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Mirza Gökgöl: Plant Scientist, Seed Collector, Agronomist, Breeder and Archaeo-Botanist

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ABSTRACT

Mirza (Hacızade) Gökgöl (1897-1981) was an outstanding scientist with multiple talents and he had worked as plant scientist, seed collector, agronomist, plant breeder, botanist and archaeo-botanist. Despite the many challenges, he faced during his education and business life, he made many innovations, published several books and articles in the area of seed science, agronomy, wheat systematic, plant breeding and even archaeo-botany. The purpose of this review article is to recognize and appreciate Mirza Gökgöl's contributions to the scientific world.

After completing his Ph. D. program in Germany, M. Gökgöl established Istanbul Yeşilköy Agricultural Research Station, performed extensive seed collecting missions for landraces and wild relatives of cultivated crops, mainly of cereals, performed characterization and breeding programs with the collected germplasm, contributed to development of Crop Domestication Theory (Gene Centres Theory), published numerous scientific research papers and books on Turkey's plant genetic resources, highlighting their significance and adverse effects of their likely loss. His publications are still among the mostly credited references in the area of plant genetic resources.

Most of the bibliographic information cited here is extracted from his personal file kept at the archive of the Ministry of Agriculture and Forestry, Turkey. Apart from the archival information, I have also referred to members of his family through personal communications, to his publications and all the available published materials about Gökgöl.

***Keywords*: Seed, seed collecting, genetic resource, biography, plant breeding

Introduction

Mirza (Hacızade) Gökgöl was born into the family of a merchant in Ganja City of today's Azerbaijan on September 14, 1897. As he indicated in his handwritten Turkish CV, his mother was Yakut and father Yusuf Hacızade (Figure 1).

He started elementary school education in 1906 in Male High School of Ganja and graduated in 1915. After elementary school, Mirza went on his education in the Novoaleksandriysk Institute of Agriculture and Forestry, Kharkov, Ukraine in autumn 1916. Almost simultaneously, the Russian Revolution broke out at the beginning of 1917. Young Mirza had to return home late 1917 due to turmoil during the revolution. Then he enrolled in High Agriculture School of Portici town of Italy at the beginning of 1919 (Figure 1). The same year Azerbaijan Government decided to send some students abroad for higher education (Zencirci *et al*. 2018). Young Mirza was one of them. Finally, he went to Berlin Agricultural College in November 1920 and graduated in 1924. He worked with professor of genetics Dr. Erwin Baur and professor of general agriculture Dr. Kurt Opitz at Berlin, and got the title of Doctor of Agriculture in 1926 and received his Ph.D. diploma, signed by Rector Prof. Aereboe on 15 April 1930 (Figure 2).

While Mirza continued his education in Berlin, problems began to arise in communication as well as in money transfer with Azerbaijan. After April 1920, the Turkish Republic took on his expenses to complete his education. Mirza Gökgöl's son Demir K. Gökgöl (1937-2012) informed on a telephone call from Germany that his father experienced serious financial difficulties those days (personal communication 1999).

After completing Ph.D. study, Mr. Süreyya of the Ministry of Agriculture, on behalf of the Minister Sabri Toprak, sent a letter to Halkalı High School of Agriculture on 26.08.1926, stating that "a very well educated person, trained by Prof. Bauer and several other distinguished Professors, scientifically capable of accomplishing the missions, Mirza Hacızade, who is of Azerbaijan origin, is appointed as "seed breeder" for Halkalı High Agriculture School". Additionally, he asked the director (in the document, director is mentioned as rector) of the School to allocate him necessary amount of land, equipment, tools for seed breeding activities, and sufficient budget for basic expenses. It was also stated due to the reason that he was of Azerbaijan origin, he might have linguistic difficulties in the beginning, but it was expected to speak Turkish properly in a short time. It was requested from the president to open a "plant breeding" course in the curriculum to be given by Dr. Mirza Hacızade, when he improves his language (Figure 3). In 1931, Halkalı High Agriculture School was relocated in Yeşilköy and was later transformed into the Yeşilköy Research and Experimenting Institute.

The Surname Law of the Republic of Turkey was adopted on June 21, 1934. The law requires all citizens of Turkey to adopt the use of hereditary, fixed surnames. His son Demir K. Gökgöl stated on a telephone call from Germany (personal communication 1999) that, his father was frequently mentioning the lake Göygöl nearby Ganja and chose "Gökgöl" as last name (Figure 4) on 17.12.1934 ("*Göygöl*" in Azerbaijani language stands for *Gökgöl* in Turkish. It is a combination of two words. "*Gök*" means "blue" and "*Göl*" means lake. Altogether it can be translated as "Blue lake"). Göygöl in Azerbaijan was declared as National Park in 2008.

Mirza Gökgöl and his wife Zühre Gökgöl had one daughter (Şule) and three sons (Selçuk, Oğuz Yusuf and Demir Kayhan). After retirement, he served as a visiting professor in Istanbul and Izmir universities. He was offered a position at the Göttingen University (Gökgöl and Taşan 1970; Karagöz 2012), but he preferred to take took short term positions at several German universities. Gökgöl retired on 7 June 1961 and passed in 1982. His grave is in Istanbul Sultanahmet Cemetery.

Mirza Gökgöl's contributions to agriculture and plant science

Mirza Gökgöl and the well-known Russian scientist, N.I. Vavilov (1887-1943) were born in the same year and their path coincided many times. Both of them acknowledged the importance of genetic diversity in crop improvement, so they began collecting genetic material. Russian scientist P.M. Zhukovsky (1888-1951) commission by Vavilov conducted three expeditions to Anatolia during 1925-1927 and collected 10.000 samples. From time to time Gökgöl provided logistic support to Vavilov's teams during their missions. Zhukovsky compiled his work in a book (Zhukovsky 1951) and acknowledged Gökgöl and his colleagues in the foreword for their cooperation during the missions. The book gives detailed information on the performances of 17 Turkish origin crop species tested at various parts of Russia. He declares that "From the researches, it is understood that Anatolia is the origin of many valuable cultural plants. Due to its location at the confluence of three continents, it is certain that Anatolia is the origin of seeds such as summer soft wheat, pulses, best sesame types, carrots, anise, melon, cucumber, alfalfa, poppy, fruit and grape which are grown all over Europe". Turkish material exceeded the yield and quality in several parts and has been the basis for breeding studies in Russia (Zhukovsky 1951).

Gökgöl collected seeds from all over Turkey between 1925-1950 with a support by the Turkish Government and the Ministry of Agriculture. He not only collected himself but also received landrace samples from locally organized government offices on his request. Finally, he succeeded to collect huge amount of material from all over Turkey. Gökgöl considered his wide diverse collection covered all genetic variation needed for wheat breeding in Turkey without any need for introductions from other regions or countries (Gökgöl 1935; 1939).

