OILSEED AND CONFECTIONARY SUNFLOWER (HELIANTHUS ANNUUS L.) LANDRACES OF TURKEY

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ABSTRACT

Turkey is one of the significant countries for the plant crop diversity. Turkey is also center of origin for many crop species. Flora of Turkey consists of high endemism about 3000 out of the 9500 plant species. Turkey is described as microcenters for some crops which are originated in different part of the world. The sunflower (*Helianthus annuus* L.) and its wild relatives were originated and domesticated in North America, providing an important genetic diversity for crop improvement. It is one of the important oilseed crops and their landraces have significant diversity in Turkey. The extend diversity of sunflower landraces or primitive commercial varieties are also very important source of genetic variability because they have adapted to local environments as a result of natural selection over centuries. Within the framework of National Industrial Plant Genetic Resources Project, sunflower landraces have been collected and conserved ex situ at the National Gene Bank in Izmir, Turkey. There are 389 oilseed and confectionary sunflower accessions conserved and maintained at the National Gene Bank of Turkey. In this study; eco-geographical distribution of sunflower landraces and the characterization result of agro-morphological variation of National sunflower collection will be presented. IPGRI / UPOV characters were evaluated to analyze the similarity and dissimilarity. Principle Component Analysis (PCA) was performed for diversity determination of sunflower accessions. The distribution areas of sunflower samples showed great diversity and very variable for morphological characters. The results of analysis exhibited broad morphological variation model of sunflower land races. The diversity among and between the landraces is result of adaptation of different ecologies and the farmers' selection in their pLITERATURE. The informal seed exchange mechanism among the farmers effect the some degree of similarity of the some accessions collected from different localities of different provinces.

Keywords: Sunflower, *Helianthus annuus* L., landraces, conservation, diversity, agro-morphological variation, eco-geographical variation, characterization, Multivariate analysis.

INTRODUCTION

Turkey is one of the distinctive countries for the plant diversity as being center of origin and/or center of diversity or microgene center for many crop species (Harlan; 1951; Tan, 2010a; Tan, 2010b; Karagoz *et. al*., 2010). Two of the Center of Origin is overlapped in Anatolia. Turkey is also described as microcentres for some crop species that are not originated in Turkey but they are divers in many characteristics. Turkey is the meeting place of three phytogeographical regions; Euro-Siberian, Mediterranean, and lrano-Turanian. Turkey's wealth in plants is apparent in the fact that about 3,700 out of the 11,707 plant taxa are endemic to the area (Güner *et. al*.2012).

Tanksley and McCouch (1997) emphasized that narrowing of the genetic base occurred firstly when changing the wild species into a domesticated species and secondly when landraces were replaced by modern cultivars. Therefore the landraces, before the replacement with modern varieties should be collected, conserved and evaluated for source of breeding for broaden the genetic base. Highly organized National Plant Genetic Resources Program (NPGRP) of Turkey conducts survey, collection, conservation both *ex situ* and *in situ* (including on farm conservation of landraces), characterization and evaluation of Turkish genetic resources and genetic diversity since 1960s (Tan, 2000; Tan, 2010b).

