 2004. The pistachio plantation area of the main producing country, Iran, has increased (53%) to 280,000 ha in 2004 (Razavi, 2006). Turkey has a big plantation area but its yield is very low when compared to the production area (Arapci *et al.*, 2005).

Pistachio is grown most intensively in Iran, Syria, Turkey and USA. The other pistachio-producing countries are in the Near East, North Africa and Southern Europe. Based on nut production data for 2009-2012, Iran is responsible for over 459,000 tons, about half (53.2%) of world production. The second highest-yielding country, USA, produces 207,000 tons, about 22.3% of world production, while Turkey is third with a yield of 117,000 tons and 12.7 % of total world production. The most important exporters in the world are Iran, USA, Greece, Italy, Syria and Turkey. Iran is considered as one of the greatest exporters, with a share of about 62.7% in the world (Razavi, 2006).

Pistachio trees are frost hardy and can normally withstand temperatures as low as -14 to . In Iran, pistachios can tolerate temperatures down to -20°C, and in Turkey pistachios can withstand winter temperatures of down to -30°C without any injury.

P. vera usually blooms during the first week of April which prevents the flowers from being damaged by late spring frost. However, plantations established in frost pockets may be at risk. Flowers may also be damaged by burn caused by dry and hot winds during the spring. Like other fruit trees pistachio requires chilling during the winter period. Under mild climatic conditions, inadequate chilling causes problems such as very low yield, unsuitable timing and low percentage of budbreak, late flowering, death of stigma, very late vegetative and generative development, late ripening, less leaf and pollen production and irregular sprouting of the buds (Kuden *et al.*, 1995). Studies have shown that the cultivar 'Kerman' needs about 1000 hours chilling (Crane and Takeda, 1979) whereas the cultivar 'Uzun' needs 600 hours and 'Ohadi' needs more than 1000 hours (Kuden *et al.*, 1995). Kuden *et al.* (1995) also reported that male trees require less chilling than females.

Summer temperatures are another very important climatic factor influencing pistachios. If the summer temperatures are insufficient then the kernel does not develop properly which prevents splitting and dehulling.

II – Pollination of pistachio

Pistachio trees are dioecious and it has been recognized since 1697 (Whitehouse and Stone, 1941) that pollination and fertilization are necessary to obtain seeded fruits. Trees are wind pollinated as pistachio flowers have no petals with which to attract insects. Therefore pistachio orchards must contain both male and female trees at suggested ratios from 1:8 to 1:11 (male to female) (Kaska, 1990; Ak, 1992). It is necessary to have enough male trees to ensure adequate pollination as insufficient pollen is a primary cause of crop yield failure. Alternatively, pollen from wild pistachios can be used to artificially pollinate *P. vera*. Protandry is common in pistachios.

Male tree should have the following traits: strong and upright growth; flowering period must be synchronized with that of female trees; flower clusters must be large and numerous; the amount of pollen produced in each cluster must be high; yield potential must be high; germination rate of pollen must be high; pollen viability *in vivo* must be long, and trees must not show alternate bearing (Ak *et al.*, 1998; Ak, 2001). Last decades farmers are realized the importance of male trees. Nowadays the new orchards are established using suitable males for female cultivars in enough number for the orchards.

III – Rootstocks

Anatolia is a major centre of diversity for the genus *Pistacia*; species are naturally distributed throughout the region, with the exception of very cold and humid areas. Pistachios are present in the form of bushes or trees of different sizes dependent upon genetic factors and soil types and climatic conditions that characterize the region. In the Mediterranean and Aegean region, *P. atlantica* trees reach gigantic dimensions. In the transitional zone between the Mediterranean and central Anatolia where the rainfall is lower, a gradual reduction in height of these trees is observed. Smaller

specimens of *P. terebinthus* are found in southeast Anatolia compared to the relatively big bushes found in the Mediterranean. Due to its wide adaptability to a variety of soils and climate, *P. terebinthus* thrives well from the coastal zone at sea level to up to in Turkey, where it is the most wide-spread of all *Pistacia* species (Kaska and Bilgen, 1998).

