Exploring Variation and Sustainable Progress of Vegetable Genetic Resources in The Black Sea Region, Turkey

Ahmet Balkaya

Ondokuz Mayıs University, Faculty of Agriculture,

Department of Horticulture, Samsun –Turkey

abalkaya@omu.edu.tr

Abstract: Turkey is an important center for plant genetic resources and genetic diversity. In Turkey, the Black Sea Region is very rich in vegetable genetic resources due to its diverse geographical, climatic and ecological conditions. Conservation and maintenance of these valuable genetic resources is essential. In order to protect the highly threatened vegetable genetic resources in this region, it was very important to set up a collection, conservation, utilization and research system. The aim of this review was to outline some of the vegetable genetic resources of the Black Sea region; their distribution, their collection and characterization; and to describe cultivar breeding programmes from 1994 to 2009 and beyond. This overview will give the agricultural scientist an insight to into the large degree of genetic diversity in Turkey, and provide information about the distribution and potential utilization of these irreplaceable genetic resources.

Introduction

The utilization of plant genetic resources is one key to improving agricultural productivity and sustainability. Plant genetic resources for food and agriculture are part of the biological wealth indispensable for securing world food supplies, alleviating poverty and sustaining rural development (Morico et al. 1998). Use of genetic resources is as old as the history of agriculture. Hundreds of plants have been bred over many hundreds of years and thousands of varieties have been developed by natural and artificial selection. Genetic erosion occurred through natural causes in earlier times, whereas recently, forest fires, misuse of forests and agricultural fields, and excessive and careless use of fertilizer and pesticides have reduced plant genetic diversity (Sarı et al. 2008). Intensive genetic improvement, together with the development of agricultural inputs, has led to the replacement of many local varieties by a few uniform modern cultivars in developing countries. For this reason, preservation of populations and landraces are very important (Balkaya & Yanmaz 2005). The genetic uniformity of cultivars of a widely grown crop makes them uniformly susceptible to biotic or abiotic hazards, and this genetic vulnerability may lead to complete crop loss. The main goal to be achieved by conservation of genetic resources is their present and future utilization for the benefit of mankind (Yawen et al. 2001). Organized collection, evaluation and conservation of crop genetic resources have gone on for two hundred years (Brush & Meng 1998). Currently, projects are being conducted in many countries for the conservation of genetic resources.

Sustainable development is a pattern of resource use that aims to meet human needs while preserving the environment, so that these needs can be met not only in the present, but also for future generations. Sustainable development ties together concern for the carrying capacity of natural systems with the social challenges facing humanity (Moffat et al. 2001). Wild plant forms and local village cultivars in any country are necessary genetic materials for improving the traits of cultivated plants, or developing new cultivars. The sustainability of plant production will only be assured by the preservation of these materials. For this reason, preservation of the genetic resources Turkey, which has rich genetic diversity, is necessary for both sustainable agriculture and life (Karayel & Bozoğlu 2008). The conservation of biological diversity, sustainable use of resources, technology transfer, intellectual property rights, provision of financing and the principle of equable sharing of benefits, have also been promoted (Waldman & Shevah 2000). The genetic diversity of landraces is thought to be of substantial economic value as part of global biodiversity, and is considered of paramount importance for future world production (Tan 2000; Stoilova et al. 2005).

Turkey is one of the most important countries in the world for plant genetic resources and genetic diversity (Tan 1998). It is also one of the 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 (Tan 1996; Özgen et al. 2000; Balkaya & Karaağaç 2005), and also has the genetic diversity centers of many wild, transitional and cultivated forms of annual and perennial, herbaceous and woody plants (Balkaya & Karaağaç 2005). The Black Sea region in the north of Turkey is one of its richest regions for crop genetic resources diversity. The region covers approximately 18 percent of the land area of Turkey, with a surface area of 141,000 km^2. The Black Sea Region, which gets its name and characteristics from the adjacent sea, extends from the border of Georgia in the east to the eastern edge of the Adapazari Plain in the west. The provinces of Artvin, Rize, Trabzon, Gumushane, Bayburt, Giresun, Ordu, Sinop, Samsun, Amasya, Kastamonu, Zonguldak, Bartin and Bolu are all in the Black Sea Region. Access inland from the coast is limited to a few narrow valleys because mountain ridges, with elevations of 1,525 to 1,800 meters in the west, and 3,000 to 4,000 meters in the east in the Kaçkar mountains, form an almost unbroken wall separating the coast from the interior. Because of these natural conditions, the Black Sea coast historically has been isolated from Anatolia. The North Anatolian Mountains are an interrupted chain of folded highlands that generally parallel the Black Sea coast. The climate of the Black Sea region is generally relatively warm and humid.It is the wettest area in Turkey, although summers are generally dry, with midsummer the driest time. The summers are shorter when compared to those of the south and the west, and the winters are rainy, with occasional snow.