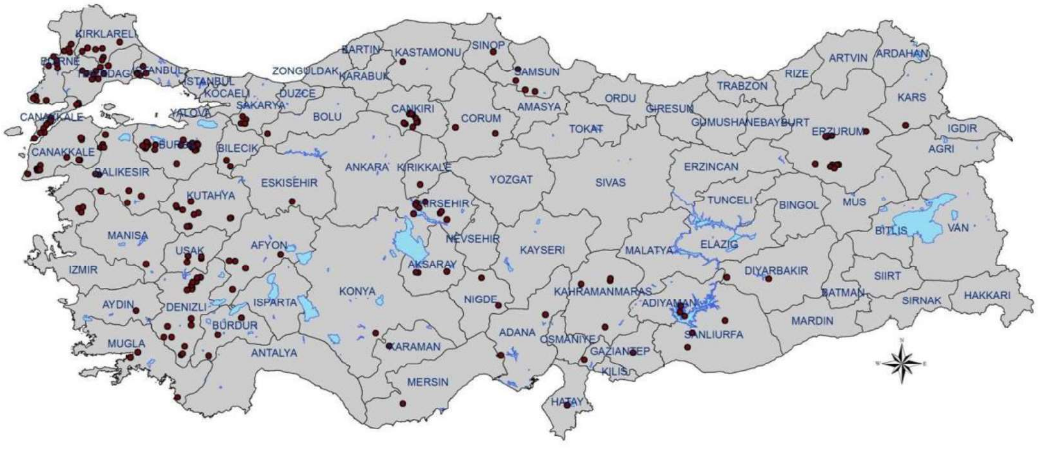
The Industrial Crops Genetic Resources Program of NPGRP is responsible for survey, collection, conservation, regeneration, evaluation, and characterization of industrial crops species (landraces and wild species (Tan and Tan, 2010; Tan and Tan, 2011; Tan and Tan, 2012; Tan et al., 2013). Environmental factors affecting the lost of wild species, the threats on landraces/local varieties are mainly the result of the replacement of landraces with modern varieties and changing the agricultural farming system. So, Industrial Crops Genetic Resources Program has yearly survey and collection program for long-term conservation of the collection at National Gene bank at Aegean Agricultural Research Institute (AARI).

Extremely variable domesticated crops as well as landraces with unique characteristics are still grown by farmers in Turkey. Fragmentation of lands lets farmers run several fields and to keep local landraces with application of traditional farming. Marginal agronomic conditions, especially steep slopes and heterogeneous soils of mountain agriculture make local landraces competitive with improved cultivars, at least in part of farming system. Economic isolation creates market limitation and minimizes to competitive advantages of improved cultivars. Local traditions and preference of diversity lead farmers to keep local landraces are the factors affect the farmers, even modern farmers, to keep their landraces or traditional crops (Tan, 2009).

From different provinces and different sources, like fields, farmer storage, threshing place and local markets of the villages, about 390 accessions confectionary and oilseed type sunflower land races were collected and stored and maintained long-term at National Gene Bank, so far. The collection and passport data, storage and characterization data are stored in National Plant Genetic Resources Data Base (Tan et al. 2015). Figure 1 shows the collection sites of sunflower land races. The collection, passport and characterization data are stored in National Plant Genetic Resources Data Base (Tan and Tan, 1998a; Tan and Tan, 1998b; Tan, 2010a; Tan, 2010b).

The Sunflower and its wild relatives were originated in North America (Heiser ve ark., 1969; Heiser, 1978; Putt, 1978; Zeven and deWet, 1982; Miller, 1987) and providing and important genetic diversity for crop improvement. Landraces are also important source of genetic variability because they have adapted to local environments as a result of natural selections over centuries. Thus, the characterization of existing collection is essential for the breeders. Characterization of genetic resources collections of confectionary and oilseed sunflower is significant to assess collection diversity for increased utilization (Tan and Tan, 2010; Tan and Tan, 2011; Tan and Tan, 2012; Tan et al., 2013; Tan et al., 2015b).

The main objectives of the this study were to analyze the degree of similarity or differences among sunflower landraces and to determine the extent of genetic diversity in sunflower landraces based on agro-morphological traits to provide information and utilization in plant breeding program.



Oilseed and confectionary sunflowers collection sites in Turkey

Figure 1. Sunflower land races collection sites in Turkey (Tan et al., 2015).

MATERIALS AND METHODS

Fifty four confectionary sunflower accessions collected from West and East Turkey, and 36 oilseed accessions collected from West Turkey maintained at National Seed Gene Bank, were characterized for assessing sustainable utilization.