Gökgöl concentrated considerable part of his studies on cereals, mainly wheat. After characterizing and evaluating thousands of accessions, he published his two volumes of books "Wheats of Turkey" (Gökgöl 1935; 1939). In these books, all the material has been botanically identified and morphologically evaluated. Among the evaluated material, he identified and published 256 new wheat varieties (Gökgöl 1955) out of 18.000 accessions. He first released "Karakılçık" durum wheat and "Zafer" barley varieties out of the material. A picture taken while Gökgöl was working in field is given in Figure 5.

Several years after the publication of Wheats of Turkey (1939), Gökgöl published classification key for all Turkish wheat varieties in full details with illustration in Gökgöl (1955). A selection of some of his publications are given in Figure 6.

Food needs of the growing population of young Turkish Republic were increasing rapidly. Being aware of this fact, Gökgöl conducted various researches on crops other than cereals such as forages, pulses, oil crops, industrial crops, potato, tobacco and so on. During his scientific career, Gökgöl managed to publish 37 papers and books (Karagöz 2012; Zencirci *et al*. 2018) on a large group of plants, but mostly concentrated on cereals. Out of the published material 18 of them were about wheat. Apart from wheat, he published on barley (1), rye (3), oats (1), rice (1), foxtail millet (1), sugar beet (1), sunflower (1), tobacco (1), castor bean (1), poppy (1), potato (2), ground nut (2), luffa (1), sweet clover (1), subtropical crops (1). There were 5 more works that Gökgöl prepared for publication but failed to publish. These were written about lentils, chickpeas, peas, beans, and faba beans. Apart from his scientific publication, he finally published a book (Gökgöl and Taşan 1970) summarizing all the work done from the establishment of the research station to his retirement (Figure 7).

Gökgöl kept herbarium specimen of all of the material he studied. He visited the Aegean Agricultural Research Institute's (AARI) Gene Bank in İzmir after his retirement and donated over 4500 of them (Tan 2010; Maggioni *et al*. 2011). Among the herbarium specimen some are the type materials of newly identified varieties by him. One of Gökgöl's herbarium specimens is given in Figure 8 (No: 1029. Ankara Province, Kızılcahamam Town).

Mirza Gökgöl's contributions to Gene Centres Theory

During his stay in Berlin, one of his instructors was plant geneticist Elisabeth Schiemann (1881-1972). Prof. Schiemann was one of the leading plant scientists of twentieth century with many studies on the history of cultivated plants, phylogeny of the wheat-*Aegilops* group and of barley (Kilian *et al*. 2013). Schiemann and Gökgöl were deeply interested in Vavilov's theory on the centres of origin of cultivated plants and they were discussing this issue among themselves. Vavilov was considering the abundance of morphological variation in an area as the main indication for the area to be a gene centre. Hence Vavilov presumed Anatolia as gene centre for diploid einkorn wheat, Ethiopia for tetraploid wheat, Afghanistan and Iran for hexaploid wheats. To develop such a conclusion towards the definition of gene centres, Vavilov conducted extensive research on a huge number of materials. As mentioned above, Gökgöl was partly engaged in these missions, he also performed systematic collecting and characterization activities.

Based on the data derived from his field studies, Gökgöl declared that the number of botanical varieties grown in Turkey considerably exceeds the number grown in other regions of the World. Thus, Gökgöl (1939) concluded that, Anatolia and adjacent regions of Iran, Syria, Palestine and Southern Caucasus formed the centre of diversity and origin for diploid, tetraploid and hexaploid wheats. A few months later, Flaksberger came to the same conclusion using Vavilov and Gökgöl's collections (Zencirci *et al*. 2018).

Mirza Gökgöl's contribution to archaeo-botany studies

Mirza Gökgöl's expertise in plant identification has occasionally attracted the attention of archaeologists. The seed samples extracted from some excavations were identified by Mirza Gökgöl. He identified both the seeds of cultivated and wild plants unearthed from the excavation, and revealed the similarities and differences between the cultivars grown in the past and those grown at that time. In an archaeo-botany paper, Gökgöl (1938) gave the following information (translated from German) about the seeds extracted from the Alacahöyük excavation area (Figure 9):

"Seeds unearthed during the excavations at Alaca Höyük in 1936

I. Wheat. *Although the seeds found were generally charred and badly damaged, there were many seeds in which the shape was well preserved. We compared the excavated material with the rich collections of our seed farm in Yeşilköy near İstanbul, which came from Çorum and Yozgat, and it could be seen at first glance that at the time of the origin of these seeds, they were very large in terms of size and shape were more mixed than now, when on the one hand there were seeds that were the same size as today, but on the other hand there were also small grains that can no longer be found today. You can see from this that humans have been making a selection for thousands of years, probably by picking the largest ears, which has resulted in a certain balance of seed sizes and also varieties. The examination of the material shows that there was no selection and balanced varieties 5-6 thousand years ago.*

II. The remaining seeds. *Very well-preserved rye -(Secale cereale* L.*)- grain and two-row barley (Hordeum distichum) are recognizable among the seeds.*

Weed seeds are the easiest to recognize:

1. *From the Leguminosae family – Lathyrus hirsutus*
2. *From the Boraginaceae family - Cerinthe minor*
3. *From the Liliaceae family - Ornithogalum*
4. *From the family Caryophyllaceae - Gittago segetum* (todays name: Agrostemma githago)
5. *From the Umbelliferae family - Bifora*

Dr. Mirza Gökgöl

Director of the Institute for Plant Breeding at Yeşilköy - Istanbul"

Conclusive remarks

Despite the many problems he had experienced and unfavourable working conditions, Mirza Gökgöl managed to be a globally important scientist, accomplishing worldwide significant works in the field of collection, evaluation and utilization of plant genetic resources. He is a scientist who has made an indelible signature on the area of plant genetic resources.

Acknowledgements

I would like to express my special thanks of gratitude to Dr. Baydur Yılmaz (1941-2007), Ex-Director of Ankara Central Research Institute for Field Crops and Advisor to the Minister of Agriculture (2005-2007) for providing M. Gökgöl's personal file from the Ministry of Agriculture's Archive Department; Şule Aral (M. Gökgöl's daughter) for the picture in Figure 5, Dr. Andrew Fairbain of The University of Queensland, Australia and Nurdan Atalan Çayırezmez of Digital Repository Manager of the British Institute in Ankara for providing the paper in Figure 8, and Erdinç Oğur of AARI for proving the picture in Figure 6.

