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An overview of winter squash (*Cucurbita maxima* Duch.) and pumpkin (*Cucurbita moschata* Duch.) growing in Turkey

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ABSTRACT

Cucurbita L. species of the pumpkin and winter squash are grown all over the world. Winter squash and pumpkin are two of the most important Cucurbit vegetable crops in Turkey. Turkey is one of the important diversity areas, for the cultivated cucurbits because of their adaptation to diverse ecological conditions as a result of both natural selection and also the selection by farmers. Farmers have maintained the local population of winter squash and pumpkin, which are mainly sold in local markets. Only one improved cultivar of the winter squash is currently grown commercially in Turkey. It is a traditional vegetable often grown in small gardens. In this contribution, the last status of winter squash and pumpkin production in Turkey, the growing techniques and problems of these winter squash and pumpkin species, their genetic collection and characterization, and the utilization of the presented species in Turkey are examined.

INTRODUCTION

The cultivation of the winter squash and pumpkin has a long history, and probably is the same age as the agriculture. The Cucurbita genus is of American origin. The word "pumpkin" (*Cucurbita moschata*) is derived from a French word, originally from the Greek, meaning "large melons". The term "squash" comes from a Native American word describing an edible gourd (Marr et al. 2004). Winter squash (*Cucurbita maxima*) originates from America and was cultivated by the ancient civilizations of Central and South America over 7000 years ago (Zvalo and Respondek 2007). There is convincing evidence from the archaeological sites in Central and South America that *C. pepo*, *C. maxima* and *C. moschata* were widely cultivated in pre-Colombian eras. *Cucurbita pepo* shares a common ancestor with *C. moschata* and *C. argyrosperma*, but not with *C. maxima* (Decker-Walters et al. 1990). The geographical distribution of the known archaeological remains of *C. moschata* indicates that it has been cultivated for more than 5000 to 6000 years (Robinson and Decker-Walters 1997). It spreat out other countries rapidly.

The center of diversity, winter squash (*C. maxima)*, lies in South American temperate zones, where landraces exhibit an array of interesting traits. Many landraces of these species are also found in North America, Australia, and different countries in Africa (Zambia and Nigeria), Asia (China, India, and Iran) and Europe (Spain and Turkey) (Ferriol and Pico 2008).

Turkey is not a center for the origin of cucurbits, but it is one of the important diversity centers for cultivating the cucurbits because of their adaptation to diverse ecological conditions as a result of both natural selection and also the farmers' selections (Sari et al. 2008). The most commonly cultivated *species* of the Cucurbitaceae family in Turkey are the *Citrullus lunatus* Thunb., *Cucumis flexuosus* L., *Cucumis sativus* L., *C. maxima* Duch., *C. moschata* Duch. and *C. pepo* L. The Cucurbitaceae landraces are still grown by farmers and are highly variable in morphology and taste, and are also used as a vegetable or for pickling in almost all regions of Turkey (Balkaya and Karaagaç 2005, Sari et al. 2008, Balkaya et al. 2010a). The winter squash and pumpkin populations have been improved through selection for centuries by farmers. In Turkey, the current production of *C. maxima* and *C. moschata* are

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based on local cultivars and are for home consumption, or sold in local markets.

The aim of this review is to present winter squash and pumpkin production in Turkey, the growing techniques and problems of the species, their genetic collection and characterization, the current and ongoing cultivar breeding programs, and the probable utilization of the presented species. This detailed overview will give an insight for agricultural scientists regarding the up to date situation with the winter squash and pumpkin production potential in Turkey, and provide information about the species.