The moderate climate and the prevalence of reasonable to good soils make this region ideal for many forms of agriculture. Historically, the Black Sea region has seen the intensive cultivation on small holdings of a wide variety of crops such as corn, beans, peas, pumpkins, kale and cabbages. The conservation and maintenance of these valuable local genetic resources is essential because they are an important source of diversity which can be used in future breeding programs (Balkaya et al. 2005). The aim of this study is to document the vegetable genetic resources of the Black Sea region, including the distribution of species, their collection and characterization, present and ongoing cultivar breeding programs, and the utilization of documented species from 1994 to 2009.

The Study

Knowledge of the extent of genetic diversity, and identification, differentiation, and characterisation of genotypes, and populations, respectively, provides an information tool for the detection of duplicates in collections, their effective extension, and better characterisation and utilization in breeding (Hornakova et al. 2003). Conserved germplasm requires accurate characterization for its efficient utilization in the future. Knowledge of variation found in a cultivated species and its pattern of distribution is important for the development of breeding programs (Gil & Ron 1992; Balkaya & Ergün 2007). Within a certain region, wide variation of plant and fruit types is observed as a consequence of natural and human selection. There is currently a large information gap with regard to the collection, classification and evaluation of Turkish genetic resources (Balkaya & Yanmaz 2001). Because of the increasing use of commercially released varieties, local varieties and genetic resources are rapidly disappearing. Consequently, there is a need to collect, characterize and evaluate remnant local populations before they disappear. It was essential to set up a collection, conservation, research and utilization system for the vegetable genetic resources of the Black Sea Region. Unfortunately, the collection and evaluation of vegetable genetic resources in that region was very limited until the early 1990s. From 1994 to the present, the vast majority of these studies have been undertaken by the Horticulture and Field Crop Departments of the Agriculture Faculty at Ondokuz Mayis University in Samsun, Turkey, and The aim of this study was to describe the vegetable genetic resources of the Black Sea region, the distribution of species, their collection and characterization, present and ongoing cultivar breeding programmes, and the utilization of presented species from 1994 to 2009. The summarized results are presented in this article.

Findings

Species belonging to the *Leguminosae* family are widely grown in the Black Sea region. The common bean is a crop of considerable global importance as a vegetable and as grain legume.The annual production of leguminous vegetable species in Turkey is 709,000 t (Turkstat 2005). Snap bean (*Phaseolus vulgaris* L.) is by far the most important cultivated legume in Turkey with a 76.9 % share, and pinto bean has a share 7.3% with 52 000 t annually (Turkstat 2005). Samsun province has a large share (17.3%) of snap bean production (94 019 t) in Turkey.

In Turkey, common bean landraces still represent important genetic resources used directly by farmers on a small scale (Balkaya 1999). Despite its foreign origin, it has adapted well and shows broad variation in the Black Sea region (Bozoğlu & Sozen 2007). Turkish farmers have grown common bean landraces due to their ability to adapt to local environmental conditions and because local people prefer them. Consequently, the common bean populations show an appreciable diversity attributable to the range of ecological and human influences. However, the old bean landraces have progressively been replaced with 'improved' new cultivars, which ensure higher yields and incomes, and meet the processors and consumers' requirements (Balkaya & Ergün 2007). From 1995-1998, a study was undertaken to firstly determine plant characteristics, and then to select suitable green bean cultivars for fresh consumption from local populations of the Black Sea region (Balkaya 1999). In the first year of the study, 166 climbing, and 34 dwarf types were collected (Table 1). Thirty-one climbing and nine dwarf lines were selected by the pedigree selection method in the second year. In the third year, 7 promising climbing lines and 1 dwarf line were determined to be cultivar

Table 1: *Ex-situ* collections of vegetable genetic materials in the Black Sea Region.