The accessions were grown in two rows and fifty plants. Twenty randomly selected plants were observed from each accession. IPGRI (Anonymous, 1985) and UPOV (Anonymous, 2000) Guidelines for the Conduct of Tests for Distinctness, Uniformity and Stability, Sunflower" were used to observe the thirty two morphological characters of plant, head/flower and seed characteristics (Table 1). The agronomic characters, days to flowering and days to physiological maturity were also recorded (Anonymous, 1985; Anonymous, 2000).

Statistical analysis and Multivariate Analysis (Principal Component Analysis-PCA) were applied to conclude the variation among the accessions (Sneath and Sokal, 1973; Clifford and Stephenson, 1975; Tan, 1983). The statistical values of quantitative characters were calculated (Steel and Torrie, 1980).

Table 1. The observed morphological characters (Anonymous, 1985; Anonymous, 2000).

Plant characteristics: Plant height (cm), Stem width (cm), Branching, Leaf shape of cross section, Leaf shape, Leaf auricules, Leaf wings, Leaf pubescence, Leaf blistering, Leaf serration, Leaf width (cm) Leaf length (cm), Leaf distribution on stem, Stem hairiness, Stem diameter (cm), Leaf angle of lowest lateral veins, Leaf: height of the tip of the blade, compared to insertion of petiole.
Head/flower characteristics: Head diameter (cm), Head attitude, Head shape, Disk flower color, Disk flower anthocyanin coloration, Pollen fertility.
Seed characteristics: 1000 seed weight (g), Seed length (mm), Seed width (mm), Seed main color Seed type (Oilseed/confectionary), Seed hairiness, Seed stripes, Seed shape.

RESULTS

I. Characterization of Confectionary Sunflower Genetic Resources of Turkey

The morphological variation on the observed characters was found highly variable for most of the characters. All accessions have released the fertile pollen, and alternate leaf arrangements, hairy stem, absent branching, short hairy leaves, triangular leaf shape, confectionary type of kernel, dark yellow head flower. No anthocyanin coloration on the disk flower was observed. Plants were mostly vigor.

Almost all leaf characters showed variation. Leaf blistering was mainly strong and medium; Leaf serration coarse and medium; Leaf shape of cross section flat and weakly convex; Leaf auricules medium and large; Leaf wings none or very weakly expressed and weakly expressed; Leaf angle of lowest lateral veins acute and right angle or nearly right angle; Leaf height of the tip of the blade compared to insertion of petiole low and medium. Seed shape presented mainly as elongated, narrow ovoid and broad ovoid. Seed main color was white and whitish grey; Seed Stripes was observed with all types as none or very weakly expressed, weakly expressed and strongly expressed. Head attitude was variable at maturity; mainly half-turned down with straight stem and turned down with slightly curved stem were observed. Head shapes were presented as concave, flat, convex. In case of days to physiological maturity, they exhibited high range (97-104 days) and some of the accessions from Erzurum had shorter maturity period, *i.e.* 97 days, representing earliness. Similar pattern were observed in 1000 seed weight (80.60-183.50 g). The variations on quantitative characters were shown in Table 2.

Table 2. The statistical values of the agromorphological characters (Tan *et. al*., 2013).

Statistical value	Days to flowering	Days to physiological maturity	Plant height (cm)	Head diameter (cm)	1000 seed weight (g)
Mean	50.87	100.69	206.69	21.47	152.44
Min.	46.00	97.00	162.90	16.70	80.60
Max.	60.00	104.00	226.30	25.70	183.50
S^2 (Variance)	6.61	3.43	173.22	3.19	385.82
S (Standard error)	2.57	1.85	13.16	1.79	19.64
SE $\bar{x}$ (Standard error of the mean)	0.35	0.25	1.79	0.24	2.67
CV (%)	5.05	1.84	6.37	8.32	12.89