WINTER SQUASH AND PUMPKIN GENETIC RESOURCES AND BREEDING ACTIVITIES IN TURKEY

Turkey is one of the domestication centers where ancient agriculture began. Vavilov (1951) described two important centers (Near East and Mediterranean) in the country. It is also one of the centers of origin, and/or diversity of several crop plants, and many plant species. Turkey is endowed with a rich diversity of families (163), genera (1.225) and species (9.000) of plants (Özgen et al. 2000, Balkaya and Karaağaç 2005), and also has the genetic diversity centers for many wild, transitional, and cultivated forms of annual and perennial, herbaceous and woody plants (Balkaya and Karaağaç 2005). Species endemism is also high. Presumably, this factor is connected to the climatic and topographic diversity of Turkey. Turkey's environment is diverse, ranging from subtropical to cold temperate zones. This ecological diversity has contributed to high genetic diversity, and allowed successful introduction and cultivation of a great number of vegetable species (Balkaya 2009). Winter squash and pumpkins are two of the most important cucurbita vegetable crops in Turkey. They were cultivated largely in different regions of Turkey, but only one registered cultivar of winter squash (namely Arıcan 97 cv.) is currently grown commercially in Turkey (Balkaya et al. 2011a). Winter squash and pumpkin landraces are sometimes grown as unimproved populations in different regions in Turkey. The exchange of types of seeds among farmers could allow for the maintenance for the genetic diversity in these winter squash populations (Balkaya et al. 2009a). These traditional landraces are important genetic resources for plant breeders because of their considerable genotypic variation. This variation is favoured and maintained by deliberate selection for specific traits by the farmers (Balkaya et al. 2010a). However, for decades, the old winter squash landraces have progressively been replaced by new cultivars, including the Arıcan 97, which ensure higher yields and incomes, and meet the requirements of both the processors and consumers (Sari et al. 2008; Balkaya et al. 2009a).

To date breeding and selection studies have been conducted on *Cucurbita maxima* and *Cucurbita moschata* populations in Turkey. The winter squash populations show great diversity in the Black Sea region of Turkey regarding their morphological characteristics, particularly in fruit length, fruit diameter, fruit shape, fruit brightness, skin thickness, flesh thickness, and color. A comprehensive collecting program for the winter squash and pumpkin populations in Turkey began in 2005 by Balkaya et al. (2005). One hundred and fifteen populations of winter squash, *C. maxima* Duch. were collected from different provinces in the Black Sea region (Bolu, Sinop, Amasya and Samsun provinces) (Balkaya et al. 2009a). From the observations, 26 winter squash genotypes were evaluated as superior using the weighting based ranking method in the first year. In the second and third years, from these selected genotypes; 9 genotypes and 5 genotypes were determined as cultivar candidates respectively. At the end of this breeding study, 55ÇA15, 55ÇA06, 55BA03, and 57SI21 genotypes were determined as being promising cultivars for further breeding efforts (Balkaya et al. 2011a). These selected promising genotypes will be developed as new registered winter squash cultivars in the future.

Twenty two local populations of pumpkin were collected in the Black Sea Region during and after the harvest in September 2005 and February 2006 (Balkaya et al. 2009b). These populations have been maintained by farmers for generations and are representative of the different pumpkin types growing in the Black Sea region. The geographical distribution of the pumpkin populations was 8 populations from Amasya, 6 from both Bolu and Samsun, and 2 from Sinop (Balkaya et al. 2009b), and the results showed a large variation among the genotypes. This study showed that the pumpkin genotypes from the Black Sea Region of Turkey have a number of characteristics useful for breeding programs. Four types were evaluated as superior when using a weighting based ranking method. At the end of this research, 1 genotype (14BO01) was selected as being promising for further breeding efforts.

Table 1.Total squash and pumpkin production in the important producer countries

Production (tonnes)	2010	2011	2012	2013
World +	23.059.686	24.274.016	24.616.115	24.679.859
1.China	6.731.978	6.965.200	7.062.760	7.155.250
2. India	4.456.296	4.695.542	4.900.000	4.900.000
3. Russian Federation	988.580	1.175.890	1.080.845	1.128.205
4. Iran	732.660	951.253	965.000	897.293
5. USA	792.700	814.330	900.880	796.872
6. Ukraine	516.900	626.900	587.800	610.800
7. Mexico	522.388	525.445	564.986	544.988
8. Egypt	658.234	633.557	559.606	543.334
9. Spain	366.500	393.100	502.600	533.200
10. Italy	508.075	538.533	520.000	530.000

ECONOMIC IMPORTANCE: IMPORTANCE AS CROP AREAS AND PRODUCTION VALUES IN VARIOUS COUNTRIES

Winter squash and pumpkin are members of the genus Cucurbita within the economically important Cucurbitaceae family. There are three economically important Cucurbita species, namely *C. pepo*, *C. maxima* and *C. moschata*, which have different climatic adaptations, and are widely distrubuted in agricultural regions worldwide (Robinson and Decker-Walters 1997; Paris and Brown 2005; Wu et al. 2007).

The Cucurbita spp. is collectively ranked among the 12 leading vegetable crops worldwide. China and India are the world leading producers. China's total squash and pumpkin production is 7.155.250 tonnes in 387.705 hectares, while India's production is 4.900.000 tonnes in 510.000 hectares (Table 1, Table 2). Other major producers are the Russian Federation, Iran, America, Ukraine, Mexico, Egypt, Italy, and Spain, respectively. Turkey is ranked 12th in the world in terms of totalsquash and pumpkin production (FAOSTAT 2015).