Mainly *P. vera*, *P. terebinthus*, *P. atlantica*, *P. khinjuk*, *P. palaestine*, *P. mutica* are distributed in Turkey. Except *P. mutica* the others are using as rootstock for *Pistacia vera* cultivars. The best rootstocks seem to be *P. khinjuk* for the all types or cultivars of pistachio nut. The weak or dwarf rootstock is *Pistacia terebinthus* for pistachio cultivars when it is budded on it. There are some research results on pistachios budded or used as rootstock some *Pistacia* spp. The incompatibility problem can occur between *Pistacia vera* seedlings and cultivars. This problem is solving using *Pistacia khinjuk* as interstocks. . Pistachio nuts are affected by rootstocks on different traits of nut quality (; Turker and Ak, 2010; Atli *et al.*, 2011).

IV – Cultivars

The most important characteristics of the pistachio nuts desired by the markets are the following: large size, high percentage of shell splitting, low percentage of blank nuts, high oil and protein content, regular bearing and high percentage of green kernels. Pistachio green kernel is one of the most desired characteristics, green kernel nuts are always at a premium. Though the green kernel is a varietal characteristic it is also related to altitude and harvest time. Generally the nuts of early harvested trees and plants grown on high plateaus produce greener kernels than those of late harvested and low land grown plants. On the other hand greenish is affected by pollen source. According to observations *Pistacia terebinthus* pollens causes metaxenia and xenia (Ak, 1992). In Turkey, 'Kirmizi', 'Uzun', 'Halebi' and 'Siirt' are the major pistachio cultivars.

Alternate bearing is one of the important features of pistachio. Alternate bearer cultivars produce heavy crops in "on" years and little or no crop in the "off" years. In contrast to other fruit species such as olive, apple etc (Ak and kaska 1992). This situation can be changed from one cultivar to another one; for example 'Siirt' variety is less alternating (Ak, 1998). Alternate bearing can be decreased by irrigation and fertilization. The farmers are aware of the importance of production of pistachio because of the high profits.

In Turkey, two female ('Barak Yildizi' and 'Tekin') and four male ('Kaska', 'Ozturk', 'Uygur' and 'Atli') were registered as cultivars. These cultivars were released by Gaziantep Pistachio Research Institute-Turkey. 'Barak Yildizi' is in need of less total heat accumulation. So it can be recommended for inland and transitional areas. This cultivar matures earlier (25-30 days before) than other standard Turkish cultivars. Chilling requirement is also low. It is suitable to consume fresh because of its earliness. 'Tekin' is suitable for the international market because of its good traits. It is high yielding, has a high splitting rate and has large fruit in size. The endocarp color is light and it bears every year regularly. That means no alternate bearing habit. 'Tekin' cultivar is better than 'Siirt' cultivar (Ak, 2014).

V – Husbandry

Pistachio orchards have been established in dry and non-irrigated lands in Turkey and Syria. The soil is ploughed in autumn in order to preserve water from winter and spring rain and sometimes snow. The soil is also cultivated by chisel ploughs in the spring and summer months to prevent evaporation. This working of the soil destroys weeds which are in competition with pistachios and are also host plants for many diseases and insects (Kaska, 1995).

Pistachio trees are irrigated in Iran and the USA and it is well known that irrigation is a very important factor in obtaining high yields and good quality. There are plans to expand Turkey's pista-

chio producing areas with new and irrigated orchards in the southeast Anatolia region, which is expected to double Turkey's pistachio production. Irrigation experiments with different rootstocks have already been started in Sanliurfa.

The use of irrigation increases leaf size, number of current year's shoots and length of shoot. Irrigation also increases yield, nut size, splitting percentage and decreases blank nut rate and degree of alternate bearing.

Irrigation system was drip irrigation which the pipeline on the surface of the soil. But in some areas birds damaged the pipeline, and to avoid this lines can be lay underground. This was very advantageous application. Irrigation by underground drip systems is already being used on olive plantations in Spain. This system has been starting to use for pistachio and almond orchard in Turkey, nevertheless farmers has some suspicious about this method. The advantages of underground drip irrigation system are: 1. lower water consumption, 2. better water distribution, 3. greater uniformity, 4. use of waste water, 5. less evaporation, 6. greater transpiration, 7. location of fertilizer, 8. less clacification, 9. fewer diseases, 10. possibility of working the ground, 11. reduction of labor, 12. longer lasting, 13. no vandalism (Ak, 2004).