Statistical value	Seed width (mm)	Seed length (mm)	Leaf width (cm)	Leaf length (cm)	Stem diameter (cm)
Mean	7.56	21.85	12.90	28.24	17.90
Min.	5.60	16.68	2.57	24.00	2.83
Max.	9.16	26.18	33.20	33.30	31.50
S^2 (Variance)	0.47	3.94	161.28	6.17	141.90
S (Standard error)	0.68	1.99	12.70	2.48	11.91
SE $\bar{x}$ (Standard error of the mean)	0.09	0.27	1.73	0.34	1.62
CV (%)	9.05	9.09	98.43	8.79	66.56

Principal Component Analysis showed that the first eight principal components (PRINs) was accounted for 73.721 % of the total variation. The detailed result of PCA with latent roots (Eigen values), percentage variance and cumulative variance values were given in Table 3. First two Principal Components (PRIN1 and PRIN2) accounted with 33.272 % of total variance. Head diameter, leaf shape of cross section, leaf distribution on stem were effective variables on PRIN1 while seed length, 1000 seed weight, head shape, and seed width were effective variables on PRIN2 to form the groups and the scattering the accessions. Highly variable one group was formed and some of the Erzurum accessions and Denizli accessions were separated from the outside of this group (Figure 2).

Table 3. Result of Principal Component Analysis (Tan *et. al.*, 2013).

PRINs	Latent Roots (Eigen values)	Percentage variance	Cumulative variance
PRIN 1	4.212	19.147	19.147
PRIN 2	3.107	14.124	33.272
PRIN 3	2.325	10.569	43.841
PRIN 4	1.970	8.956	52.797
PRIN 5	1.398	6.352	59.149
PRIN 6	1.222	5.554	64.703
PRIN 7	1.110	5.047	69.750
PRIN 8	0.874	3.971	73.721

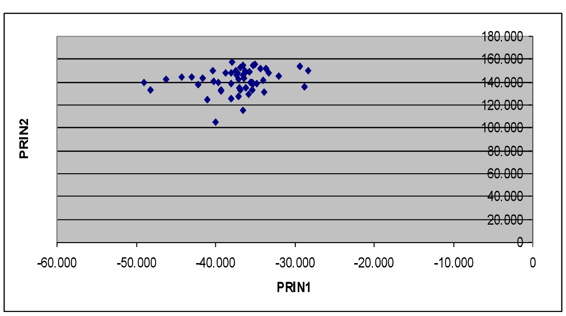


Figure 2. Distributions and grouping of the samples on PRIN1 and PRIN2 (Tan *et. al.*, 2013).

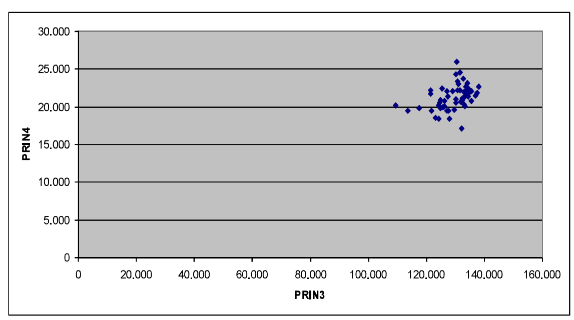


Figure 3. Distributions and grouping of the samples on PRIN3 and PRIN4 (Tan *et. al.*, 2013).

Second pairs of Principal Components (PRIN3 and PRIN4) accounted with 52.797% of total variance. Leaf shape of cross section, leaf width, physiological maturity and plant height were effective character on PRIN3 whereas leaf width, leaf length, and leaf blistering were effective characters on PRIN4. In this scatter one compact group was formed and some accessions of Erzurum province with tall plant heights and with long vegetation period were split out this group (Figure 3). The third pairs of Principal Components (PRIN5 and PRIN6) accounted with 64.703% of total variance were formed by the influence of effective variables leaf blistering on PRIN5 and head attitude on PRIN6. In this scatters, one group were observed as in the other principal component pairs. Pattern was almost same with other scatters and some accessions were scattered outside of the group (Figure 4) (Tan *et. al*., 2013).

