Review Article

Ekin
Journal of Crop Breeding and Genetics

6(1):11-26, 2020

www.ekinjournal.com

Ekin International biannual peer-reviewed journal

Utilization of Stress Tolerant Local Genotypes in Wheat Breeding Program in Context to Global Climate Change

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Citation:
Ayrancı R., Bagci SA., 2020. Utilization of Stress Tolerant Local Genotypes in Wheat Breeding Program in Context to Global Climate Change. Ekin J. 6(1):11-26, 2020.

Received: 16.08.2019 ***Accepted: 20.10.2019*** ***Published Online: 27.01.2020*** ***Printed: 27.01.2020***

ABSTRACT

Global climate change is one of the most important factors threatening world food security. Agriculture has a key role in the sustainability of life. The weakest aspect of agricultural production is that it is very susceptible to the effects of changes in climate factors. At the beginning of climate change in the world and in our country, increasing air temperatures and drought generated attention. Cereals have a very important role in ensuring world food security. Wheat has the maximum cultivated area among cereals and is mostly grown in rain-fed areas. Global climate change and consequent environmental stress factors cause significant yield losses in wheat. Many preventive measures are being taken to reduce the impacts of global climate change. One of these measures is to improve new wheat varieties that are resistant or tolerate to environmental stress factors. The greatest need for wheat breeding programs is the availability of appropriate genetic resources and genotypic diversity that can adapt to changing climatic conditions. In this context, local varieties offer an important potential of gene resources in terms of resistance to marginal climatic conditions. In Turkey, local varieties have been widely used in breeding programs since the 1960's. Gerek 79 (BW), Dağdaş-94 (BW) and Kızıltan-91 (DW), most tolerant varieties in dry conditions, have been widely grown during winter in /facultative regions. Those varieties have local hybrid varieties such as Yayla-305, Ankara-093/44 and Uveyik, respectively.

Keywords: Breeding, climate change, drought, landraces, wheat

Introduction

Global climate change directly affects crop production systems, which are the source of world food security through ecosystems. Perhaps, the most important result of climate change for our country and the Mediterranean Region in which our country is located is that the high pressure band around 30 degrees latitude will shift towards the poles with the increase of the average temperature in the world. In terms of Turkey, the central, southern and southeastern regions are already within the semi-arid climate zone and face the risk of desertification. Climate change, which will further increase its impact in the near future, will transform the climate of the southern half of our country into a climate similar to our southern neighbors Syria and Iraq, and our central and northern regions will face the climate structure of our southern regions. For our country, this means that the risk of drought and desertification will increase in all regions.

The industry and high technology developed by mankind have polluted our global living environment and atmosphere and warning bells are tolling with global climate change. Global organizations, states, universities, research institutions and scientists are making great efforts both to restore our ecosystem which is deteriorated by global climate change back to factory settings and take measures against the devastating effects of this change. In this context, wheat production areas, which are at the center of many sectors affected by global climate change and which are the most important plant species in terms of agriculture and world food security, are waiting for an urgent solution. In addition, there is a need for new varieties with strong adaptability to adapt to changing environmental conditions and relevant roadmaps to be followed.

In this study, global climate change, its impacts, threat areas and the current situation are examined and in this context, the aim is to evaluate the situation of our wheat gene resources which will shed light on the solution of the problem and to examine the solutions that can be generated with wheat breeding programs.

Global Climate Change

Global climate change is one of the most important factors threatening world food security. The climate, which expresses the average condition of weather conditions observed for many years anywhere in the world, also includes extreme values and statistical changes in weather conditions. Climate scientists describe climate change as long-term and slowly developing changes in climate conditions with large-scale (global) and significant local impacts (Türkeş 2008). The annual average of hot and cold periods shows a difference of 10^{o}C. To the best of our current knowledge, there have been many natural changes in the climate system throughout the world's 4.5 billion-year geological history. Climate changes in geological periods, did not only change the geography of the world through glacial movements and sea-level changes, but also caused significant changes in the ecological systems.

The greenhouse effect is one of the most important natural factors for the climate system. Plant greenhouses pass short-wave solar rays, while preventing a major part of the ground (thermal) radiation with long wavelengths from escaping. The thermal radiation held in the greenhouse heats the greenhouse and forms a suitable growing environment for plants. A similar situation is observed in the atmosphere. In cloudless and clear weather, a significant portion of the short-wave solar rays reach the earth through the atmosphere and are absorbed there. However, a portion of the long-wave ground radiation emitted from the hot surface of the earth is absorbed by a large number of trace gases (greenhouse gases) in the upper levels of the atmosphere before escaping into space, and then released back to Earth. The most important natural greenhouse gases are water vapor (H_2O) followed by carbon dioxide (CO_2), methane (CH_4), diazotmonoxide (N_2O) and the ozone (O_3) gases found in the troposphere and the stratosphere (atmosphere part above the troposphere)(Türkeş 2007). In average conditions, the radiation from the sun and the long wave ground radiation that escape into space are balanced. This natural process which regulates the heat balance is called greenhouse effect because the gases in the atmosphere are permeable to incoming solar radiation and in contrast the long wave ground radiation released back is much less permeable and as a consequence the earth warms more than anticipated. As a result of the increase in the impact of industrialization, the greenhouse gas concentrations in the atmosphere are well above the past levels measured or determined by analysis, causing the global climate to change.