Mirza Hacızade Gökgöl (1897-1982)

Figure 1. Mirza Gökgöl’s hand written CV submitted to the Ministry of Agriculture (1927)

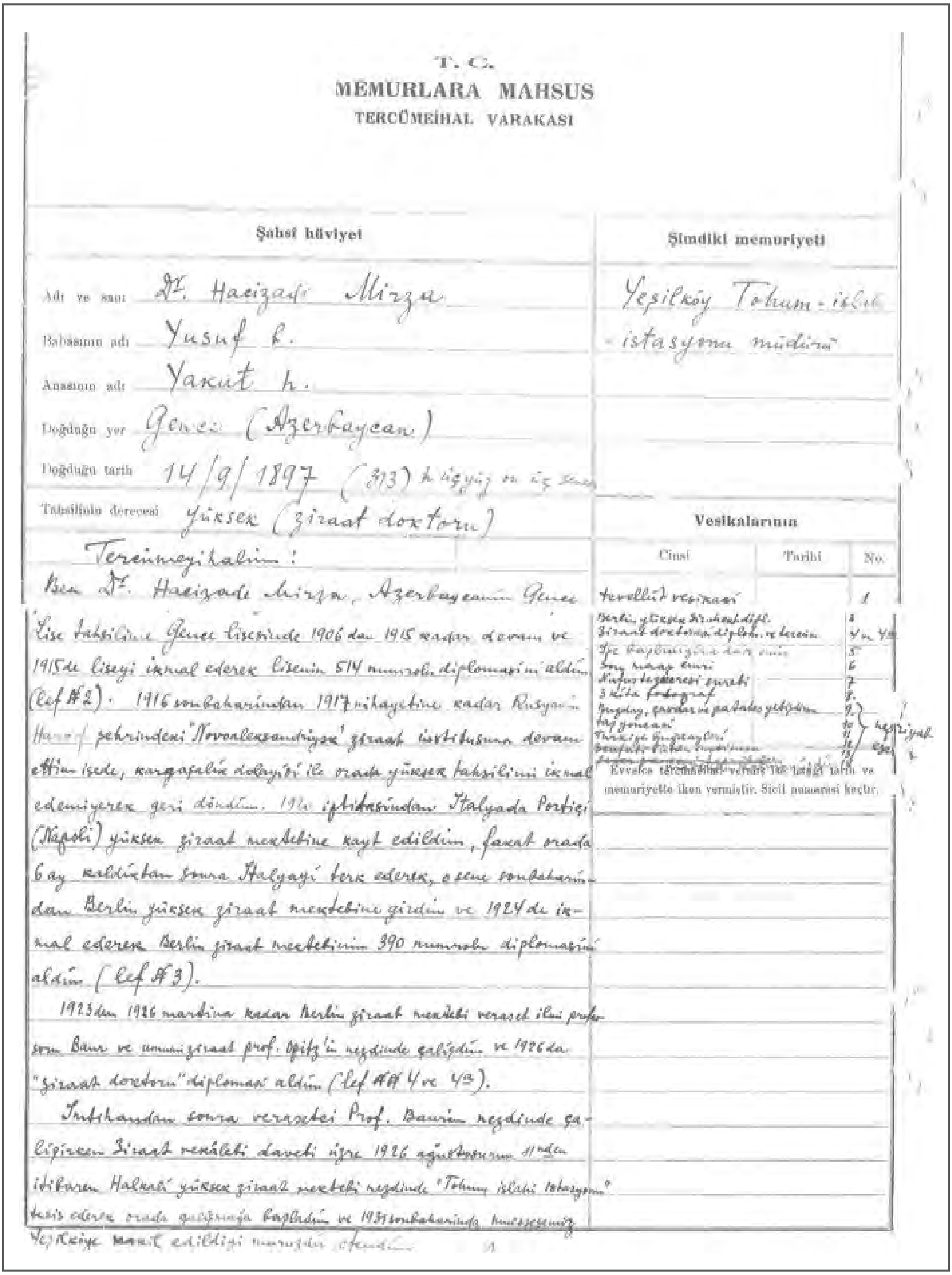

Figure 2. Mirza Hacızade's Ph.D. Diploma (1930)

#4.

Die
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Berlin

verleiht durch diese Urkunde

Herrn Mirsa Hadschi-Sade

aus Gandja (Aserbaidjan)

die Würde eines

Doktors der Landwirtschaft

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Professors Dr. Aereboe

durch seine Dissertation

„Ueber die Beziehungen zwischen dem Witterungsverlauf und der Höhe der Beschaffenheit des Weizenertrages"

sowie durch die vorgenommene mündliche Prüfung seine wissenschaftliche Befähigung erwiesen und hierbei das Zeugnis

„Bestanden"

erworben hat.

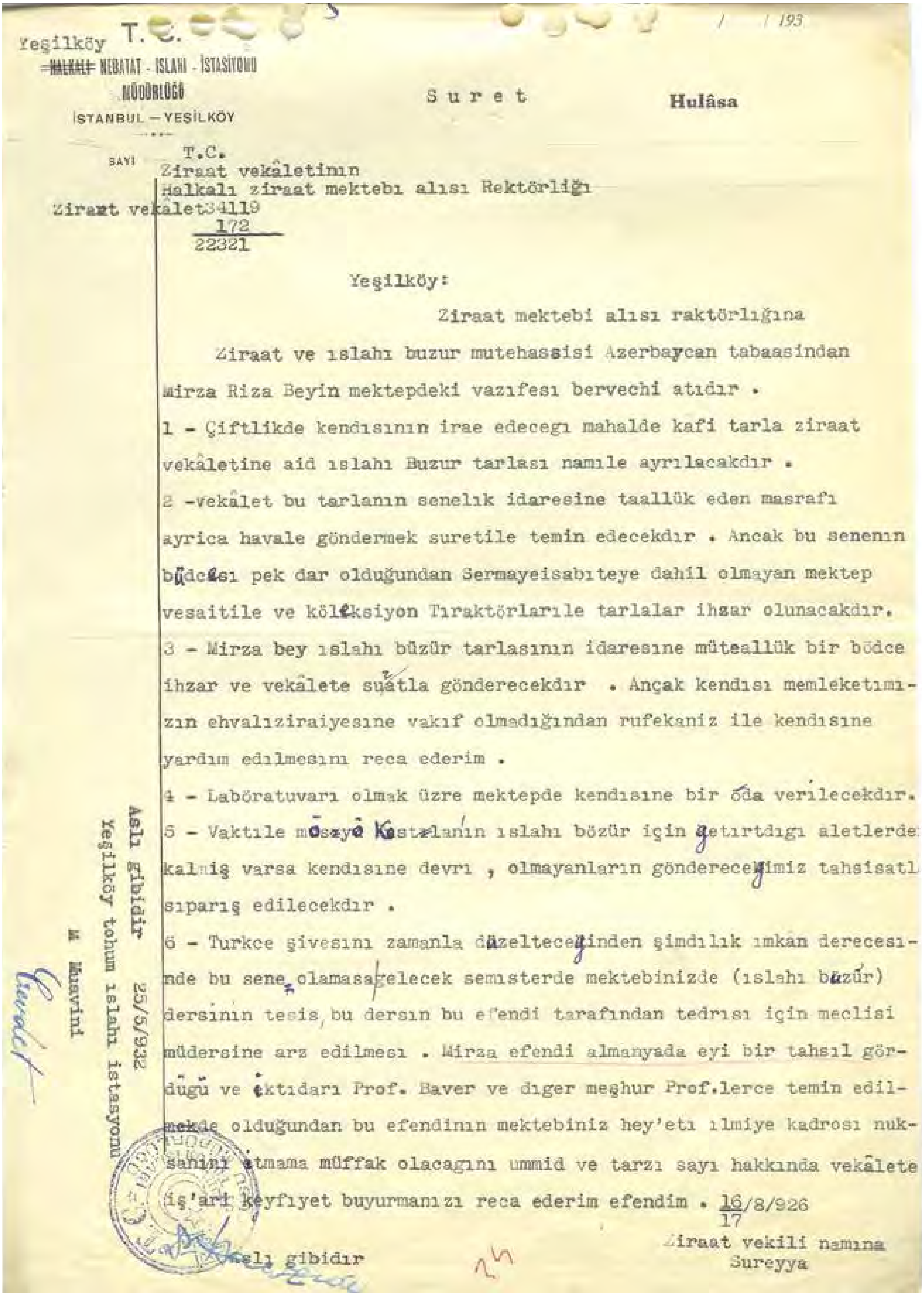
Berlin, den 15. April 1930.