Turkey is located between 36° and 42° N and from 26° to 45° E, and is characterized by mountainous areas in center, and flat coastal plains in other locations. While the coastal regions enjoy milder climates, the inland Anatolian plateau exposes extremely hot summers and cold winters with low rainfall. The Aegean and Mediterranean coasts have cool rainy winters and hot, moderately dry summers. Western and Southern Anatolia have a typical Mediterranean climate near the coast, with mild wet winters, and long, hot, dry summers (Güler 2004). Turkey's environment is diverse, ranging from subtropical to cold temperate zones. This ecological diversity has contributed to high genetic diversity (Balkaya and Karaagaç 2005). The Black Sea region has seen intensive cultivation on small holdings of a wide variety of crops such as corn, beans, peas, pumpkins, kale, and cabbages (Balkaya 2009).

Winter squash and pumpkins are two of the most important Cucurbit vegetable crops in Turkey. The annual winter squash and pumpkin production in Turkey is 93.672 tonnes, according to 2014 records (Table 3). In Turkey, the Ankara province has a large share (11.6 %) of winter squash and pumpkin production with 10.836 t, followed by Sakarya (9.283 t), Düzce (8.046 t), Eskişehir (7.765 t) Samsun (6.664 t), and provinces, respectively (TUIK 2015).

Table 2.Total squash and pumpkin area harvested in the important producer countries

Area harvested (ha)	2010	2011	2012	2013
World +	1.727.669	1.773.911	1.778.773	1.797.194
1. India	481.235	502.081	510.000	510.000
2. China	364.736	377.427	383.005	387.705
3. Cameroun	120.000	119.690	120.000	124.675
4. Iran	47.767	59.774	60.000	56.304
5. Cuba	56.597	56.788	52.380	55.865
6. Russian Federation	53.200	56.600	53.400	53.925
7. Ruanda	45.334	45.217	46.000	46.500
8. Bangladesh	39.164	39.143	40.500	42.000
9. USA	37.600	37.030	36.980	37.110
10. Mexico	32.100	31.206	34.001	32.996

Table 3. Winter squash and pumpkin production in the important producer provinces of Turkey

Production (tonnes)	2010	2011	2012	2013	2014
Turkey	89.368	93.099	93.612	95.076	93.672
1. Ankara	9.447	13.415	11.676	11.498	10.836
2. Sakarya	7.102	8.639	9.385	9.378	9.283
3. Düzce	4.631	4.670	6.674	8.081	8.046
4. Eskişehir	4.398	3.448	3.870	5.408	7.765
5. Samsun	6.599	6.440	6.769	6.685	6.664
6. Çankırı	1.613	1.758	3.416	3.726	3.997
7. Bilecik	3.563	3.868	3.865	3.885	3.668
8. Antalya	3.180	3.409	3.173	3.366	3.199
9. Balıkesir	3.473	3.325	2.950	3.321	3.179
10. Bursa	4.041	3.943	3.984	3.820	2.738

In Turkey, the Ankara province has the most important winter squash and pumpkin cultivated area with 653,6 ha, followed by Eskişehir province (332,2 ha) and Sakarya province (299,6 ha) (Table 4).

UTILIZATION OF WINTER SQUASH AND PUMPKIN FRUITS IN TURKEY

Winter squash and pumpkin are usually grown for their fruit, and immature for summer squash, and mature for the winter squash and pumpkin. The ripened fruit of *C. maxima* can be boiled and roasted for human consumption. Also, their seeds and flowers are consumed by humans (Bisognin 2002). Mature and young fruits, male flowers, seeds, and young tips of the vines are consumed in pumpkins. In Turkey, pumpkins are used at the immature and mature fruit stages, and is a major ingredient for several vegetable dishes. Both female and male flowers of the pumpkin plants can be consumed. Fresh flowers that are fully open are suitable for cooking (Balkaya et al. 2009b).

Pumpkin seeds are consumed throughout the world and are increasing in popularity, but the commercial market for pumpkin seeds is still relatively small (Cascio 2007). Pumpkin seeds have also been used in traditional medicine as a vermifuge, and are among several food plants and herbs containing fatty acids and phytosterols that are used for the treatment of benign prostatic hyperplasia (Zhang et al. 1994, Dvorkin and Song 2002). In Turkey, dry pumpkin seeds, eaten on any empty stomach, are used to as an effective treat for tapeworm, (Balkaya et al. 2010b).