	English name/Turkish name	Scientific binomial	Collected sites	Number of Accessions
Leguminosae				
	Green bean/ Taze fasulye	*Phaseolus vulgaris* L.	9	200
	Pinto bean/Barbunya	*P. vulgaris var. pinto*	1	44
	Dry bean/ Kuru fasulye	*Phaseolus vulgaris* L.	1	400
	Pea/ Bezelye	*Pisum sativum* L.	5	27
	Broad bean/ Bakla	*Vicia faba* L.	4	10
Brassicaceae				
	Kale/Yaprak-Kara lahana	*B. olearaceae var. acephala*	5	127
	Cabbage/Baş lahana	*B. olearaceae var.capitata*	11	95
Cucurbitaceae				
	Pumpkin-Bal kabağı	*Cucurbita moschata* Duch.	4	22
	Winter squash-Kestane k.	*Cucurbita maxima* Duch.	4	115
Solanaceae	Pepper-Biber			
	Green peper/sivri biber	*C. annum var. longum*	7	37
	Red pepper/Kırmızı biber	*C. annum var. conoides* Mill	1	56

candidates (Balkaya & Yanmaz 1999). Twenty one bean cultivars (15 cultivar candidates and 5 commercial cultivars) were identified in both laboratory and field tests. In field tests, earliness, plant (height), leaf (color, size of terminal and side leaflets, shape of terminal leaflet), flower (size of bract, color), pod (size, shape of cross section, color, stringiness, surface texture, degree of curvature, prominence of grains) and seed (size, shape, color), were determined. In laboratory tests, seed protein bands were obtained by SDS-PAGE. Candidatesfor cultivar status and commercial cultivars showed different morphological characters and protein banding (Balkaya & Yanmaz 2003).

Pinto bean (Phaseolus vulgaris L. var. Pinto) is a traditional crop in Turkey. Farmers grow local varieties selected and maintained by themselves. Pinto bean is an especially important food in Samsun province of the Black Sea region. It is consumed as fresh pods, fresh seed or dry seeds. Forty four pinto bean populations were collected (Table 1) and evaluated according to morphological, earliness and yield traits under Samsun ecological conditions in 2003 and 2004 (Balkaya & Ergün 2007). Results showed that populations displayed significant differences for pod length, width, pod shape in longitudinal section, pod shell thickness, pod color, stringiness and pod curvature. Principal component analysis showed that the first four PC axes explained 83.3% of the total multivariate variation. Data were subjected to cluster analysis and several groups were identified, with most of the populations clustered into six groups. A dendrogram was prepared to evaluate morphological differences among populations. It revealed high variation. The results provided information on the diversity and breeding potential of Turkish pinto bean germplasm (Balkaya & Ergün 2008). Another study was conducted to identify and select valuable genetic resources of the pinto bean populations. From observations, 10 genotypes were determined superior after using a weighting based ranking method for fresh pod and fresh grain pod in the first year. In the second year, from these superior genotypes; 4 genotypes (55ÇA07, 55ÇA15, 55TE15 and 55TE20) for fresh pods and 5 genotypes (55ÇA01, 55ÇA05, 55ÇA15, 55ÇA24 and 55TE 15) for fresh grain pods were selected as promising genotypes. At the end of this research, selected genotypes will be developed into new pinto bean varieties in future years (Balkaya & Ergün 2007).

Artvin province is located in the eastern Black Sea region. Landraces of common bean were collected from 279 locations in 74 villages in 7 districts of the province (Bozoğlu & Sözen 2007). Landraces were sorted into 400 samples according to their growth habit, seed color, color pattern and shape. It was determined that these populations can be used in cultivar improvement programs and other breeding studies for both fresh consumption and dry seed yield.