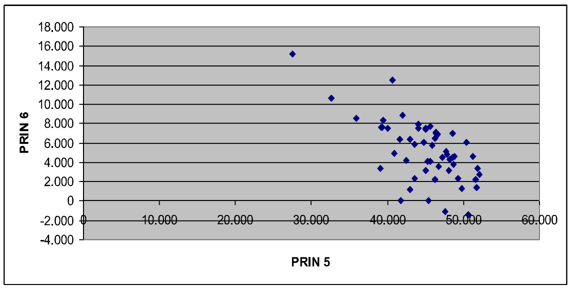


Figure 4. Distributions and grouping of the samples on PRIN5 and PRIN6 (Tan *et. al*., 2013).

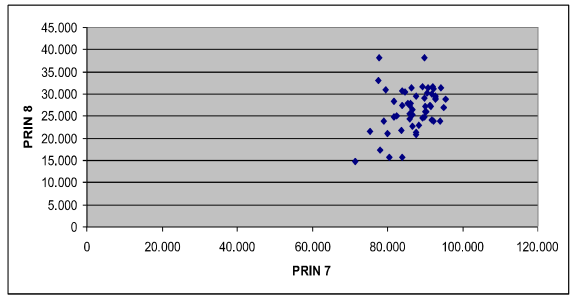


Figure 5. Distributions and grouping of the samples on PRIN7 and PRIN8 (Tan *et. al*., 2013).

The accessions in this group were very distinct from each other mainly with their very variable characteristics of head attitude. Some of the Erzurum and Denizli accessions were scattered from the group in different directions.

The fourth pairs of Principal Components (PRIN7 and PRIN8) accounted with 73.721% of total variance were formed by the influence of effective variables, leaf distribution on stem, plant height, and seed stripes on PRIN7 and leaf distribution on stem, leaf blistering, seed shape and plant height on PRIN8. In this scatters one group were observed (Figure 5). The distribution pattern was very diverse (Tan *et. al*., 2013).

II. Characterization of Oilseed Sunflower Genetic Resources of Turkey

The morphological variation on the observed characters was found highly variable for most of the characters. There was no variation on pollen fertility, type of phyllotaxis, external petal color, number of head, Seed hairiness. All accessions have released the fertile pollen, with hairless seeds, dark yellow ray flower, and alternate leaf arrangements. Plants were mostly vigor. Stems were mostly pubescence. Leaf shape was observed mostly as triangular, but cordate and rounded leaves were also observed and recorded. Head angle was very variable at maturity, and all types were observed (0°, 45°, 90°, 135°, 180° and 225°). Head shapes were also presented as concave, flat, convex and misshapen. Type of branching was another diverse character, but mostly basal branching and top branching were observed. The fully branched with central head were also observed in some plants of some accessions. The variation on quantitative characters was shown in Table 4. In case of plant height, they exhibited high range (157.0-273.5) of variation. Similar pattern were observed in the 1000 seed weight (78.4-142.25 g).

Table 4. Statistical values of the quantitative characters (Tan and Tan, 2012).

Statistical values	Days to flowering	Days to physiological maturity	Plant height (cm)	Head diameter (cm)	1000 seed weight (g)	Husk percentage (%)
Mean	56.00	110.97	185.43	20.61	96.26	28.69
Min.	52.00	108.00	157.00	16.40	78.40	20.95
Max.	71.00	121.00	273.50	27.00	142.25	50.79
S^2 (Variance)	24.74	8.54	878.36	5.01	168.34	57.48
S (Standard error)	4.97	2.92	29.64	2.24	12.97	7.58
SE $\bar{x}$ (Standard error of the mean)	0.83	0.49	4.94	0.37	2.16	1.26
CV (%)	8.88	2.63	15.98	10.86	13.48	26.42