LS

Landwirtschaftliche Hochschule Berlin.

Der Rektor
gez. Aereboe

Figure 3. Letter from the Ministry of Agriculture to Halkalı Agricultural School for the employment of Mirza Hacızade (1926)



Yeşilköy T.C. / 193

~~HALKALI~~ NEBATAT - ISLAHI - İSTASİYONU MÜDÜRLÜĞÜ

İSTANBUL — YEŞİLKÖY

Suret

Hulâsa

SAYI

T.C.
Ziraat vekâletinin
Halkalı ziraat mektebi alısı Rektörliği
Ziraat vekalet 34119
172
22321

Yeşilköy:

Ziraat mektebi alısı raktörlığına

Ziraat ve ıslahı buzur mutehassisi Azerbaycan tabaasindan Mirza Riza Beyin mektepdeki vazıfesı bervechi atıdır .

1 - Çiftlikde kendısının irae edecegı mahalde kafi tarla ziraat vekâletine aid ıslahı Buzur tarlası namıle ayrılacakdır .

2 -vekâlet bu tarlanın senelık idaresine taallük eden masrafı ayrica havale göndermek suretile temin edecekdır . Ancak bu senenın büdcesı pek dar olduğundan Sermayeisabıteye dahil olmayan mektep vesaitile ve kölleksiyon Tıraktörlarıle tarlalar ihzar olunacakdır.

3 - Mirza bey ıslahı büzür tarlasının idaresıne müteallük bir bödce ihzar ve vekâlete sürtla gönderecekdır . Ançak kendısı memleketımızın ehvalıziraiyesıne vakıf olmadığından rufekaniz ile kendısıne yardım edılmesını reca ederim .

4 - Laböratuvarı olmak üzre mektepde kendısıne bir oda verilecekdır.

5 - Vaktıle mösyö Kostalanın ıslahı bözür için getırtdıgı aletlerde kalmış varsa kendısıne devrı , olmayanların göndereceğimiz tahsisatl sıparış edilecekdır .

6 - Turkce şivesını zamanla düzelteceğinden şimdılık ımkan derecesınde bu sene olamasa gelecek semısterde mektebinizde (ıslahı büzür) dersinın tesis, bu dersın bu efendi tarafından tedrısı için meclisi müdersine arz edilmesı . Mirza efendi almanyada eyi bir tahsıl gördüğü ve iktıdarı Prof. Baver ve dıger meşhur Prof.lerce temin edilmekde olduğundan bu efendinın mektebiniz hey'etı ılmiye kadrosı nuksanını itmama müffak olacagını ummid ve tarzı sayı hakkında vekâlete iş'arı keyfıyet buyurmanızı reca ederim efendim . 16/8/926
17

Ziraat vekili namına
Sureyya

Aslı gibidir

Aslı gibidir 25/5/932
Yeşilköy tohum ıslahı istasyonu
M Muavini
Cevdet

Figure 4. “I accepted Gökgöl as my last name. My signature is below”


T. C.
TOHUM ISLAH İSTASYONU
YEŞİLKÖY - İSTANBUL

17/XII/

Ben Soy adı olarak Gökgöl ü aldım.

İmzam aşağıdadır.

Dr. Gökgöl

Dr. Mirza Gökgöl
Sicil numarası
(218)

Tasdik olunur.

26

Figure 5. Gökgöl working on genetic material in the field (Source: Şule Aral)

Figure 6. A selection of Mirza Gökgöl’s publications

Figure 7. Excerpt from Gökgöl and Taşan (1970)

Mirza GÖKGÖL

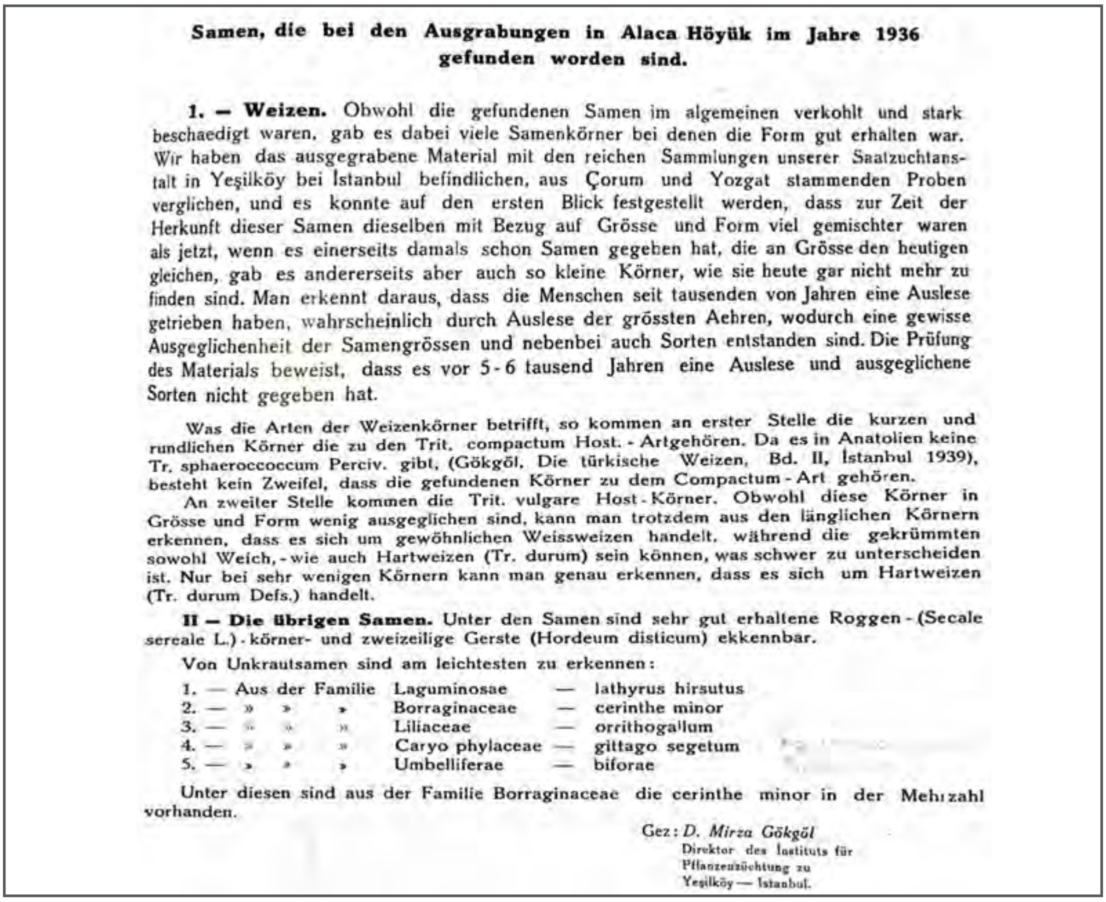
Azerbeycanın Gence şehrinde 1897 yılında doğmuştur. Lise tahsilini Gence'deki Rus Gimnazimunda yapmıştır. Yüksek tahsiline Rusya - Harkov'da başlamıştır. 1920 yılında İtalya - Napolideki Portici Yüksek Ziraat Okuluna kaydolunmuş ise de, aynı yıl Berline giderek Berlin Yüksek Ziraat Okulunda tamamlamış ve 1923 de buradan diploma almıştır. 1926 yılında da Ziraat Doktora diplomasını almışır. Aynı zamanda tohum ıslah müfettişliği kursuna da iştirak ederek ıslah müfettişi (Saatzucht-Inspektör) diploması almıştır.

