Sunflower (*Helianthus annuus* L.) genetic resources, production and researches in Turkey

Ahmet Semsettin Tan1,∗ and Yalcin Kaya2

1 Sunflower Breeder and Geneticist, Menemen, Izmir, Turkey
2 Trakya University, Dept. of Genetics and Bioengineering, Edirne, Turkey

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Abstract – Sunflower is one of the leading oilseed crops and it is widely grown in the Thrace region of Turkey. In 2017, in Turkey as a whole, oilseed and confectionary sunflowers were grown on 779.622 ha with a total production of 1 964 385 t of seed, and average yields of 2.64 t ha−1 for oilseed and 1.67 t ha−1 for confectionary types. Turkey is one of the important countries for crop diversity and has been described as a microcentre in different parts of the world. Landraces of sunflower (*Helianthus annuus* L.) show significant diversity in Turkey and have been collected in the framework of the “National Industrial Plant Genetic Resources Project” (NPGRP). Nine hundred and thirty two oilseed and confectionary sunflower accessions are in longterm conservation in the National Seed Gene Bank of Turkey. The mission of the National Sunflower Research Project is to develop improved germplasm and hybrid varieties by conventional and biotechnical breeding techniques in Turkey. New germplasm and breeding lines have been developed to improve oilseed and confectionary sunflower hybrids with desired characters including high yield and oil quality, resistance to diseases such as: *Plasmopara halstedii* (Farl.) Berl de Toni., *Puccinia helianthi* Schw., and *Orobanche cumana* Walr. Adverse conditions are also taken under consideration. These studies are integrated with agronomic and other related research.

Keywords: sunflower / *Helianthus annuus* L. / production / landraces / Turkey

Résumé – Tournesol (*Helianthus annuus* L.) en Turquie: ressources génétiques, production et recherche. En Turquie, le tournesol est l’une des principales cultures d’oléagineux et est principalement cultivé dans la région de Thrace. En 2017, les tournesols oléagineux et de bouche ont été cultivés sur 77 9622 hectares en Turquie pour une récolte de 1 964 385 t et des rendements moyens de 2640 t/ha pour le premier et 1 670 t/ha pour le second. La Turquie est l’un des principaux pays pour la diversité des cultures et est décrite comme un microcentre pour certaines cultures originaires de différentes régions du monde. Les variétés du tournesol (*Helianthus annuus* L.) présentent également une diversité importante en Turquie. Les variétés de pays de tournesol ont été rassemblées dans le cadre du « Projet national de ressources génétiques pour les cultures industrielles » (National Industrial Plant Genetic Resources Project, NPGRP). Neuf cent trente-deux entrées (932 entrées) de tournesol oléagineux et de bouche sont en conservation à long terme à la Banque nationale de ressources génétiques de Turquie. Le projet de recherche national sur le tournesol a pour mission de développer du matériel génétique amélioré au moyen de techniques de sélection conventionnelles et biotechnologiques pour la région de Thrace et d’autres zones de production en Turquie. De nouveaux germplasmes et lignées parentales ont été mis au point pour améliorer les variétés hybrides oléagineux et de bouche avec les caractères recherchés: rendement élevé et huile de bonne qualité, résistance aux maladies telles que *Plasmopara halstedii* (Farl.) Berl de Toni., *Puccinia helianthi* Schw. et *Orobanche cumana* Walr. Les comportements en conditions défavorables sont également pris en compte. Ces études sont également intégrées à des recherches en agronomie et d’autres sujets connexes.

Mots clés : tournesol / *Helianthus annuus* L. / production / variétés de pays / Turquie

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∗Correspondence: a_s_tan@hotmail.com
1 Introduction

Turkey is an important country concerning plant genetic resources and center of origin or micro gene center for several crop species (Harlan, 1951) that did not originate in the country, but shows diversity for many characteristics (Tan, 2009; Tan, 2010a, b; Karagoz et al., 2010). Two centers of origin (Mediterranean and Near Eastern) overlap in Anatolia. About 3700 of the 11 707 plant taxa found there are endemic to Turkey (Guner et al., 2012). The National Industrial Crops Genetic Resources Research Project aims to survey, collect, conserve long term, characterize, regenerate and utilize the industrial crop genetic resources of Turkey. This collection is a source of germplasm to be used in breeding programs.