When used at the ripening stage or after storage, pumpkins provide a valuable source of the carotenoids and ascorbic acids that play a major role in nutrition as antioxidants in the form of pro-vitamin A and vitamin C (Whitaker and Robinson 1986, Pandey et al. 2003). Winter squash is low calorie, good source of complex vegetable carbohydrates, and dietary fibre. It is also a source of niacin, iron and betacarotene. Usually, the dark erthe skin is, the higher the beta carotene content. Further, winter squash and pumpkins are a good source of vitamin A (Whitaker and Robinson 1986). It is also an excellent source of fibre, vitamin E, vitamin C, manganese, magnesium and potassium. It also contains vitamins B1, B3, B5 and

Table 4. Winter squash and pumpkin are harvested in the important producer provinces of Turkey

Area harvested (ha)	2010	2011	2012	2013	2014
Turkey	3.993,6	4.148,9	4.150,6	4.105,7	4081,6
1. Ankara	521,1	714,1	691,9	673,6	653,6
2. Eskişehir	184,6	137,9	147,2	215,9	332,2
3. Sakarya	212,8	283,1	295,5	297,1	299,6
4. Samsun	281,5	270,7	279,6	260,8	260,1
5. Bilecik	207,0	212,4	212,3	210,7	202,4
6. Düzce	117,1	118,8	169,1	204,3	201,8
7. Kütahya	232,0	238,5	182,0	192,5	183,0
8. Bursa	209,5	200,0	204,0	198,5	150,5
9. Balıkesir	135,0	133,5	108,5	122,3	127,0
10. Antalya	112,7	116,8	107,7	104,5	101,5

B6 (Heflebower and Drost 2010).

WINTER SQUASH AND PUMPKIN GROWING TECHNIQUES WITH APPLICATIONS IN TURKEY

The seeds of the winter squash and pumpkins were sown into plug trays containing peat, organic manure and sand, and mixed at a ratio of 4:2:1. The seedlings were transplanted in May (this sometimes changes according to regions) at the 4-5 leaf stage in Turkey. It is recommended to start in early May (Balkaya et al. 2011b). Depending on the days to maturity, some local winter squash and pumpkin varieties may need to be planted either earlier or later than that date. In some regions of Turkey, the seeds are sown sometimes directly into open fields at later periods. The winter squash seeds require a minimum soil temperature of 15 ^{o}C in order to germinate. They are also easily destroyed by the frost in the early sowing period. After 7 to 14 days, the plants emerge through the soil surface.

The winter squash and pumpkin plants should be grown in well-drained, sandy loams, with high levels of organic matter and a pH of 6,0 to 6,5 for good quality production (Kamble et al. 2000). For good growth, fresh animal manure or a cover crop into the soil in the fall, or well-rotted manure or compost into the soil before planting is recommended. The requirements for the fertilizer and manure should be based on a soil test for winter squash and pumpkin growing. The winter squash and pumpkin respond well to the applications of manure. Hence, 4-6 tonnes of burn farmyard manure should be added to each decare. The Cucurbit plants require low nitrogen and high potassium and phosphorous for good fruit development. Commercial fertilizer is necessary for both high yield, and for quality fruits in winter squash and pumpkin production. Therefore, 4-6 kg pure nitrogen (N), 5-10 kg pure phosphorus (P_2O_5), and 4-8 kg potash (K_2O) should be applied per decare. If possible farmyard manure should not be used, and these values should be increased to 1,5 or 2 times (Sari 2011). Pumpkins prefer their water applied under foliage. Regular wetting of the foliage not only encourages mildew, but also removes the bait deposits once the fruit has set. Plants tolerate wet conditions fairly well, but foliar diseases and fruit rot increase.

Winter squash and pumpkins need more space than the summer squash (Heflebower and Drost, 2010). The seedlings were planted in a field spacing of 2.8 × 2.0 m in Turkey (Balkaya et al. 2010a). However, many growers prefer to use a wider spacing than this distance.

Winter squash and pumpkin are warm season crops that are both cold weather and frost sensitive. The best crops growth occurs at 20 to 25 ^{o}C. At temperatures above 35 ^{o}C, male flowers sometimes predominate, resulting in fewer fruit for that period. Likewise, low temperatures also have an adverse effect on the flowering and fruit set. Low humidity is favorable for production due to lower incidences of fruit and foliar disease. Any stress in winter squash and pumpkin growing, which pertains to a lack of water during fruit sizing, can lead to the development of blossom-end rot. The first irrigation should be carried out immediately after planting, with the second and subsequent irrigations given at weekly intervals, or even more frequently, depending upon the need.