1926 Tummuzunda Berline gelmiş olan zamanın Türkiye Ziraat Vekili merhum Sabri Toprak tarafından Tohum Islahcısı olarak Türkiyeye davet edilmiş. II/Ağustos/1926 yılında Halkalı Ziraat Mektebi Alisine bağlı Tohum Islah İstasyonunu kurmuş ve 1931 de İstasyonu Yeşilköye şimdiki yere nakletmiştir. Aynı Müesseseden Haziran 1961 tarihinde emekli olarak ayrılmıştır.

— 3 —

Figure 8. One of Gökgöl's herbarium specimens in AARI Gene Bank (No: 1029. Ankara Province, Kızılcahamam Town, Source: Erdinç Oğur)

Figure 9. Gökgöl M (1938). Samen, die bei den Ausgrabungen in Alaca Höyük im Jahre 1936 gefunden worden sind (Seeds found during the excavations at Alaca Höyük in 1936)



Samen, die bei den Ausgrabungen in Alaca Höyük im Jahre 1936 gefunden worden sind.

1. — Weizen. Obwohl die gefundenen Samen im algemeinen verkohlt und stark beschaedigt waren, gab es dabei viele Samenkörner bei denen die Form gut erhalten war. Wir haben das ausgegrabene Material mit den reichen Sammlungen unserer Saatzuchtanstalt in Yeşilköy bei İstanbul befindlichen, aus Çorum und Yozgat stammenden Proben verglichen, und es konnte auf den ersten Blick festgestellt werden, dass zur Zeit der Herkunft dieser Samen dieselben mit Bezug auf Grösse und Form viel gemischter waren als jetzt, wenn es einerseits damals schon Samen gegeben hat, die an Grösse den heutigen gleichen, gab es andererseits aber auch so kleine Körner, wie sie heute gar nicht mehr zu finden sind. Man erkennt daraus, dass die Menschen seit tausenden von Jahren eine Auslese getrieben haben, wahrscheinlich durch Auslese der grössten Aehren, wodurch eine gewisse Ausgeglichenheit der Samengrössen und nebenbei auch Sorten entstanden sind. Die Prüfung des Materials beweist, dass es vor 5-6 tausend Jahren eine Auslese und ausgeglichene Sorten nicht gegeben hat.

Was die Arten der Weizenkörner betrifft, so kommen an erster Stelle die kurzen und rundlichen Körner die zu den Trit. compactum Host. - Artgehören. Da es in Anatolien keine Tr. sphaeroccoccum Perciv. gibt, (Gökgöl. Die türkische Weizen, Bd. II, İstanbul 1939), besteht kein Zweifel, dass die gefundenen Körner zu dem Compactum - Art gehören.

An zweiter Stelle kommen die Trit. vulgare Host - Körner. Obwohl diese Körner in Grösse und Form wenig ausgeglichen sind, kann man trotzdem aus den länglichen Körnern erkennen, dass es sich um gewöhnlichen Weissweizen handelt, während die gekrümmten sowohl Weich, - wie auch Hartweizen (Tr. durum) sein können, was schwer zu unterscheiden ist. Nur bei sehr wenigen Körnern kann man genau erkennen, dass es sich um Hartweizen (Tr. durum Defs.) handelt.

II — Die übrigen Samen. Unter den Samen sind sehr gut erhaltene Roggen - (Secale sereale L.) - körner- und zweizeilige Gerste (Hordeum disticum) ekkennbar.

Von Unkrautsamen sind am leichtesten zu erkennen:

1. — Aus der Familie Laguminosae — lathyrus hirsutus
2. — » » » Borraginaceae — cerinthe minor
3. — » » » Liliaceae — orrithogallum
4. — » » » Caryo phylaceae — gittago segetum
5. — » » » Umbelliferae — biforae

Unter diesen sind aus der Familie Borraginaceae die cerinthe minor in der Mehrzahl vorhanden.

Gez: *D. Mirza Gökgöl*
Direktor des Instituts für Pflanzenzüchtung zu Yeşilköy — Istanbul.

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

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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°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**