All above advantages are valid for all kind of fruit trees. In fact this system now in experimentally using at Ceylanpinar State Farm for pistachio orchard. The yield seems to be regulated, because there was alternate bearing habit of especially 'Kirmizi' variety. This underground irrigation system was established in a 20 da area where the adult tress (30 years old) using 'Siirt' and 'Kirmizi' cultivars. The depth of lineis approximately 20-25 cm deep from soil surface. After this experiments of governmental orchard, farmers are practiced in their pistachio and almond orchards. This irrigation system is using in Iran because of lack of water.

Fertilization is a very important factor in obtaining high quality yield from fruit trees. The degree of fertilization largely depends on irrigation and pH of soil. The pH of soils in the main production areas of Iran is between 7.2 and 8.5, with an average of 7.9. Pistachios are tolerant to salinity, and studies have shown that they can tolerate an electrical conductivity (EC) of 8.0 dS/m without considerable decrease of in yield (Sheibani, 1995).

Soils of pistachio orchards often have inadequate levels of nitrogen, phosphorus, potassium and organic matter. In a survey conducted in 30 pistachio orchards in southeast Anatolia, Tekin *et al.* (1985) found that in many orchards the trees were markedly deficient in phosphorus and zinc and slightly deficient in nitrogen, iron and manganese. The level of potassium was found to be adequate in many orchards though there were some districts where trees showed slight deficiencies. In such regions the soil pH varied between 7.5 and 9.3 and the organic matter content was very low.

Crane and Maranto (1988) claimed that pistachio is not an excessive nitrogen consumer when it is abundantly available in the soil. Nitrogenous fertilizers should be chosen depending on the soil pH. For example, in the southeast Anatolia region only ammonium sulphate is recommended as a source of nitrogen because of the alkaline soils. Nitrogenous fertilizers should be given at the end of February or the beginning of March at the rate of 1.5 to per tree (Kaska, 1995). In the USA, boron plays a unique role in pistachio production. Responses to foliar boron application include increased pollen viability and germination rate, increased fruit set and yield, decreased blanking percentage and increased leaf boron concentration (Brown, 1995).

Fertilizers are applied regularly and produce better vegetative growth. Pruning should also be carried out although care must be taken with trees growing on poor and dry soils. In Turkey and Syria, pruning is carried out once after harvesting and once again before flowering. Pruning is carried out by hand in most countries apart from the USA where mechanical pruning is necessary due to such good vegetative growth resulting from irrigation.

VI – Harvesting

Pistachios are harvested from late August to late October depending on cultivar. During maturation the colour of the exocarp changes from light green to pale cream or white. The hulls can be removed from the fruits by being squeezed between the fingers. Another sign of maturity is splitting of the shell. Kernel dry weight and crude fat content also increase (Ak, 1998).

In Turkey and Syria, pistachio nuts are harvested manually as clusters which can easily be separated from branches by bending them back. Nuts drop on to canvas spread out under the trees. The clusters are put in sacks and brought to drying yards where they are laid out and left to dry in the sun. The in-shell nuts are separated from their clusters and left again in the sun for further drying. In Turkey, all the cultivars except Siirt and Ohadi are stored with their hulls. The nuts are kept in the sun until they are completely dry and then put in sacks and stored (Kaska, 1995).

In Iran, harvesting is carried out in a similar manner to that in Turkey. However, in the USA machines are using to harvest the pistachios. Post-harvest practices such as dehulling, drying, separation of blank nuts and separation of split nuts are mechanized.

Turkey has the advantage of producing nuts free from aflatoxins, due to low humidity and high temperature experienced during growing and harvesting. Processing systems are also undergoing modernization. Turkish cultivars are also preferred in many European and American markets due to their good taste and uniformly green kernels. The pistachio nut is considered good for human health due to its nutritive content.

VII – Pest and diseases

The main pistachio pests are: Psylla (*Agonoscena pistaciae*), the pistachio twig borer (*Kermania pistaciella*, Ams.), pistachio fruit moth (*Recurvaria pistaciicola*, Danil.), pistachio leaf hopper (*Idiocerus stali* Fieb.), pistachio root beetle (*Capnodis cariosa*) etc.