Some Effects of Global Climate Change

Significant changes in the global hydrological cycle due to global climate change, such as the melting of land and sea glaciers, rising sea levels, displacement of climatic zones and increasing epidemic diseases, are expected to incur significant changes that will directly affect ecological systems and human life. Although scientific studies on this subject have begun long ago, international steps have been taken to attract the attention of the world since the early 90s and necessary warnings have been made to countries. In this context, global climate change is one of the most important factors threatening world food security. Food security, which means that all human beings are physically and economically accessible to healthy and adequate food, has always been at the center of mankind's struggle for existence and has been the strategic target of all states since ancient times to the present (Şahinöz 2016). The starting point of the process related to food security is agriculture where the first form of food emerges. In this sense, agriculture has a key role in sustaining life. The weakness of agricultural production is that it is very vulnerable to the effects of changes in climate factors (Şaylan 2010). In terms of agricultural areas, rising air temperatures and drought are the most important risks caused by global climate changes. This is followed by the effect of changes in the precipitation system. What needs to be emphasized here is the expected change in the distribution of precipitation, although the total annual precipitation of the world will increase slightly. Climate change is expected to increase the duration between precipitations and the severity of precipitation. Increasing the time between two precipitations means meteorological drought for us. Increasing the intensity of rainfall increases the number and strength of floods on the one hand, and on the other hand the soil does not have time to absorb water which means that soil moisture will decrease and ground waters cannot be adequately supplemented. The ideal situation in terms of soil is some rain every day. In this case, both the amount of water in the soil layers increases, and the seepage accumulates and feeds the groundwater resources. However, in sudden and severe rains, the water is swept away by floods into the sea before it can infiltrate into the soil and feed it. If we add to this the increase in soil water loss due to the increase in average temperatures, the magnitude of the problem awaiting us is manifested more accurately. In addition to the global problems posed by climate change, the Mediterranean Basin we live in is one of the most affected regions in the world. Since our country is located in this geography, it is a necessary step to examine the changes that await us in more detail. Solar energy is not evenly distributed across all parts of the world. This energy heats the equator belt much more and the poles much less. As a result, the heated air in the equator rises and a low pressure zone is formed. On the contrary, since the cooling air collapses downward at the poles, they are high pressure zones. However, even if the ascending air in the equator moves towards the poles, due to the rapid rotation of the earth, it collapses downward around 30 degrees latitude in the northern and southern hemispheres before it reaches the poles and forms a high pressure band. As a result, the presence of arid regions and deserts can be more easily known. Due to this movement in the atmosphere, the central latitudes of the Arabian Peninsula, the Sahara region in Africa, the region north of Namibia and South Africa, the Arizona and New Mexico states in the USA and the central regions of Australia are among the most well-known deserts in the world. Perhaps the most important result of climate change in terms of our country and our country's Mediterranean Region is the shift of this high pressure band around 30 degrees latitude towards the poles with the increase of the average temperature of the world (Quan *et al*. 2004; Frierson *et al*. 2007; Seidel *et al*. 2007; Johanson and Fu 2009). In terms of Turkey, the central, southern and southeastern regions are already within the semi-arid climate zone and face the risk of desertification. Climate change, which will further increase its impact in the near future, will transform the climate of the southern half of our country into a climate similar to our southern neighbors Syria and Iraq, and our central and northern regions will face the climate structure of our southern regions. For our country, this means that the risk of drought and desertification will increase in all regions (Türkeş 2007).

Drought is when rainfall is less than expected in an area. Therefore, there may be dry periods not only in regions with low rainfall but also in rainy regions. To mention drought, the time when precipitation is normal or below the expected level must last for at least one season or one year. In other words, drought occurs when rainfall is less than normal in a certain region (Mishra and Singh 2010).The occurrence of drought is influenced by the amount of precipitation as well as temperatures, relative humidity, high winds, timing and quality of precipitation, for example, whether rainfall occurs when crops are planted, rainfall rate and duration. Drought is a temporary deviation from normal, unlike aridity, which is a permanent climate characteristic. Drought is a transient condition, but can last for years, unlike heat waves that last no more than a few days or weeks and its impact is more severe when it is accompanied with heat waves.

According to the Intergovernmental Panel on Climate Change (IPCC) evaluation report, the increase in temperatures increases the likelihood of serious, widespread and irreversible effects. An increase of 1 or 2°C compared to pre-industrial temperatures increases the risks of climate change considerably. In the event of an increase of 4°C or more, global risks are considered high or very high and which will have a serious and widespread impact in terms of specific or threatened systems, global and regional food security and human activities such as food production or outdoor work (IPCC 2014).

The fact that even in the most optimistic scenario, warming in Turkey during 2016-2040 which is the closest period, will be between 0.5-1.5°C and more than 1.5°C in summer in the Aegean and Mediterranean regions is a source of concern (Hüdaverdi *et al*. 2016).

Global Climate Change and Agriculture

Most of the crop production in the world is done in dry agricultural areas depending on the amount and seasonal distribution of precipitation. The distribution of agricultural lands in the world is presented in Table 1. The total agricultural area that can be cultivated in the world is 1.6 billion ha and about 0.3 billion ha which amounts to 20% of this area is irrigated, while 80% (1.3 billion ha) of arable land is dry farmed (UN 2017).

When analyzed in terms of use of agricultural land in Turkey, it is seen that a large portion of the agricultural areas of crop production are in dry farming areas in a manner similar to the distribution in the world (Table 2). 6.600 thousand ha portion of the 23.375 thousand ha of agricultural land in Turkey with the exception of meadows and pastures (28%) is irrigated (DSI 2018) while the remaining 16.775 thousand ha portion (72%) is rainfed.

Cool climate cereals are the indispensable plants of rainfed agricultural areas. Cereals have a very important role in crop production and wheat has a very important role in ensuring world food security. As of 2018, the cultivation area of cereals in the world is 674.1 million ha, of which 394.4 million ha consists of hot climate cereals and 279.7 million ha consists of cool climate cereals. The proportion of cool climate cereals of wheat cultivation area in the world is 78% with 218.3 million ha (USDA 2019). In Turkey, 11.1 million hectares of cereals are planted, out of which 10.4 million hectares consist of cool climate cereals and wheat has a 74% share with 7.7 million hectares with cool climate cereals (TURKSTAT 2018).

It is evident that the wheat cultivation area is the most important product in a global sense in terms of total production and the amounts used in human and animal nutrition. Currently, 762 million tons of wheat is produced annually in the world (USDA 2019) and wheat provides an estimated 20% of the energy needs and 25% of the protein needs of the 7.2 billion population of the world (Tansı 2019). At the same time, wheat contributes to the nutrition of animals in a major way from which meat and milk are obtained and which have an important place in human nutrition. Any of the factors affecting wheat production and cost will affect all communities because wheat constitutes the largest part of the world production in international trade and it is the most traded agricultural product.

Global climate change and the resulting high temperatures and drought cause significant yield losses in wheat. There are some studies on economic losses caused by drought. According to Mishra and Singh (2010), the economic loss caused by the massive drought in 1988 was about $40 billion, and another study estimated that the drought between 1980 and 2003 incurred a cost of $144 billion. In Europe, drought has caused an average of 5.3 billion euros of economic damage per year since 1991, while the cost of the 2003 drought amounted to 8.7 billion euros. In Australia, where drought has become a chronic problem and the 10-year mega-drought between 1997 and 2006 has been called a historical record, the production of winter cereals decreased by 60% and the production of total cereals and livestock products decreased by 35% at the end of the drought in 2006 compared to the production in 2005 (Murphy and Timbal 2007) and this caused $ 3.5 billion in economic damage in the rural areas of the country (Mishra and Singh 2010).

Similar situations have also been experienced in Turkey. In the post-2001 period (November 2001-November 2006), precipitations deviating from normal in general in the winter, spring and summer of 2007 which were below long-term averages in many parts of the country led to a new series of meteorological drought events. Consequently, agricultural, hydrological and socioeconomic droughts occurred (Türkeş 2007). The droughts incurring in December 2006-August 2007 were effective, especially in Turkey’s Marmara, Aegean and Central Anatolian regions and in the western Mediterranean and West-Central Black Sea region. Agricultural drought, which was observed in March-April-May in the wheat production season in 2019, caused a 50-60% yield loss depending on the plant growth period, duration and intensity in the Central Anatolia region. In fact, in some sub-regions it was impossible to harvest the crop.