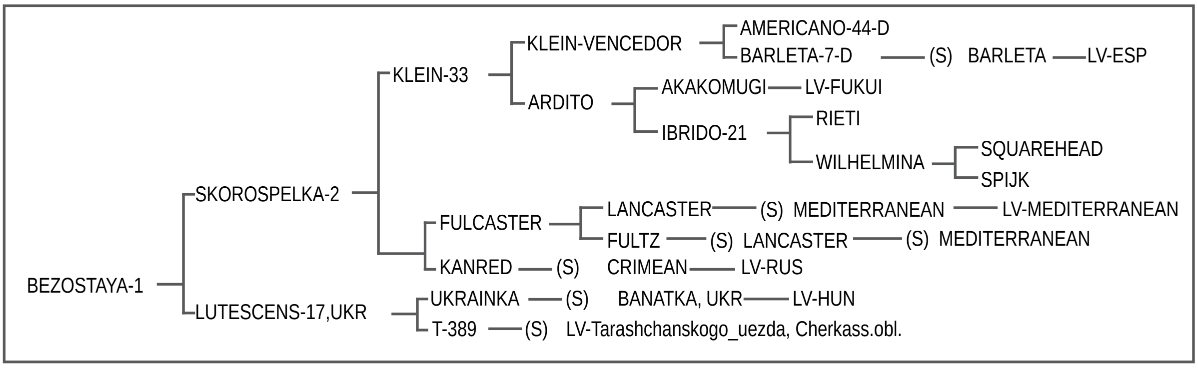
Source: TURKSTAT, 2018

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

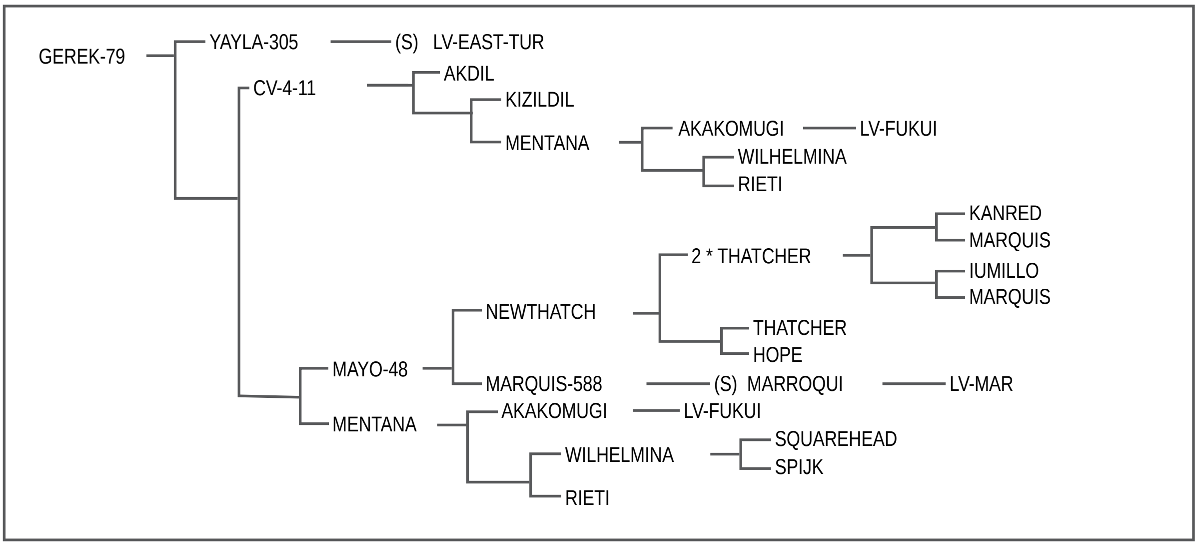
Regions	Landraces	Resilience Properties
Thrace and Marmara Region	Akbaşak (*T. durum* Desf. v. *leucurum* Al.) Tunus (*T. durum* Desf. ssp. *duro-compactum* Flask. v. *recognitum* Perc.)	
Aegean Region	Bindane (*T. aestivum* L. ssp. *vulgare* Vill. v. *erythroleucon* Körn) Akova (*T. aestivum* L. ssp. *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