Helianthus annuus L. originated in North America, where wild sunflowers provide important genetic diversity for crop improvement (Heiser et al., 1969; Heiser, 1978; Putt, 1978; Zeven and de Wet, 1982; Miller, 1987; Gobbelen et al., 1989; Schneiter, 1997). Landraces are also important sources of genetic variability, because they have adapted to local environments as a result of natural selections over centuries. Thus, the evaluation of existing confectionary and oilseed sunflower landraces is essential for increased utilization. Characterization studies indicated that confectionary land races are highly variable for morphological characters (Tan, 1993; Tan, 2002; Tan, 2010a, b; Tan and Tan, 2010; 2011; 2012; Tan et al., 2013a, b; Tan et al., 2016a, c; Tan et al., 2017b; Altunok Memiş, 2018; Altunok Memiş et al., 2018).

2 Sunflower genetic resources in Turkey

Crop genetic bases became narrowed since landraces were replaced by modern cultivars (Tankesley and McCouch, 1997). Therefore, in the framework of National Plant Genetic Resources Program (NPGRP), since the 1960s, Turkish landraces of many species have been surveyed, identified then collected before they disappeared and conserved at the National Seed Gene Bank at the Aegean Agricultural Research Institute (AARI) in Izmir, Turkey (Tan, 2000; Tan, 2010b). The sunflower genetic resources collections are included in this seed bank as part of the “Industrial Crops Genetic Resources Project” (Tan and Tan, 1998a, b; Tan, 2000; Tan, 2009; Tan and Tan, 2010, Tan, 2010a, b; Tan and Tan, 2011, 2012; Tan et al., 2013a, b; Tan et al., 2016a, c; Tan et al., 2017c).

These landraces or primitive cultivars are very important sources of genetic diversity, with their adaptability to local environments as a result of natural or farmer selection over centuries. To date, over 932 oilseed and confectionary sunflower accessions collected from sunflower fields, farmer storage and markets are long term ex situ conserved at the National Seed Gene Bank of Turkey (Anonymous, 2017a; Altunok Memiş et al., 2018). Figure 1 shows the collection areas of sunflower land races in Turkey (Anonymous, 2017a; Tan et al., 2017c; Altunok Memiş, 2018).

The oilseed and confectionary sunflower genetic resources received from the National Seed Gene Bank of Turkey were observed for 43 morphological, phenological and technological characters identified by UPOV (Anonymous, 2000) and IBPGR (IBPGR, 1985).

The data were evaluated by Principal Component Analysis (PCA), and Cluster Analysis and the eco-geographical distribution and agro-morphological variation of both oilseed and confectionary sunflower landraces at National Gene Bank have been published (Sneath and Sokal, 1973; Clifford and Stephenson, 1975; Tan, 1983). The distribution areas of sunflower samples showed significant variation within and between accessions. Distinct groupings were determined in principal components and the results of analyses exhibited broad morphological variation for land races (Tan and Tan, 2010, 2012; Tan et al., 2013a, b; Altunok Memiş, 2018).

This genetic diversity and its characterization are very important for hybrid sunflower variety breeding because parental lines with diverse origin have higher potential heterosis, then hybrids made from closely related parents (Kaya, 2010; Kaya, 2014a; Kaya, 2016). Thus, both

Fig. 1. Collection sites of sunflower land races in Turkey.
confectionary and oilseed sunflower land races have been evaluated and utilized in breeding programs at AARI and TARI (Thrace Agricultural Research Institute).

3 Sunflower production in Turkey

An increasing world population makes necessary increased availability of human foods. Vegetable oils are an important source of energy. Production of sunflowers with high yield, oil percentage and oil quality will help to reduce the oilseed production gap in Turkey, which is one of the leading countries for sunflower production. Data presented in Table 1 shows that oilseed and confectionary sunflowers were grown on 77,962 ha producing with 1,964,385 t of seed and an average yield of 2.64 t/ha oilseed and 1.67 t/ha for confectionary types in 2017 (Anonymous, 2017b).

Hybrid varieties constitute approximately 95% of production, but farmers generally prefer to use low yielding landraces when they grow confectionary sunflowers. Major provinces producing oilseed and confectionary sunflower in 2016 are given in Tables 2 and 3.