Measures to Mitigate the Impact of Global Climate Change

Many measures are being taken to reduce the effects of global climate change, such as the sustainable planning of agricultural water use and the development of cultivation techniques. Sustainability of agricultural water use depends on achieving both the plant production processes and the efficient management of water in a region by irrigating enough to meet the needs of the plants in the relevant area without compromising the continuity of water resources. In an age where high temperatures and droughts are on the agenda and we are experiencing their effects, human beings should be aware of the profound meaning of transforming a drop of water into a product.

In this context, the coordination of issues related to water management and drought in our country has been given to the General Directorate of Water Management by a decree law. The duties of the “Water Management Coordination Board” established for this purpose can be briefly listed as follows; (1) Determine the necessary measures for the protection of water resources within the framework of integrated watershed management. (2) Ensure inter-sectoral coordination, cooperation and acceleration of water investments for effective water management. (3) Develop strategies, plans and policies to achieve the objectives set out in national and international instruments. (4) Evaluate the implementation of the issues to be fulfilled by public institutions and organizations in watershed plans. (5) Ensure high level coordination and cooperation.

On the one hand, measures are being taken for the protection and effective use of water; while on the other hand, it is necessary to carry out studies for the identification of plant varieties suitable for changing climatic conditions and for the development of cultivation techniques. Climate change causes significant deviations in the adaptation of plants. In any region, the period between the last frost date of spring and the first frost date of autumn is considered as the plant growth season and therefore studies predict that the growth season will expand with the global climate change, the intensity of the temperatures will increase, the number of frosty days and the snow cover will decrease gradually during the winter period (Kadıoğlu 2017). This situation requires that the most suitable cultivation technique, rotation systems and plant varieties are determined according to the climate by carrying out new studies for changes that may occur in the adaptation of plants according to the changing climate order.

Wheat Breeding Programs

One of the measures to be taken against global climate change is the development of new varieties that are resistant or tolerant to environmental stress factors and compatible with changing environmental conditions. Breeding studies aim to develop new plant varieties with desired properties for any target growing area. Two basic backgrounds and infrastructure are needed to achieve these objectives.

Initially, the agro-ecological regions where new varieties will be produced should be well defined and the cultivation techniques to be applied in the region should be known. The characteristics that the new model plant will need to gain resistance and adapt to new environmental conditions will be defined by determining the characteristics of varieties grown in the relevant regions which will not thrive in the changing environmental conditions.

The second point is that the breeder has the genetic source and the genotypic variation that carries the characteristics (gene or genes) that are desirable in the new candidate varieties to be developed. Properties that provide plant resiliency against environmental stress factors that adversely affect plant growth such as high temperatures, drought, cold, and cause large yield losses, are quantitative characters controlled by multiple genes. The level and stability of plant resistance varies according to the number of genes controlling the resiliency property and their interaction with the environment. In this respect, the hereditary mechanism increasing the resiliency or tolerance of plants to environmental stress factors is complex. Considering the issue in terms of wheat which is a strategic product in ensuring food security, breeding programs have been carried out for the last 100 years in both Turkey and the world to develop varieties that enhance resilience against environmental stress factors. Many mechanisms (escape, tolerance, endurance, etc.) that can provide resistance or tolerance to environmental stress factors in wheat have been identified by valuable studies conducted by wheat breeders, agronomists and physiologists. In addition, agronomic, phenological, physiological, biochemical and molecular properties that control the defense system of wheat have been discovered (Ayrancı *et al*. 2010).The breeders' skill lies in determining the parent genotypes to be designed that have the strength, high yield and quality characteristics to adapt to the global climate change process and succeed in combining the superior characteristics of these genotypes in the model plants. Developing tolerant varieties for environmental stress conditions is much more difficult than developing high performance varieties for optimum conditions. As a matter of fact, when the new wheat varieties included in the national varieties list are reviewed, the low number of varieties developed for dry conditions in winter is quite astonishing. The most important way to overcome this challenge is to have access to genetic resources that possess the desired characteristics for the model plant and have sufficient genotypic variation in this regard.

Wheat Genetic Resources

Variation sources in a wheat breeding program include varieties involved in production, advanced lines obtained in the breeding program, introduction material and local genetic plant resources such as local populations. The varieties included in the production are the varieties which have gained a certain level of resistance with the genetic progress provided for breeding purposes by using the existing genetic resources (germplasm) when they were developed. These varieties also undertake an important function such as being a gene source for new varieties to be developed. Currently, these varieties are widely grown in stress environments, and there are situations where they cannot respond to the needs generated by global climate change. Therefore, there is a need for the development of new varieties that are resistant to marginal environmental stress conditions as well as resources with a more robust resilience. Another source of variation are advanced lines and these genotypes, which have reached the last stage of the breeding process but have not been able to become a variety when evaluated for all the characteristics they possess, can be used as a gene source again for one or more of the characteristics. Advanced lines are indispensable gene resources in breeding programs. When the historical processes of breeding programs are taken into consideration, advanced breeding lines are valuable genotypes that have been selected with a view on the breeding purposes and include carefully selected rootstocks based on hybridization studies covering tens of years and selection criteria covering different stress conditions and locations which have accumulated superior characteristics. At the same time, advanced lines can easily transfer these accumulated genetic properties to hybrid plants during hybridization. Therefore, advanced lines are widely used in breeding programs. Another source of variation that needs to be emphasized in breeding varieties is the introduction material. For example, a gene pool of certain types of wheat may exist in a country or region. If the genes in this gene pool are inadequate to meet the needs and if there are genes that control the desired properties in another part of the world, it is necessary to find ways to reach and use them. Improvement can be achieved with introductory material without too much trouble. As a matter of fact, national or international seed gene banks and breeding institutions carrying out international breeding programs offer very important opportunities in this field. In this context, when the breeding programs carried out in Turkey are evaluated, we can say that major successes have been achieved. An average yield level of 2800 kg/ha has been reached since the average yield level of 700-800 kg/ha during the early years of the Republic of Turkey (TURKSTAT 2012; TURKSTAT 2018). When the wheat yields in Turkey are considered separately for irrigated and non-irrigated conditions, in a normal year non-irrigated conditions will yield 5000 kg/ha while irrigated conditions will deliver 10000 kg/ha under research conditions and there are yet many paths to take in this area. Undoubtedly, the genetic base used in combination breeding, combining the desired properties in newly developed varieties and effective selection studies have played a very important role in the improvement of these yield levels as well as the contribution of the methods, technology and infrastructure used in breeding. Especially in recent years, breeding studies have been carried out, in order to endow the variety candidates with the desired characteristics in the shortest way, varieties which have provided a certain genetic progress, advanced lines and introduction material have been used as the genitor in hybridizations to reach the current yield levels. However, this approach narrowed the genetic variation in bread wheat varieties. Currently, there is a bottleneck in terms of parental genetic material in the formation of hybridization combinations for the development of new varieties that will ensure resistance to biotic and abiotic stress conditions due to global climate change.