Statistical values	Stem width (cm)	Seed length (mm)	Seed width (mm)	Leaf width (cm)	Leaf length (cm)	Number of leaf
Mean	12.19	6.21	30.69	23.41	22.46	2.38
Min.	10.66	4.92	24.10	16.60	18.00	1.70
Max.	16.70	8.00	45.40	33.00	30.90	3.40
S^2 (Variance)	2.22	0.59	24.44	18.72	15.39	0.17
S (Standard error)	1.49	0.77	4.94	4.33	3.92	0.41
SE $\bar{x}$ (Standard error of the mean)	0.25	0.13	0.82	0.72	0.65	0.07
CV (%)	12.22	12.38	16.11	18.48	17.47	17.39

Table 5. Result of Principal Component Analysis (Tan and Tan, 2012).

PRINs	Latent Roots (Eigen values)	Percentage variance	Cumulative variance
PRIN 1	8.766	35.062	35.062
PRIN 2	3.507	14.029	49.091
PRIN 3	2.194	8.776	57.867
PRIN 4	1.675	6.700	64.567
PRIN 5	1.451	5.803	70.370

Principal component analysis (PCA) showed that the first five principal components (PRINs) accounted for 70.370 % of the total variation. The detailed result of principal component analysis with Latent Roots (Eigen values), Percentage Variance and Cumulative Variance values is given in Table 5. First two Principal Components (PRIN1 and PRIN2) accounted with 49.091 % of total variance. Plant height, leaf length, leaf width, seed length, Stem width and husk percentage were effective variables on PRIN1, and head size, pubescence on leaf and plant vigority were effective variables on PRIN2 to form the groups and the scattering the accessions. Only one group was formed which consist of oil types and confectionary types were separated from this groups (Figure 6). Second pairs of Principal Components (PRIN3 and PRIN4) accounted with 64.567% of total variance. Leaf shape is effective character on PRIN3 and seed length, head flower color, leaf edge and leaf shapes are effective characters on PRIN4. In this scatter one group was formed which consists of oil types and all confectionary types and some oil types with large seed were outside of this group (Figure 7). The third pairs of Principal Components (PRIN4 and PRIN5) accounted with 70.370 % of total variance were formed by the influence of effective variables seed length, head flower color, leaf edge and leaf shape on PRIN4 and type of branching, head flower color and Pubescence at stem on PRIN5. In this scatters one group were observed as in the other principal component pairs. Pattern was almost same the confectionary types were outside of the group (Figure 8) (Tan and Tan, 2012).

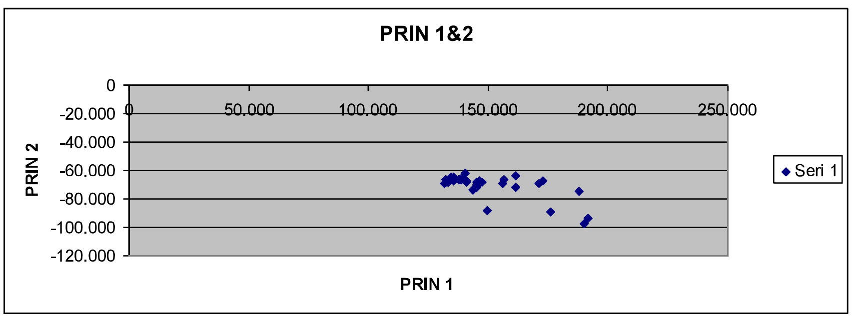


Figure 6. Distributions and grouping of the samples on PRIN1 and PRIN2 (Tan and Tan, 2012).