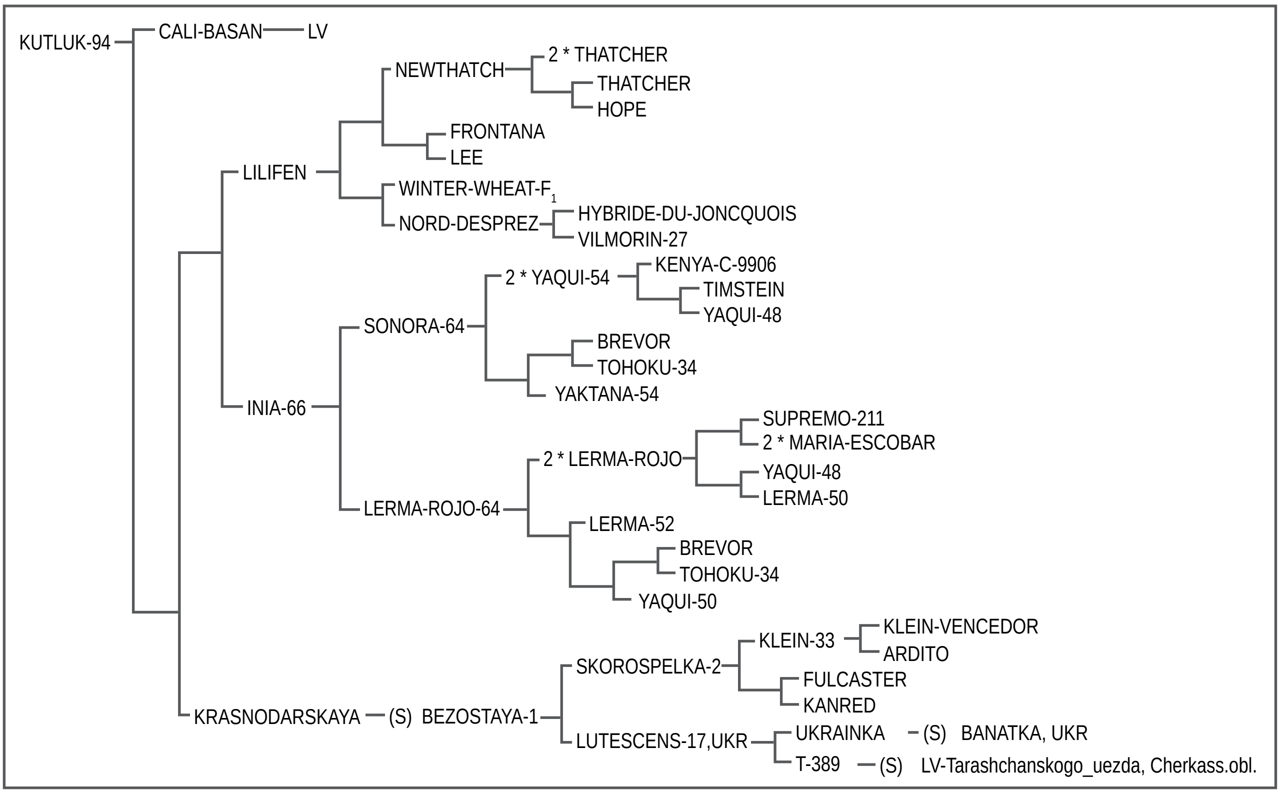
Figures 1. The pedigree of Bezostaya-1



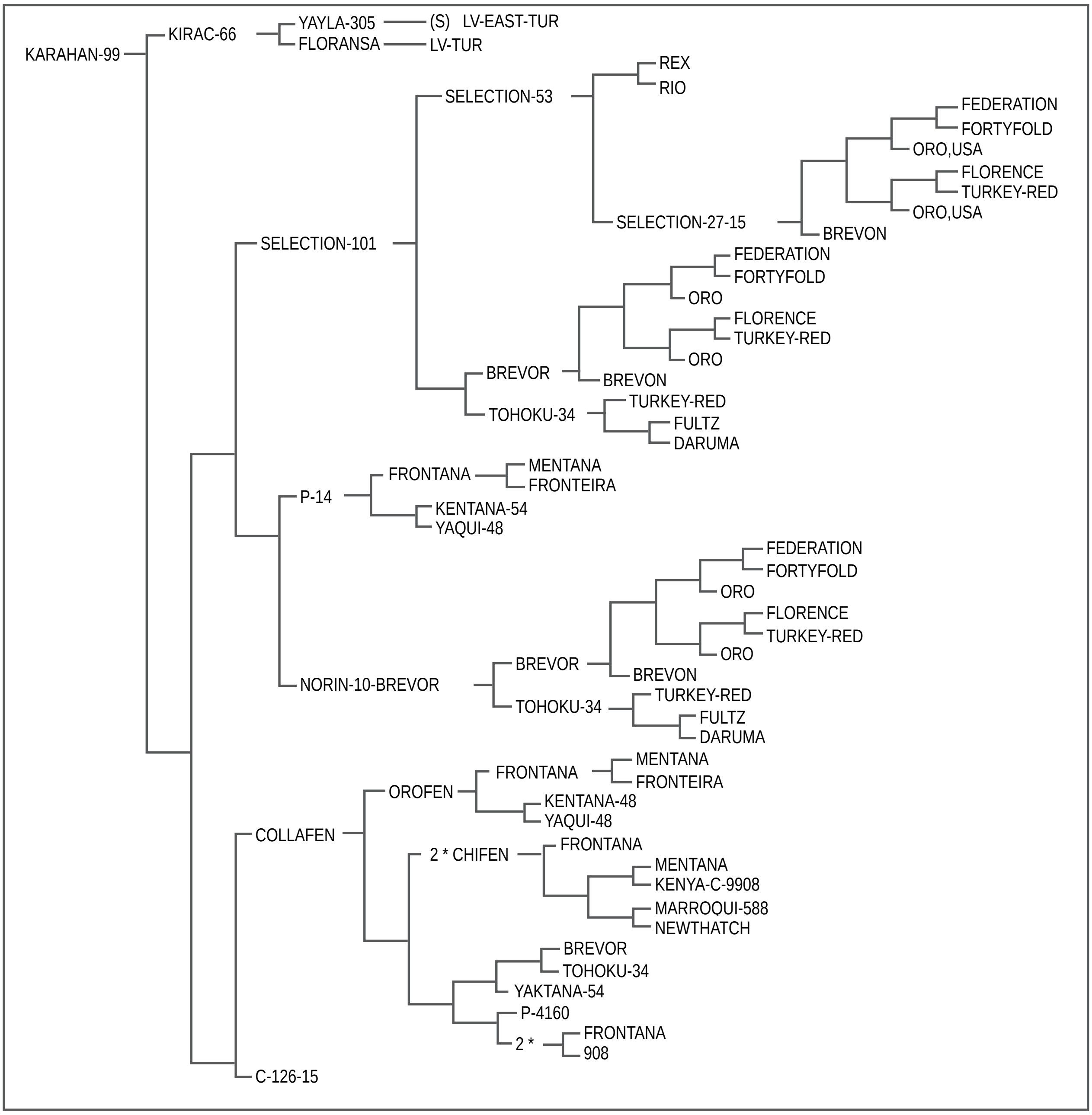
Figures 2. The pedigree of Gerek-79



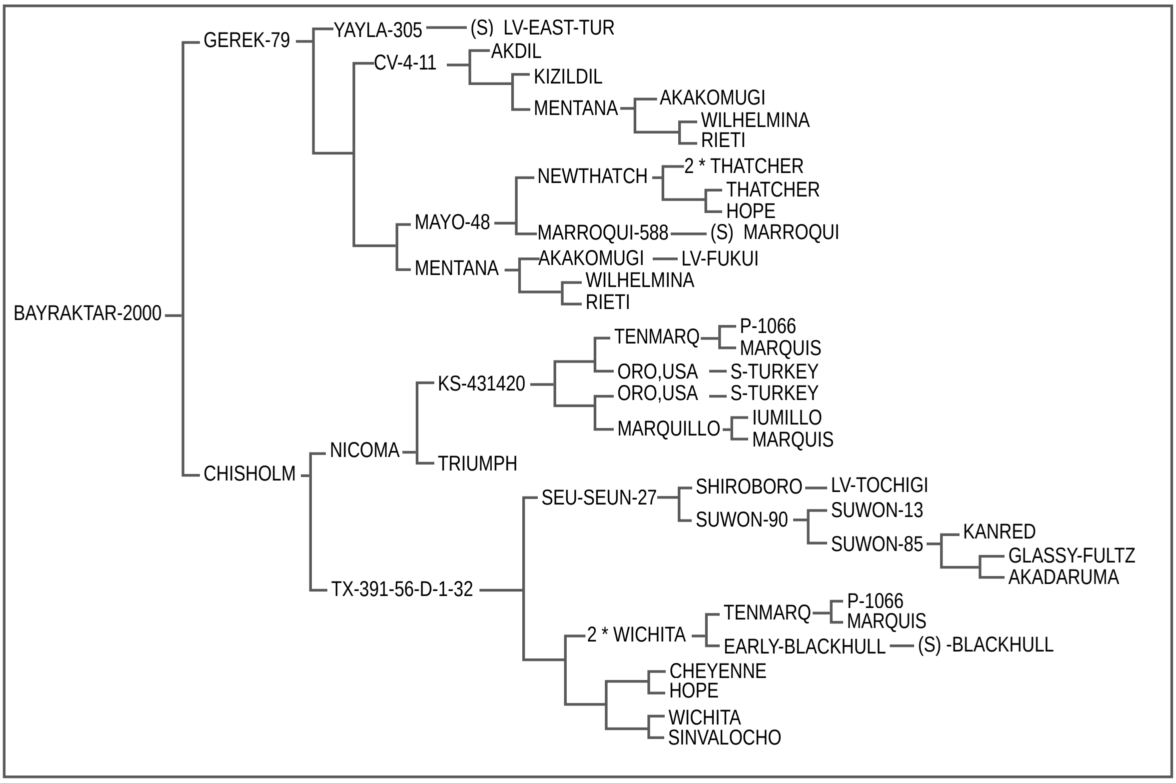
Figures 3. The pedigree of Kutluk-94



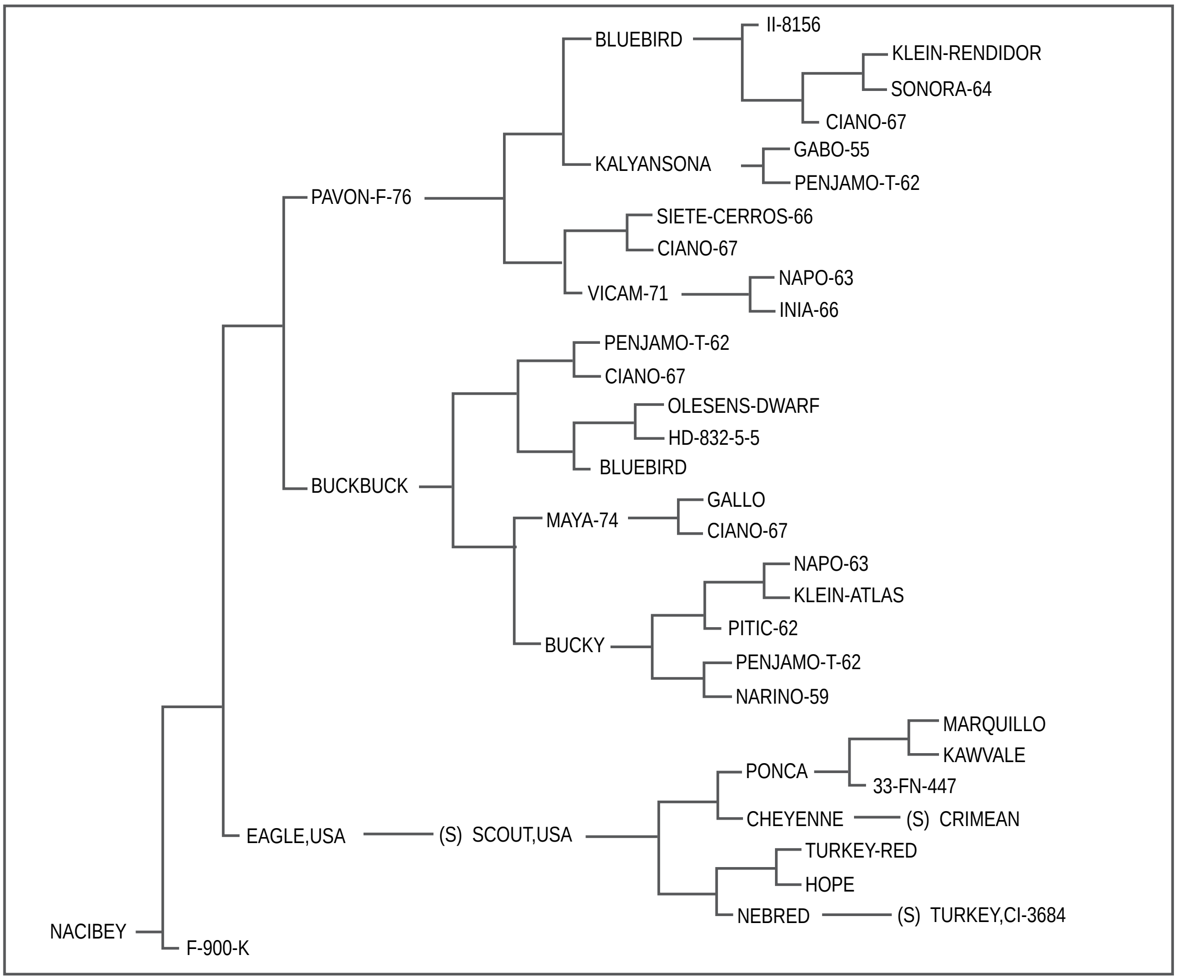
Figures 4. The pedigree of Karahan-99



Figures 5. The pedigree of Bayraktar-2000



Figures 6. The pedigree of Nacibey



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Stability of Quality Parameters of Bread Wheat (*Triticum aestivum* L.) Genotypes Under Drought Stress Condition

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ABSTRACT

Change in amount and distribution of precipitation during grain filling period is one of the major limiting stress factors of wheat quality and yield in Trakya region. Identification of the genetic stability and development of good quality cultivars are very important issues for wheat production in the region. In the present research, it was investigated that the effects of various levels of drought stress condition at different plant growth phase in quality parameters of bread wheat genotypes. This research was conducted in 2008-09 and 2009-2010 growing seasons. The experiment was established with 15 genotypes in randomised complete block design with 3 replications. Drought treatments were on the main parcel and genotypes on the sup-plots. In the research; grain yield, 1000-kernel weight, test weight, protein content, hardness, wet gluten, gluten index and sedimentation value and also correlation among these characters with stability parameters were investigated in wheat genotypes. According to results of the research; protein content, wet gluten content, hardness and sedimentation were negatively affected under irrigation condition during grain filling phase. Drought stress condition at GS51-94 had a positive effect on protein content, wet gluten and hardness. The highest test weight and 1000-kernel weight was determined under irrigation conditions. Non-treatment condition had a significant effect on sedimentation value. Based on stability parameters genotypes Pehlivan, Aldane and BBVD7 well adapted to overall environmental conditions for 1000-kernel weight. For test weight cultivars Gelibolu, Kate A-1, and Pehlivan were well adaptable to overall environmental conditions. Aldane had higher sedimentation under fertile environmental condition. Evaluation of quality parameters and drought application Aldane was the best performing cultivar and limitation of irrigation during grain filling period had a positive effect on quality parameters except 1000-kernel weight and test weight.

***Keywords*:** Bread wheat, quality parameter, drought treatments, stability parameters

Introduction