Wheat Landraces

The solution to the problem regarding gene resources that are resistant to biotic and abiotic stress conditions caused by global climate is like in the past offered by landraces with their strong adaptation properties. In fact, Gökgöl characterized thousands of wheat landraces collected from all parts of Turkey between the years 1929-1955 and determined more than 18 thousand types and 256 new wheat varieties from among them which are an infinite treasure for plant breeders (Zencirci *et al*. 2018).Turkey is known as the gene center where the primary cultures of some plant species (wheat, barley, chickpeas, etc.) are carried out. For reasons such as its different climate and soil properties and different geographical regions, being located at the crossroads of Asia and Europe, covering the gene centers of the Mediterranean and Near East as well as three significant phyto-geographical regions put Turkey in a very important place in terms of germplasm in the world. Wild species of the same plant species and landraces are available among the gene resources in Turkey. Scientists have reported very important findings in studies on the collection, taxonomic classification and characterization of landraces, which are invaluable gene resources in the development of new plant varieties intended to reduce the effects of environmental stress factors caused by global climate change and threaten plant production (Akçura 2006; Özberk *et al*. 2010). In this context, some local varieties and resilience characteristics according to regions are listed as follows: (Table 4).

Numerous studies have been carried out in Turkey to determine the resistance properties of some local bread and durum wheat varieties against stress factors. In 1984, ICARDA carried out a study in Turkey which involved 2420 local durum wheat single spike samples collected from 172 locations in 28 provinces. The phenological and agronomic characteristics of Turkish durum wheat varieties were examined and important genotypic variations were determined in this study. It has been reported that the material constituted 8 different adaptation groups according to the environments from which they were collected and that the material had a high grain weight and early spiking properties that could be used in the wheat breeding programs targeting both normal environments as well as stress environments (Damania *et al*. 1996). On the other hand, the flag leaves of 90 wheat landraces acquired from nine Mediterranean countries including Turkey were characterized in terms of drought and cold stress (Pecetti *et al*. 1993). As a result of the study it was determined that the landrace wheat material obtained from Turkey had the highest level of tolerance against cold and there was a positive correlation between cold tolerance and the small flag leaves. Similarly, Tahir and Valkoun (1994) carried out a study in which 2806 wheat genotypes from different countries such as Turkey, Algeria, Ethiopia, Pakistan and Afghanistan were tested for cold tolerance. As a result of work carried out under field conditions, it was reported that the material collected from locations in Afghanistan, Algeria, Ethiopia and Pakistan had limited tolerance for cold and a high mortality rate while the material collected from locations in Turkey and Iran sustained vitality at -11 °C temperatures and had a higher survival rate than the materials from the other countries. (Dokuyucu *et al*. 2004) studied 14 physiological, agronomical and morphological characteristics collected from 63 local wheat populations in cultivation areas in Kahramanmaraş province and 10 local wheat populations obtained from the Aegean Gene Bank

National Institute of Agriculture. As a result of the evaluations, it was reported that there were 14 variety groups of local wheat varieties and that there were significant differences especially in terms of thousand grain weight, grain weight per spike, grain number per spike and grain weight. In a study carried out by Küçüközdemir (2016), 180 purified landraces collected from the Eastern Anatolia Region and 5 registered varieties were tested for tolerance to cold. As a result of the study carried out under laboratory conditions, it was reported that all registered varieties and 28 local genotypes survived at -13°C while 4 registered varieties and 7 landraces survived at -15°C. Local wheat varieties also have significant genetic potential in terms of resistance to biotic stress factors. Harlan collected 2.121 wheat landraces from different cultivation areas in Turkey between the years 1948-64. This material was tested for wheat rust diseases and the material which was susceptible to black rust was placed into protection in the gene bank. In the development of germplasm resistant to a yellow rust disease epidemic in the northwest of the USA 15 years after these studies, 51 lines carrying *Yr-10* resistance gene for yellow rust and *Bt-8, Bt-9, Bt-10* resistance genes for must disease were selected and these genotypes were used in the USA as a gene source for the development of new varieties (Damania *et al*. 1996).

A study was carried out on 200 selected pure local winter bread wheat lines collected from different provinces in Turkey to determine their reaction against some important fungal diseases and it was determined that four lines were resistant to yellow rust, 7 lines were resistant to brown rust, 4 lines were resistant to black rust and 1 line was resistant to smut (Akan 2017). In another study carried out by Mamluk and Nachit (1994) to determine new resistance resources for (*Tilletia foetida* and *Tilletia caries*) must disease in durum wheat, a genotype sequence formed from wheat landraces collected from Turkey was assessed by PCR and Cluster Analysis. As a result of this study, 26 genotypes were determined as new resistance resources against smut disease. In a study that examined the distribution of smut disease resistant resources based on geographical regions all over the world, it was reported thatthe wheat landraces of Turkey had a significant variation in terms of resistance to common and dwarf bunt (Bonman *et al*. 2006). In a study carried out by Poyraz and Gümüş (2016), the presence of some *Bt* genes (*Bt-5, Bt-8, Bt-10, Bt-11* and *Bt-12*) that control resistance to must disease were examined in 10 wheat varieties. In the study, it was determined that Kutluk and 4-11 wheat genotypes contain *Bt-10* and *Bt-11* resistance genes. (Imren *et al*. 2015) carried out a study with some modern bread wheat varieties, local varieties and culture varieties with landraces in their pedigrees for their reaction against root lesion nematode (*Pratylenchus thornei* and *P. neglectus*). The study reported that no modern wheat varieties were fully resistant to these diseases, that only landraces or cultured varieties with landraces in their pedigrees (4-11, P 8-6, Ankara 093/44, Sürak 1593/51, Yayla 305, Sertak, Kıraç 66) displayed a moderate resistant reaction. In 1977-78, a study was conducted for two years under field conditions at Eskişehir, in which14 wheat varieties were tested against mosaic virus disease. As a result of the study, it was found that Ak 702 and Zincirli varieties did not show any symptoms of the disease (Kurçman, 1981).