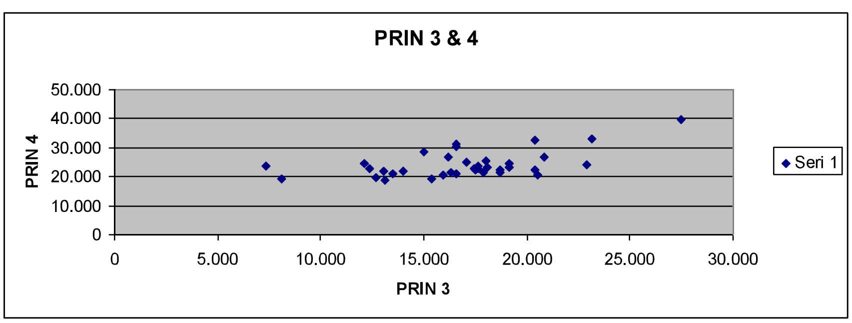


Figure 7. Distributions and grouping of the samples on PRIN3 and PRIN4 (Tan and Tan, 2012).

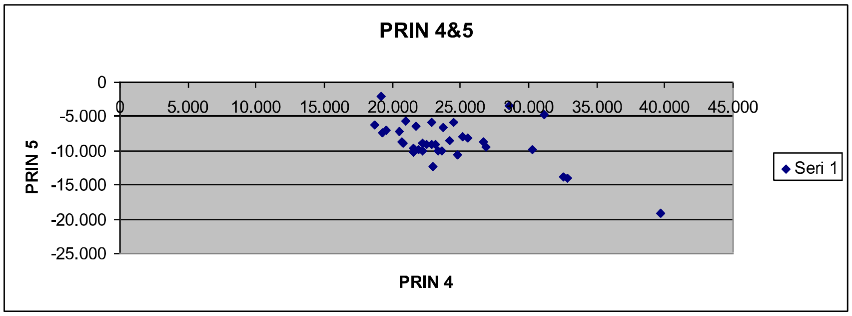


Figure 8. Distributions and grouping of the samples on PRIN4 and PRIN5 (Tan and Tan, 2012).

CONCLUCION

Sunflower land races, especially the confectionary types were very variable for morphological characters. The distinct separation on the morphology of accessions mostly depended on the types of accessions whether oilseed or confectionary types. The variation was also observed not only among accessions but also within the accessions.

Although locality separation by germplasm origin was observed in the accessions, but in general, the origin was not corresponded closely with the grouping pattern. The variation of the land races among and within the provinces and even in the villages on some characters brings up the consideration of the adaptation to different ecological conditions and also the different pLITERATURE of the farmers selection. The some degree of similarity of the some accessions collected from different localities of different provinces may result of the informal seed exchange mechanism among the farmers (Tan and Tan, 2010; Tan and Tan, 2012; Tan *et. al*., 2013).

Landraces show varying degrees of morphological and genetic integrity and may change with time, but they are recognized by farmers on the basis of a number of morphological and agronomic criteria. However, scientists and breeders may look to preserve particular genetic resources of crops, as a means of ensuring that the maximum possible range of genetic variability is available for today and future. Therefore the landraces, before the replacement with modern varieties should be collected, conserved and evaluated for source of breeding. For this purposes the existing sunflower land races still growing by farmers are collected and characterized and used in the sunflower breeding programs.

The genetic diversity plays an important role in plant breeding. Hybrids of parental lines with diverse origin, generally display a greater heterosis than those between closely related parents (Tan, 1993; Tan, 2005). The characterization of existing sunflower collection is essential for the breeders. Thus, the existing confectionary and oilseed sunflower genetic resources collections are started to characterize and evaluate for utilization at the breeding program at AARI.

Sunflower genetic resources have also been using in sunflower breeding program to develop new varieties. Improved germplasm, and breeding lines (A, B and Rf lines) of oilseed and confectionary type of sunflower germplasm, hybrids (TURAY, SUN 2235), open pollinated variety (EGE 2001), hybrids parental lines have been developed by conventional breeding techniques. New oilseed and confectionary type of sunflower hybrids improved for registration (Tan, 2010c; Tan *et. al*., 2015a) for the direct benefit of the countries agricultural sector.

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