The Thrace region produces 49.3% of Turkish oilseed sunflowers in Tekirdag, Edirne, Kirkkareli, and Canakkale provinces. This is followed by the Mediterranean, Central Anatolia, Southeastern Anatolia, Black Sea, South Marmara and Aegean regions. These provinces produce a total of 39.7% of production (Anonymous, 2017b). Linoleic (conventional) types represent 97% of sunflower production, high oleic types 3%. The main confectionary seed production areas are in Central Anatolia and the Aegean Region (Anonymous, 2017b).

Sunflower contributes 1,800,000 tons to the total production of 2,700,000 tons of all oilseed crops in Turkey. This production is not sufficient to cover local oil consumption,
partly because, although 9.71 million tons of oilseed sunflower are used directly, 600.777 million tons are exported (Tab. 4). To cover the oilseed deficit, Turkey paid 3.5 million US dollars in 2016 to import oilseed and its derivatives, including 7.38417 million tons of sunflower oil at a cost of 1.015 million US dollars (Tab. 4). While 3.82263 million tons of oilseed sunflower were imported with a value of 2.63925 million US dollars; 0.48259 million tons were exported (Tab. 5). It would be useful to increase, perhaps even double sunflower production in Turkey.

Turkey oilseed processing capacity is 1.750 million tons but only 55% of the capacity of the 110 oil plants is utilized. Seed processing capacity and sunflower oil consumption in Turkey are given in Table 6. Turkish refinery capacity is 4 million tons per year, but the utilization rate of the existing 110 facilities was 70% in 2016 (Anonymous, 2017c). The production of additional oil seeds would create added value. There are some additional potential sunflower production areas such as the Aegean Region and South East Anatolia with suitable ecological conditions for both main and second crop sunflower production in Turkey.

Turkey imports the oilseed sunflower seeds mainly from Bulgaria, Ukraine, Romania, Russia and Moldova. On the other hand, almost half of the raw sunflower oil import is from Ukraine, while the other part is from Russia, Argentina, Romania and Bulgaria. The most exported countries of refined sunflower oil are Iraq, Syria, Lebanon and Thailand (Anonymous, 2017c).

### 4 Sunflower research in Turkey

The mission of the “National Sunflower Research Projects” at TARI and AARI, and the other Agricultural Research Institutes in Turkey is to breed well adapted and high

| Table 4. Sunflower oil export and import values of Turkey (Anonymous, 2017c). |
|---|
| Years | Import |  | Export |
| | Metric tons | US $ | Metric tons | US $ |
| 2007 | 163 115 | 138 039 000 | 31 906 | 36 002 000 |
| 2008 | 411 660 | 647 095 000 | 98 714 | 164 582 000 |
| 2009 | 323 596 | 468 305 000 | 101 432 | 110 618 000 |
| 2010 | 223 998 | 271 020 000 | 75 886 | 100 509 000 |
| 2011 | 469 858 | 629 068 000 | 204 872 | 338 658 000 |
| 2012 | 742 877 | 987 295 000 | 271 257 | 416 884 000 |
| 2013 | 625 849 | 908 122 000 | 346 256 | 496 198 000 |
| 2014 | 812 401 | 1 177 993 000 | 665 241 | 790 130 000 |
| 2015 | 798 170 | 1 101 230 000 | 618 525 | 680 701 000 |
| 2016 | 738 417 | 1 015 306 000 | 600 777 | 637 448 000 |

| Table 5. Sunflower seed export and import values of Turkey (Anonymous, 2017c). |
|---|
| Years | Import |  | Export |
| | Metric Ton | US $ | Metric Ton | US $ |
| 2007 | 596 147 | 260 166 000 | 10 052 | 26 598 000 |
| 2008 | 455 995 | 365 145 000 | 7826 | 30 277 000 |
| 2009 | 468 277 | 240 620 000 | 16 195 | 35 054 000 |
| 2010 | 645 607 | 348 113 000 | 21 643 | 58 912 000 |
| 2011 | 905 686 | 589 577 000 | 32 402 | 81 161 000 |
| 2012 | 754 162 | 443 958 000 | 56 268 | 114 321 000 |
| 2013 | 710 843 | 474 001 000 | 34 700 | 103 301 000 |
| 2014 | 556 909 | 406 154 000 | 33 521 | 111 730 000 |
| 2015 | 340 192 | 237 984 000 | 35 202 | 78 875 000 |
| 2016 | 382 263 | 263 925 000 | 48 259 | 120 887 000 |