Using Landraces in Wheat Breeding Programs

The current ancestors of modern wheat varieties known in the world and Turkey are based on local wheat populations. Located in one of the important centers of the origin of wheat in the world, Turkey has a unique importance in this regard. Indeed, Skowmand and Rajaram (1990) reported that the parents of some registered varieties had been genotypes collected from Turkey and that wheat landraces had been used as genitors to develop many known wheat varieties. In the 1870's Turkey Red, bread wheat originating in Turkey which is included in the pedigrees of numerous modern varieties, was planted around Kansas City in the US for the first time. The genotype is known to have white grains, a high straw-hay yield and is known to be tolerant against rust diseases but susceptible to some other leaf diseases (Quisenberry and Reitz 1974). In the early years of the Republic of Turkey, seed breeding stations were established to counter the variety requirements in agricultural production and started wheat breeding work at these stations. In the early stages of the breeding work, Eskişehir Seed Breeding Station was established in 1925 (1925-1935) and efforts were carried out to develop new varieties by collecting the local populations in the hands of the farmers by means of batch selection or phase selection methods. Bread wheat varieties such as Ak 702, Sertak 52, Yayla 305, Sivas 111/33, Köse 220/39, Ankara 093/44, Sürak 1593/51, Kösemelez 1718, Hybrid 13, 4-11 and 4-22 were developed within this scope. On the other hand, durum wheat varieties such as Kunduru 414/44, Akbaşak 073/44, Karakılcık 1133 and Sarıbuğday 710 are among the varieties developed duringthis period (Altay and Kutalmış 2013). During the following years, on the one hand Research Institutes in Turkey were carrying out breeding works by selecting and developing wheat landraces for rain-fed stress conditions, and on the other hand landraces were included in crossbreeding programs as rootstock to develop stress resistant cultivars. As a matter of fact, Kunduru 1149 (Durum), Kıraç 66, Bolal 2973, Sürak 1593/51, Yektay 406, Berkmen 469 bread wheat varieties were developed and introduced into production. In the 1960s, intensive agriculture was introduced, however the available varieties were unable to adapt to this. Varieties from Mexico (CIMMYT) were imported and introduced, especially for coastal areas. Sonora 64, Inia 62, Pitic 62, Penjamo 62, Super x, Siete cerros varieties are among the varieties of this period. Out of these, only Penjamo 62 has been in production for many years while the others were discontinued due to yellow rust. Landraces have been widely used in Turkey by including them in hybridization breeding programs especially in the 1960s. In the 1970s, while the national breeding programs expanded on the one hand, the proportion of landraces within the germplasm used in hybridization programs began to decrease and the share of introduction material started to increase. It is noteworthy that there are landraces in the pedigrees of varieties that stand out in terms of resistance to stress conditions and stable adaptation. For example, Gerek-79 (BW), Dağdaş-94 (BW) and Kızıltan-91 (DW) are the most tolerant varieties for arid conditions and are widely grown in winter / facultative regions. There are landraces in the hybrids of varieties such as Yayla-305, Ankara-093/44, Kıraç 66, Hybrid 13 and 4-11, respectively. The pedigrees of some modern varieties (Bezostaya-1, Gerek-79, Kutluk-94, Karahan-99, Bayraktar-2000, Nacibey) for which landrace wheat varieties have been used as gene resources are shown in figures 1, 2, 3, 4, 5, 6.

Currently, 45 agricultural research institutes, faculties of agriculture and privately owned research institutes in Turkey are carrying out breeding works with various plant species and mostly wheat. At the same time, agreements were signed with the International Maize and Wheat Improvement Center (CIMMYT) and the *International Center for Agricultural Research in the Dry Areas* (ICARDA) in 1980 and 1986, and the International Winter Wheat Development Program (IWWIP) was established. Thus, Turkey is developing new wheat varieties, within ~~a~~ wheat breeding program system that is integrated with the world.

However, at the point reached today, when the varieties included in the national varieties list which are produced as seed and offered to farmers within the scope of national seed production programs are examined, the number of stable varieties with a high tolerance level developed for stress conditions is considerably less than the number of high performance varieties developed for optimum conditions. The former seed varieties developed especially for marginal climate and soil conditions are discontinued from seed production programs or their production amounts are reduced because they cannot compete with the yield levels of modern varieties during normal years and the proliferation of new varieties produced by seed producers and their introduction into the production areas. Therefore, farmers' access to these seeds remains limited.

Conclusions

In order to reduce the destructive effects of marginal ecological conditions such as droughts and high temperatures in recent times, which are increasingly influenced by global climate change, agricultural producers should be offered alternative new varieties and certified seeds in which they can obtain satisfactory yields under these conditions. In order to contribute to the solution of this vital problem on a global scale, especially universities and breeding institutions should characterize the local gene resources of unique importance in the world again with current knowledge and technological infrastructure and make a more detailed screening and material with important genetic properties should be registered and all resources should be mobilized to develop new varieties with special adaptation capabilities to contribute to the solution of the global problem. What we want to emphasize here is not to repeat the past, but to discover what we need for the future. The loss of any genetic material that has been developed so far should not be tolerated because it is obsolete and must be kept in gene banks so that it can be reused in the future.

Genetic resources and local varieties that are uniquely important for global climate change are threatened by various elements of pressure. These include dam construction and water collection areas, industrialization, environmental pollution, urbanization and the development of intensive farming techniques. With the awareness that our genetic resources are entrusted to us for future generations, it should be a necessity to ensure the continuity and protection of these species and to protect them in gene banks with some supports if necessary, especially in ecologies where local varieties are cultivated.

Table 1. World agriculture areas, 2017

	Area (Billion Ha)	Ratio to World Landarea (%)
World Land Area (Ice Free Land Area)	**13.2**	**100**
Agricultural Area (Fields and Horticulture)	**1.6**	**12**
Irrigated Agricultural Area	0.3	(20)
Dry Farming Area	1.3	(80)
Meadows and Pastures	**4.6**	**35**
Forest	**3.7**	**28**
The Other	**3.3**	**25**

Source: United Nations, 2017

Table 2. Agricultural areas in Turkey, 2017

Usage	Area ('000 Ha)
Total Agricultural Area	**37.992**
Total Cultivated Agricultural Area	**20.032**
Field Crops Area	
Cultivated Area	15.532
Fallow	3.697
Vegetable Gardens Area	798
Ornamental Plants Area	5
Total Perennial Plants Area	**3.343**
Orchards and Spice Plants Area	2.080
Vineyards	417
Olive Groves	846
Meadows and Pastures	**14.617**

Source: TURKSTAT, 2018

Table 3. Cereal planting area, production and yield in Turkey, 2017

Cereals	Area ('000 Ha)	Production ('000 Tons)	Yield (kg/da)	Share in Planting (%)	Share in Production (%)
Field Crops Area					
Planted Area	15.532				
Fallow	3.697				
Cereals (Winter type)					
Wheat	7.669	21.500	280	**68.9**	**59.5**
Barley	2.425	7.100	293	**21.8**	**19.7**
Rye	101	320	317	0.9	0.9
Oats	**113**	250	221	0.8	0.7
Triticale	46	150	329	1.02	0.4
Total	**10.373**	**29.320**		**93.3**	**81.2**
Cereals (Spring type)					
Maize	639	5.900	923	**5.7**	**16.3**
Rice	110	900	821	0.98	2.5
Millets	3	4.7	218	0.0	0.0
Total	**751**	**6.804**		**6.74**	**18.8**
Grand Total (Cereals)	**11.124**	**36.124**		**100**	**100**