Pistachio psylla (*Agonoscena pistaciae* Licht): This is the most destructive pest of pistachio grown in Turkey and Iran. The damage caused by this insect includes direct injury as a result of sucking plant sap and stunting the tree, shedding of leaves, fruits and the buds, increasing the rate of nut blanks, lowering the quality of nut, hindering transpiration and photosynthesis due to the closure of stomata by honeydew secreted from the insect larvae and/or sooty mould growing on leaves if conditions become favourable.

The main diseases: Septoria leaf spot, Verticillium wilt, *Phytophthora parasitica*, Root and crown rot, stigmatomycosis, etc. Septoria leaf spot caused by *Septoria pistaciae*. It is controlled with preventative fungicide sprays such as dithiocarbamates (e.g. Zineb, Mancozeb). Copper fungicides are also effective, but they should only be applied after the fruit has reached size, since they might be phytotoxic to very young fruit. Applications should begin after the first leaves have unfolded and if necessary be repeated at monthly intervals up to the beginning of June (Michailides and Young, 1989; Michailides, 1998).

Integrated Pest management application is very important for the Good agricultural Practices applicant farmers (Ak, 2015). Nowadays Turkish government is supporting the Good agricultural Practices orchards through consultants of special firms.

VIII – Conclusions

Pistachio nut culture is centuries old in Iran, Turkey and Syria. In these countries the area under pistachio nut is the largest and the number of trees is the highest in the world. In spite of these facts

the production is very low in Turkey and Syria. The kernel taste is good but the nuts are small and their splitting percentage is low. However, one should bear in mind that Turkey is the only country in the world that pistachio nuts are grown in such marginal lands with dry climate and poor, rocky and calcareous soils. The latest development is the processing system is changed at Ceylanpinar state farm in Sanliurfa. Pistachio orchards and production development will be seen in some European Countries and some west Asian countries. New technologies have been started to be used in Turkey. The government of Turkey is supporting, running experiments to solve different problems.

Worldwide supply of and demand for pistachios are generally in equilibrium and the producer countries usually are the consumers at the same time. While Iran, Turkey, United States, and Syria are the top consumers, the highest consumption among the European countries is in Italy. The majority of pistachios grown globally (60%-70%) is consumed as saltily roasted snacks, and 30-40% consumed in the confectionary industry as an ingredient in chocolate, cakes, ice cream and other sweets. In the United States and Europe, however, 90% of pistachios are consumed as salty nuts.

In order to increase the competition power of Turkish pistachio sector, production costs have to be reduced and new cultivars oriented toward international markets must be developed or adopted as well as issues in farming and marketing have to be resolved. Agricultural practices in pistachio production on irrigated land help maintain both the demand-supply equilibrium and the stability in international markets and so, the Southeastern Anatolia Project is an opportunity in this respect. Nevertheless, Turkey as being the consumer of what is produced domestically looks nothing but a closed economy.

Varietal choice, production and price stability are essentially important factors in pistachio export. First we need to find out which varieties are most wanted at the international level: roasted nut varieties or varieties used in confectionary industry? In other words, what are the criteria of countries on this matter? It is important to determine correctly what the best answer is to these questions. Problems often arise when it comes to storing of pistachios after the harvest. For example in recent years, Iran is reportedly having export problems arising from defects in pistachio storage. The Southeastern region of Turkey where pistachios are grown widely has an advantage in this respect, since the dry and hot climate prevailing in the region provides for safe storage conditions free of aflatoxin, which is suspected to cause liver cancer in humans and other animals. Iranian pistachios, illegally entered Turkey, are perceived as Turkish pistachios, leading to problems when they are consumed either domestically or internationally upon imported from Turkey. Other important point is the problem of unstable price policies. Prices set by different policies each year have negative impacts on both domestic and international markets. While it is possible to solve existing problems pertaining to an agricultural commodity, like pistachios native to Turkey, by applying serious and stable policies, it feels quite frustrating not to be dominant in pistachio markets globally. Hazelnut is the first nut for Turkish economy, but pistachio is also very important for South East Anatolia Region. Because of this reason governmental support has been provided last decades. This support is mainly for irrigation of non- irrigated pistachio orchards (Isgin and Ak, 2011). Nowadays government of Turkey is supporting Good Agricultural Practices in pistachio orchards. Farmers also follow the advisors about these subjects to produce high yield and to get high profit.

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