| Table 6. Sunflower seed processing capacity and sunflower oil consumption in Turkey (Anonymous, 2017c). |
|---|
| 1000 Metric tons /Years |
| 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
| Seed processing capacity | 1590 | 1730 | 1695 | 1640 | 1900 | 1560 | 1630 | 1750 |
| Sunflower oil consumption | 650 | 726 | 846 | 825 | 870 | 827 | 876 | 971 |
yielding varieties, and to develop knowledge and technology for the Turkish sunflower industry. Research is conducted to develop sunflower varieties with improved yield, oil quality, resistance to diseases such as downy mildew [{*Plasmodiophora halstedii* Farl de Toni}], rust (*Puccinia helianthi* Schw.), *Sclerotinia*, *Rhzopus*, *Botrytis Macrophomina* and *broomrape* (*Orobanche* sp.), other desired characters and adverse conditions (Tan, 1993; Kaya et al., 2004; Kaya and Evci, 2007; Kaya et al., 2009; Kaya, 2010; Tan, 2010a, b, c; Kaya et al., 2013, 2014; Kaya, 2016).

In Turkey, the main constraints for sunflower are attacks by *broomrape* and *downy mildew* (DM) but resistance is available to both parasites. Sunflower rust races have been identified under field conditions (Kaya et al., 2004; Kaya and Evci, 2007; Kaya et al., 2009; Tan, 2010a, b, c; Tan, 2010a; b; Kaya et al., 2012, 2013, 2014; Tan, 2014; Tan et al., 2016a, b; Tan et al., 2017a, b).

To date, oilseed and confectionary sunflower open pollinated variety, parental lines (CMS, maintainer, and restorer lines) and hybrid varieties have been developed and evaluated in yield trials under main and catch crop production seasons. Variety performance tests and yield trials indicated that sunflower can give with satisfactory yield performance (2.50–5.5 t/ha) in both seasons in Thrace, Aegean, and Mediterranean Regions of Turkey (Kaya, 2010; Tan, 2010a, b; Kaya, 2014b; Tan, 2014; Tan et al., 2016b; Kaya, 2016; Tan et al., 2017a, b). The Aegean Region that has suitable ecological conditions for both cropping systems should be considered for sunflower production, in order to decrease the vegetable oil gap in Turkey.

High oleic and herbicide resistant (IMI and SU groups) sunflower varieties are being developed. There are research programs to develop oilseed and confectionary sunflowers for both main and catch crop production seasons. Sunflower germplasm has been developed from sources such as cultivars and breeding populations and tested for general and specific combining ability. Inbred lines, candidate and commercial varieties are evaluated in preliminary and yield trials on a regional basis for both main and catch production seasons in the Aegean Region and other parts in Turkey. In addition, agronomic studies are made on effects of sowing date, plant population, fertilization, irrigation and honeybee pollination on seed yield, oil content, oil quality, silage quality and other plant characteristics.

There is a lack of certified confectionary seed production with desired quality for this type of crop. Consequently, land races are generally used for confectionary sunflower production in Turkey. However, they are not suitable for combine-harvesting because they are not uniform in terms of plant height and physiological maturity (Tan, 2010b; Tan and Tan, 2010). New high yielding oilseed and confectionary sunflower hybrids have been improved and registered for the direct benefit of the agricultural sector and increased sunflower production in the country (Kaya, 2010; Tan, 2010a, b; Aldemir et al., 2016; Altunok et al., 2016; Tan et al., 2016b, Tan et al., 2017a, b).

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### 5 Conclusion

Sunflower is one of the main oilseed crops that contribute to the economy of Turkey for both human and animal nutrition, creating employment and internal and external trade. Production needs to be increased by breeding high yielding varieties tolerant and or resistant to biological and physiological constraints. Sunflower landraces having diversity will also contribute improving high yielding oilseed and confectionary sunflower hybrids.

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