Pea (Pisum sativum) is important species in the grain legumes. Twenty seven populations were collected (18 from Samsun, 3 from Giresun and Sakarya, 2 from Artvin and 1 from Tokat (Table 1). Wide variation in agronomic characteristics was observed between genotypes (Karayel & Bozoğlu 2008). It was determined that these populations could be used in cultivar improvement programs and breeding studies for both fresh consumption and forage varieties.

Ten faba bean populations were collected from districts and villages of Samsun, Amasya, Sinop and Tokat provinces (Peksen et al. 2006). There was no significant difference among faba bean populations for green pod yield. Green pod yield per plant was positively and significantly correlated with the number of pods per plant, and pod length and thickness. Seed length, seed width, seed thickness and 100 seed weight ranged between 18.04-23.56 mm, 13.24-17.10 mm, 7.93-8.94 mm and 119.07 and 162.61 g for faba bean populations, respectively (Pekşen et al. 2007).

Brassicas are widespread as wild, weedy and cultivated forms throughout Turkey (Davis 1982; Küçük 1996). Vegetable brassicas are an important and highly diverse group of crops grown world-wide that belong mainly to the species **Brassica oleracea** and **Brassica campestris (Monteiro & Lunn 1998).** In Turkey, cabbage is the most economically important member of the genus Brassica. According to FAO records from 2007, Turkey's total cabbage production was 658,665 t (Faostat 2008). Morphological variability is high among the white head cabbage genotypes of Turkey (Balkaya et al. 2005). Cultivar selection studies have been conducted on cabbage populations in various parts of Turkey since 1980. Ninety five white head cabbage populations were collected before and during harvest time between September 1998 and March 1999 from different eco-geographical regions of Turkey. (Yanmaz et al. 2000). They are mainly used for preparing cooked meals or salads. The cabbages were divided into two groups on the basis of their head morphology. The first group was flat and round, of dark green leaf color, medium hard with leaves having a thin midrib, used for stuffing, and the second group was round or long round, of light green leaf color, with thick leaves and midrib, used for pickling (Yanmaz et al. 2000). Data from field experiments conducted between 1999 and 2001 were analysed by multiple variance analysis. Cluster analysis based on 12 quantitative and 10 qualitative variables identified 10 distinct groups. A dendogram was prepared to evaluate morphological similarity among the white head cabbage genotypes. The multiplication and evaluation of these genotypes was carried out at the Black Sea Agricultural Research Institute in Samsun province. Appropriate lines were evaluated during the S4-S8 inbreeding generations. The first Turkish hybrid cultivar candidates were developed at the end of this research, and the registration applications for new hybrid cultivars were done in 2008.

Kale production is economically important in Turkey where it is grown intensively in the Black Sea region, but it is not commonly grown in the other regions of Turkey (Balkaya & Karaağaç 2005). Annual production is approximately 92,000 t and Samsun province produces over 40% of Turkish kale (Turkstat 2005).Kale is mainly used as a green vegetable, Many of the kales grown as vegetables have very crisp and curled leaves. Farmers often use the most tender leaves for human consumption and older ones for forage (Balkaya 2002). Kale populations were collected in 2001 from the Black Sea region, and evaluated according to morphological characters (Balkaya et al. 2004). In the first year, 127 kale populations were collected from different eco-geographical areas in this region. Twenty-two populations were determined superior by using a weight based ranking method. The populations exhibited a range of 15.9-21.9 cm for leaf length, 10.4-13.2 cm for leaf width, and 0.26-0.35 mm for leaf thickness. Eleven types were selected as being promising for further breeding efforts (Balkaya & Yanmaz 2005). According to two-year yield results from trial data, 4 kale cultivar candidates (namely Balkaya, Yanmaz, Elif, and Ayça cv.) were selected. Registration of these new kale cultivars was done in 2008 .

Cucurbitaceae is one of the most important cultivated families in Turkey. No wild types, or forms of genera, such as Cucumis, Cucurbita, Citrullus and Lagenaria have been found in Turkey. (Küçük et al. 2002; Balkaya & Karaağaç 2005) However, in many crops, including cucurbits, diversity centers have been identified in Anatolia (Harlan 1951). In almost all regions of Turkey, landraces of Cucurbitaceae are highly variable in morphology and taste.