The plants were harvested manually at full maturity. Winter squash and pumpkins can be harvested whenever the fruits have turned a deep, solid color, and when the skin is hard (Motes et al. 2013). The pumpkin and winter squash are still alive even after they mature and are removed from the vine. It is best to harvest the fruit with a part of the peduncle attached in order to prolong its storage life. Winter squash needs about three to four months to mature. Pumpkins are harvested earlier than winter squash. The harvest period begins at the end of September and lasts until the middle of October in Turkey (Balkaya 2009). The fruits are normally harvested in one or two pickings. The average fruit weight of the pumpkin should be about 1-3 kg. The winter squash fruits are heavier (averagely 6-12 kg/fruit) than the other squashes (Vural et al. 2000).

The squash and pumpkin's yield are affected by genotypic and environmental factors. The mature fruit size is especially influenced by genetics, the environment, and the plant conditions during the development of the pistillate flower and fruit (Maynard 2007). The yield of the winter squash and pumpkin varieties varied from 6 ton/da to 10 ton/da in Turkey (Salk et al. 2008).

The storage life of the winter squash and pumpkins ranges from 2 to 12 months (Monsour 2009). The storage life of the pumpkin is shorter than the winter squash. The optimum storage conditions are a cool, dry place, with temperatures of 10-15 ^{o}C and 60-70 % relative humidity (Salk et al. 2008).

SWOT ANALYSIS of WINTER SQUASH AND PUMPKIN PRODUCTION, POTENTIALS IN TURKEY

We conducted a SWOT analysis on the winter squash and pumpkin production aimed at finding out its potential, as well as the needs of the sector. This method is a structural planning procedure to avaluate the strengths, weaknesses, opportunities, and threats, involved in this study (Lawrence, 2009).

The major strengths of winter squash and pumpkin production were cited as suitable agro-ecological conditions and traditional winter squash and pumpkin cultivation. Other cited strengths with the existing market included the demand for this crop and cheap labor, respectively. Turkey is very rich in winter squash and pumpkin genetic resources. There are over 570 local genetic resources in the seed gene bank in Turkey. The variation and diversity of the Cucurbit vegetable genetic resources in Turkey have greatly contributed to the genetic improvement of these vegetables.

The top weaknesses for winter squash and pumpkin production in Turkey were related to low yield values, which result in high production costs. In Turkey, there are local cultivars for the winter squash and pumpkin, which are open-pollinated populations. Compared with commercial varieties, the populations of the Turkish winter squash and pumpkin are less productive, and their fruits lack both uniformity and field durability. Only one registered cultivar of winter squash (namely Arıcan 97 cv.) is currently grown commercially in Turkey. Ongoing research at Ondokuz Mayis University might provide opportunity with improving the new open pollinated varieties of winter squash and pumpkins in Turkey. Other weaknesses are the domination of traditional production, inadequate growing techniques, low investment capacity from producers, and an old-fashioned marketing system. Specific problems were also found in plant protection related to effectiveness, i.e., the quality of plant protection products.

According to the SWOT Analysis, we may identify the following major opportunities, respectively. The high internal demand has increased over the last few decades. In addition, there is the possibility to contribute to job creation for family members in Turkey. The last opportunity was that the development of the processing industry for these crops.

Turkish farmers have a long tradition in winter squash and pumpkin production. The use of modern technologies was at low levels in some regions. Winter squash and pumpkin growers need to adapt capacity building in production planning, post-harvest management, quality control and marketing stages. Another level of technical assistance is needed for farmers' organisations. The major threat to winter squash and pumpkin production was the reduction in earnings in over recent years. Therefore, migration from villages to urban areas has increased in these regions.

CONCLUSION

Turkey is very rich in Cucurbit genetic resources due to its diverse geography and ecology. One of the priorities in vegetable production in Turkey should be improved winter squash and pumpkin production. There is a need to improve the quality of the products. Only one improved cultivar of winter squash is currently grown commercially. It will be useful to develop new commercial cultivars and preserve genetic diversity by vegetable breeders. It would be very beneficial to complete the description of winter squash genotypes grown in Turkey, and identify all the populations with desirable characters for winter squash breeding, and use all of the technological tools available. In conclusion, there is a need to start promoting breeding activities and seed production of winter squash and pumpkin crops in the private sector in Turkey. Additionally, there is a need to start promoting modern techniques in winter squash and pumpkin cultures such as quality seedlings, hybrid seeds of high potential yields, proper fertilizer use, and preventive protection from diseases and pests.

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