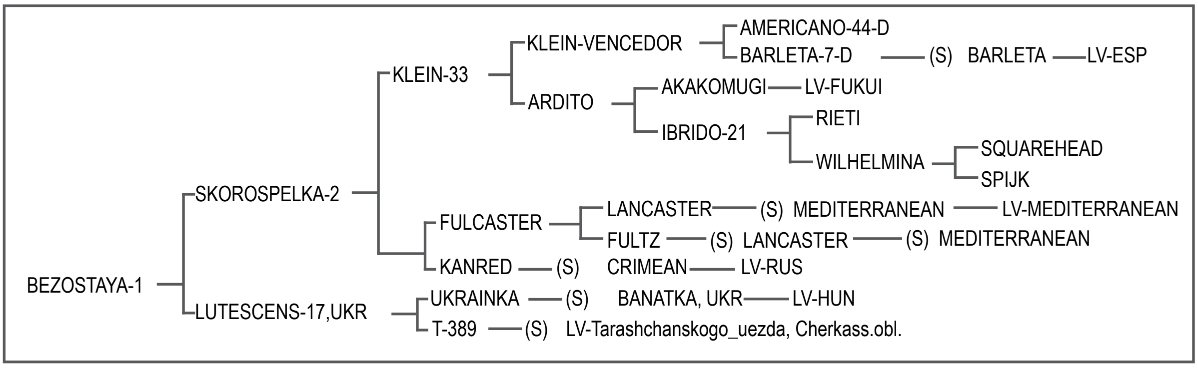
Source: TURKSTAT, 2018

Table 4. The characteristics of some wheat landraces in Turkey according to regions.

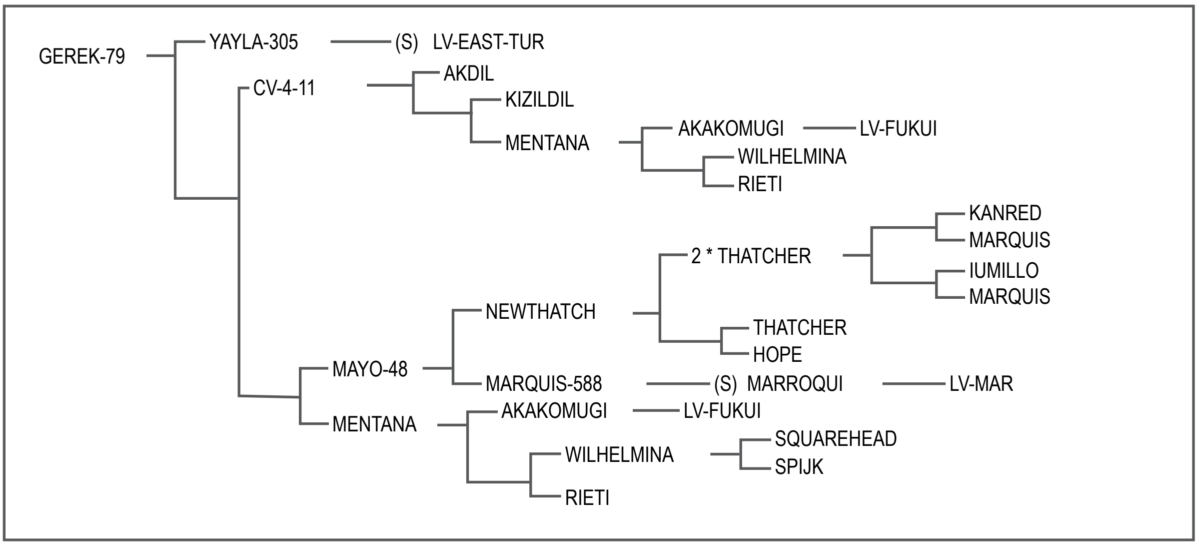
Regions	Landraces	Resilience Properties
Thrace and Marmara Region	Akbaşak (*T. durum* Desf. v. *leucurum* Al.) Tunus (*T. durum* Desf. ssp. *duro-compactum* Flask. v. *recognitum* Perc.)	
Aegean Region	Bindane (*T. aestivum* L. ssp. *vulgare* Vill. v. *erythroleucon* Körn) Akova (*T. aestivum* L. ssp. *vulgare* Vill. v. *albidum*) Akpüsen veya Çam Buğdayı (*T. durum* Desf. v. *leucurum* Al.)	
Mediterranean Region	Yerli, Kıbrıs Buğdayı and Amik (*T. durum* Desf. v. *affine* Körn) Havrani	
Central and Eastern Anatolia Regions	Köse (*T. aestivum* L. ssp. *vulgare* Vill. v. *delfii* Körn.) Zerun, Zeron or Zerin, Conkesme Kırik, Polatlı Kösesi	Resistant to winter conditions, drought, rust and must diseases.
	Kışlık veya Germir (*T. aestivum* L. ssp. *vulgare* Vill. v. *erythroleucon* Körn.)	Resistant to adverse winter conditions, drought, rust and smut diseases.
	Asıl Germir (*T. aestivum* L. ssp. *vulgare* Vill. v. *graecum* Körn.) Sünter (*T. aestivum* L. ssp. *vulgare* Vill. v. *erythroleucon* Körn.)	Tolerant to must and rust diseases but very low tolerance to adverse winter conditions and drought.
	Kızılca (*T. aestivum* L. ssp. *vulgare* Vill. v. *ferrugineum* Körn.)	Resistant to adverse winter conditions, drought and lodging.
	Kızıl Topbaş (*T. aestivum* L. ssp. *compactum* Host. v. *rubriceps*) Şahman, Kunduru, Üveyik (*T. durum* Desf. v. *hordeiforme* Körn.)	Resistant to must disease, moderately winter conditions, more resistant to drought.
Black Sea Region	Sarıbaş (*T. durum* Desf. v. *hordeiforme* Körn) Diş Buğdayı (*T. durum* Desf. v. *leucurum*Al.)	
Southeastern Anatolia Region	Sorgül (*T. durum* Desf. ssp. *duro-compactum* Flask. v. *pseudo-hordeiforme* Flaks.)	A tall plant, the lodging variety has a limited tolerance for significant leaf diseases
	Havrani (Haran)	
	Beyaziye, Şemsati	Resistant to cold, heat and drought