Winter squash (Cucurbita maxima Duch.) and pumpkins (Cucurbita moschata Duch.) are two of the most important cucurbit vegetable crops in the Black Sea region. Winter squash populations show great diversity in morphological characteristics, particularly in fruit length, fruit diameter, fruit shape, fruit brightness, skin thickness, and flesh thickness and colour, in the Black Sea region of Turkey. One hundred and fifteen populations of winter squash, Cucurbita maxima Duch. were collected from different provinces of the Black Sea region (Bolu, Sinop, Amasya and Samsun provinces) in 2006 and 2007 (Balkaya et al. 2008a). The collection showed appreciable phenotypic variation in fruit shape, fruit color, fruit brightness, fruit dimensions and fruit weight. This study also demonstrated that substantial differences in seed dimensions exist in Turkish winter squash populations. Seed length ranged from 15.0-25.7 mm, seed width from 7.6-15.5 mm, and seed thickness from 1.4-6.1 mm. With regard to seed length to thickness ratio and seed width to thickness ratio, populations showed a range of 3.2 to 14.2, and 2.2 to 8.5, respectively. Data were analysed using principal component analysis (PCA). PCA revealed that the first two PC axes explained 67.0% of the total multivariate variation (Balkaya et al. 2009). From observations, 26 winter squash genotypes were evaluated as superior by utilising a weighting based ranking method in the first year. In the second year, from these selected genotypes; 9 winter squash genotypes were selected as promising genotypes. At the end of this research, selected genotypes will have beee developed into new winter squash varieties. In addition, selected types were evaluated at the DNA level using randomly amplified polymorphic DNA (RAPD) markers for some morphological characters,and this evaluation showed that these genotypes are genetically different each other. (Balkaya et al. 2008a).

Twenty two local populations of pumpkin were collected in the Black Sea Region during and after the harvest in September 2005 and February 2006 (Table 1). The 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 pumpkin populations was 8 populations from Amasya, 6 from bothBolu and Samsun, and 2 from Sinop (Balkaya et al. 2008b), and results showed a large variation among the genotypes. This study showed that 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.

Turkey is a micro-gene centre for many landraces, including the Solanaceae (Küçük 2003) These landraces are still grown by farmers in almost all regions of Turkey. Peppers are commonly grown in the Black Sea Region of Turkey and Samsun is a major producer province. Thirty seven green pepper populations were collected from Samsun, Amasya, Tokat, Kastamonu, Bartin, Gumushane and Giresun provinces in the Black Sea Region (Table 1). Morphological identification of collected populations were done by documenting their vegetative and pomological traits (Kar et al. 2007). In another study, fifty six red pepper populations were collected from different eco-geographical areas in the research region. Research showed that populations had 11.2-19.2 cm fruit length, 4.8-7.2 cm fruit width, and 4.3-5.8 mm for flesh thickness. They exhibited a range of 653.9-1415.5 g for the total fruit weight/plant, 7.2-13.5 for fruit number/plant, 53.0 -155.0 mg/100 g for ascorbic acid, 5.2-8.0 % for total soluble solids, and 8.0 -11.9 % for total dry weight (Karaağaç 2006).

The collection protocol was designed to ensure that the collected genotypes effectively represented the vegetable genetic resources present in the Black Sea region. Some of these vegetable genetic resources may not be suitable for standard cultivars in terms of productivity and plant characteristics, but their genetic content should be conserved (Balkaya & Karaağaç 2005). The seeds of populations collected and characterized in these studies were preserved at -20o C for long term storage in the Turkish seed gene bank (AARI), and they are also stored at 4o C at the Horticultural Department of Ondokuz Mayis University's Agriculture Faculty in Samsun, Turkey. All these materials form a vegetable gene pool which is used to maintain important traits, to broaden the genetic base of cultivars, and serve as a source of new diversity for agriculture.

Conclusions

The variation and diversity of vegetable genetic resources of the Black Sea region has greatly contributed to the genetic improvement of many vegetables. Many registered vegetable cultivars and cultivar candidate have been developed from those plant gene collections. On-going research at Ondokuz Mayis University may help to improve the economics and sustainability of vegetable production in both the Black Sea region and Turkey.

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