Source: Özberk *et al*. 2016

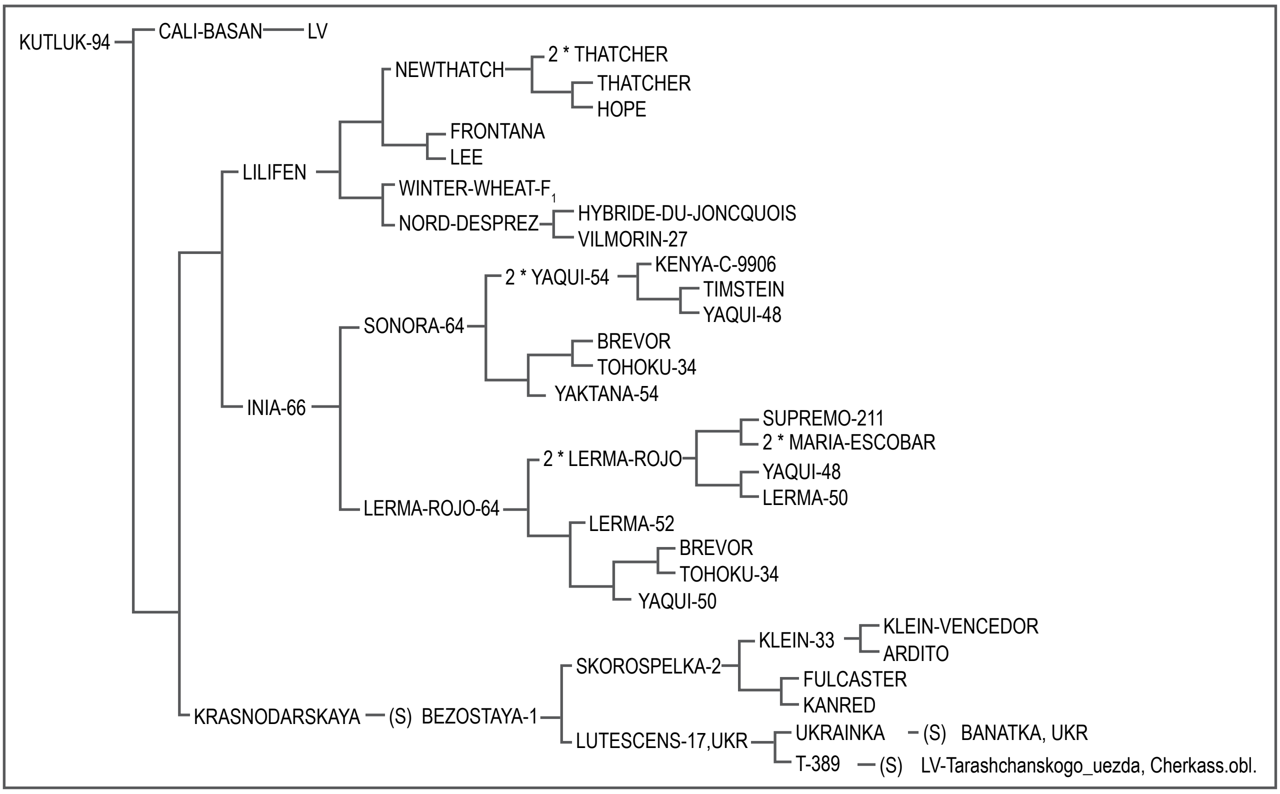
Figures 1. The pedigree of Bezostaya-1



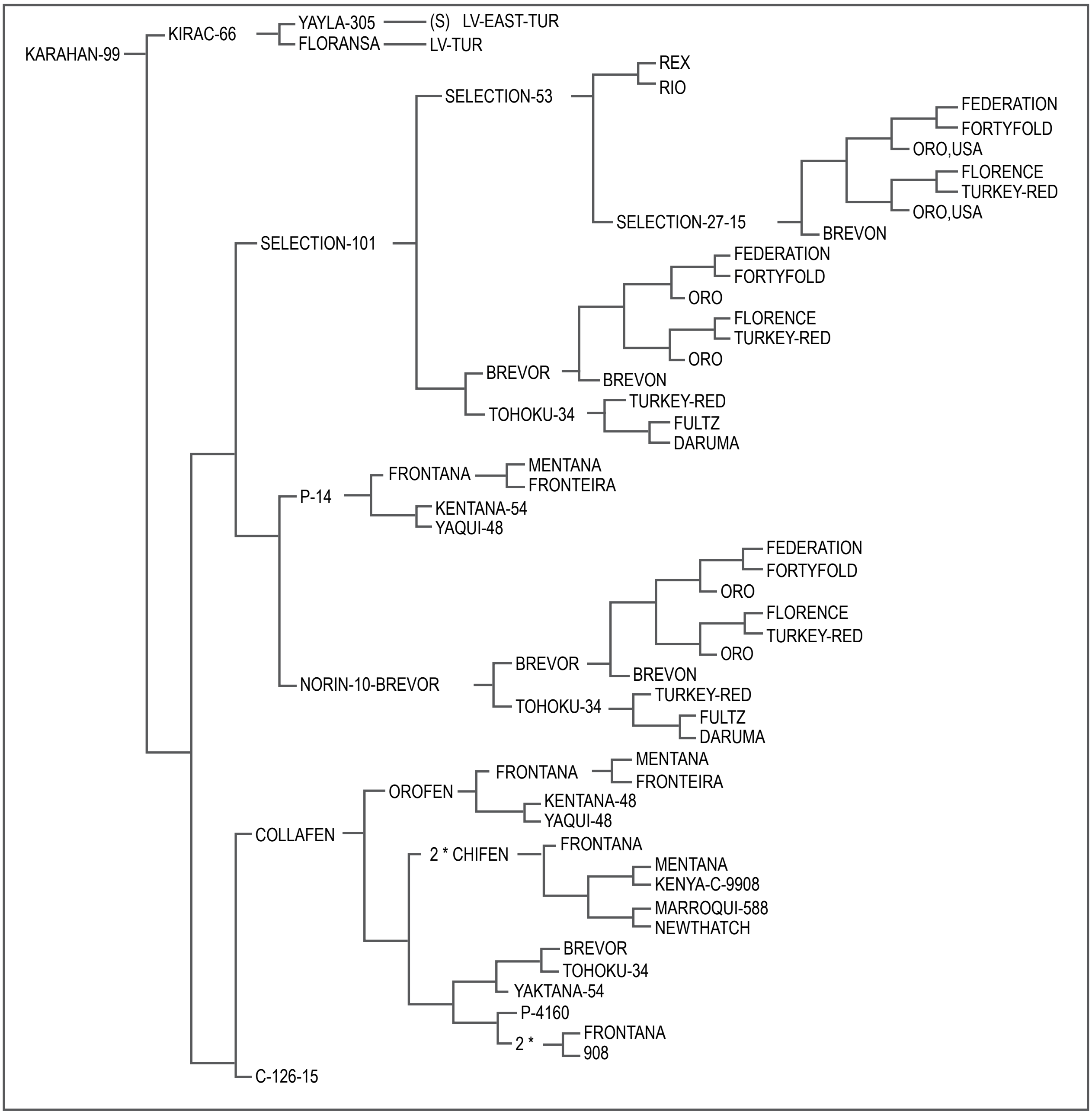
Figures 2. The pedigree of Gerek-79



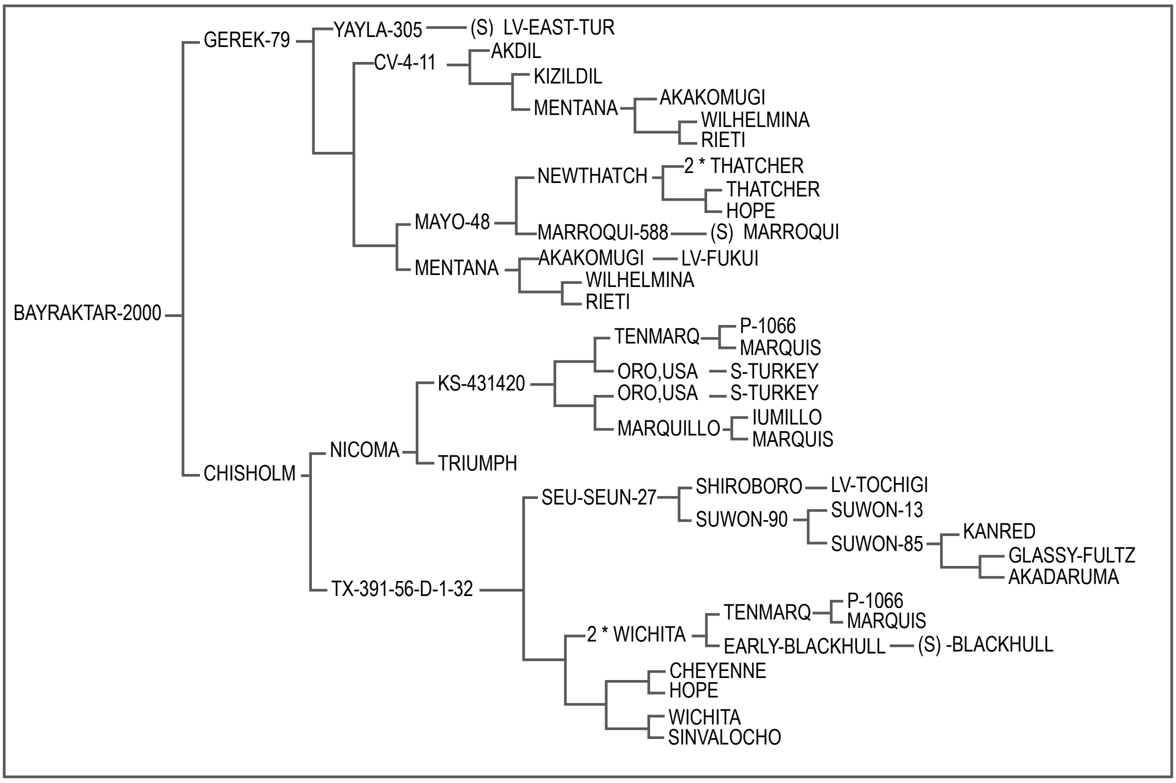
Figures 3. The pedigree of Kutluk-94



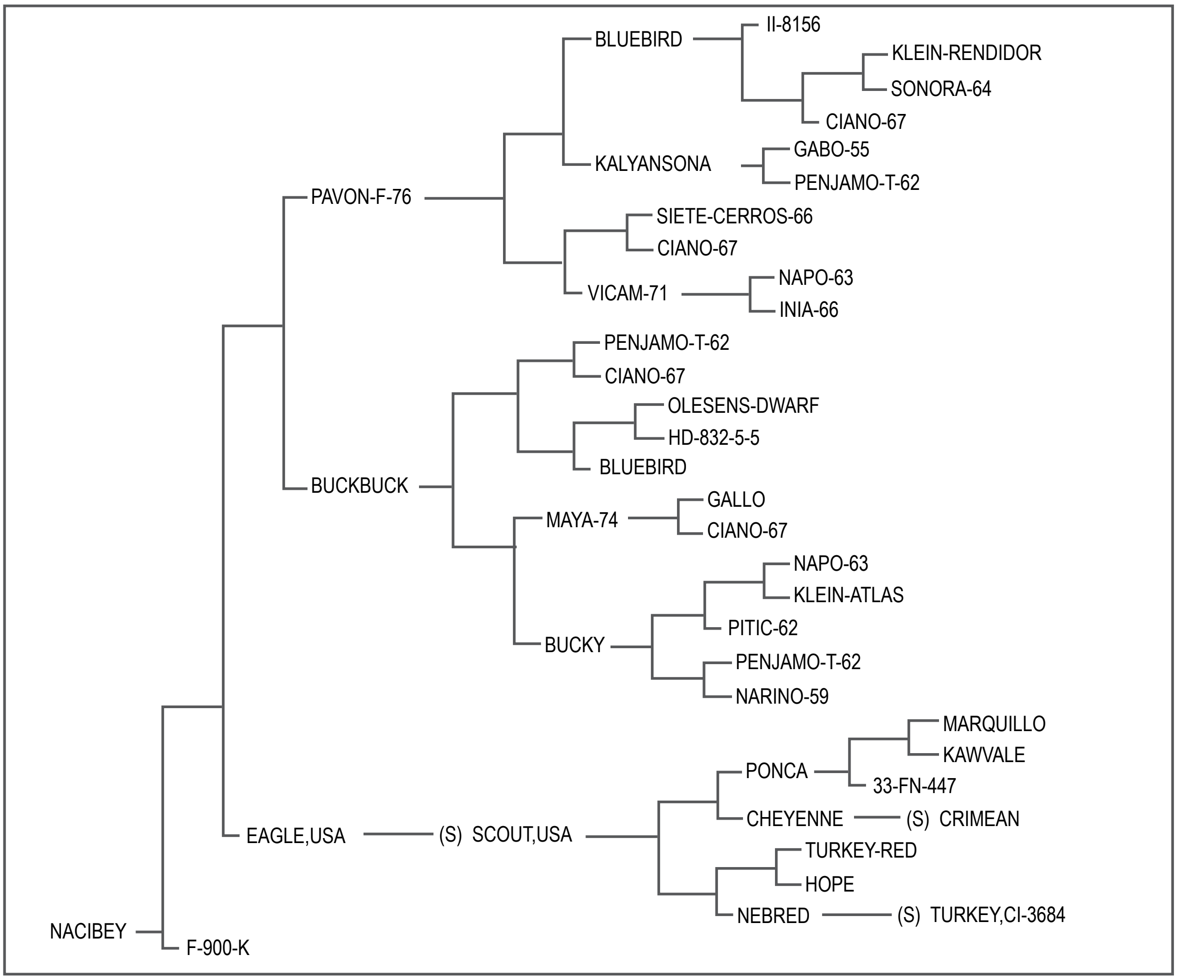
Figures 4. The pedigree of Karahan-99



Figures 5. The pedigree of Bayraktar-2000



Figures 6. The pedigree of Nacibey



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