Wheat is grown under a wide range of environmental conditions where climatic factors such as temperature and moisture combined with agronomic inputs vary with location and year. The manifestation of those effects in the developing kernel impacts the value of the crop by influencing yield, grain characteristics and flour quality. Within the kernel, complex programs of gene expression control physiological and biochemical processes, including water uptake and kernel expansion, accumulation of starch and protein, maturation and desiccation. A better understanding of the genetic program of grain development and the influence of specific environmental variables on that program is required to minimize the effects of environment on yield and quality (Altenbach *et al.* 2003). Climate change is gradually increasing the average world temperature, while also reducing water resources and causing agricultural lands to become drier. Parallel to these negative developments, the world population is rapidly rising while the area of agricultural/arable lands remain constant. Many scientists believe that the inability to produce enough food to feed the increasing world population will inevitably lead to food wars. In this context, it is imperative to increase yield per unit area by developing varieties that are more resistant to biotic and abiotic stresses (Yıldırım *et al*. 2017). Environmental factors play a main role in the expression of genotype characteristics (Peterson *et al.* 1998). In wheat, grain yield and baking quality are dependent on the environment, genetic factors and the interaction between them (Yan and Holland 2010; Coventry *et al.* 2011). Environmental conditions during anthesis and grain filling are important factors in the baking quality classification of wheat (Jiang *et al.* 2009). The weather conditions during the growing season, especially the rainfall quantity and temperature, have a substantial influence on the plant metabolic processes, and thus on wheat quality (Balla *et al.* 2011). A measure of the relative yield stability of the durum wheat genotypes under a wide range of environmental conditions is essential for determining efficiency a genotype evaluation program. Hence, a number of statistical procedures have been developed to enhance breeder's understanding of genotype-environment interaction (GEI), stability of genotypes and their relationships (Akçura *et al.* 2009). Limited water condition, drought, is one of the most important abiotic stress factors. Depending on the season, drought can limit crop production seriously. Plant responses to drought stress are complex mechanisms which include molecular changes and extend to the whole plant metabolism influencing the morphology and phenology of plants (Blum 1996; Chaves *et al.* 2003; Condon *et al.* 2004). Stress during the grain-filling stage may have an even greater effect on wheat, as it may cause reduced grain-filling (Wardlaw and Moncur 1995). Drought is the main factor limiting the productivity of crops in Mediterranean areas. The introduction of physiological traits into crops that improve their tolerance to drought is necessary if yields under these conditions are to be efficiently improved. Variability is important aiming to obtain drought-tolerant genotypes via the optimization of traits (Gonzales *et al.* 2010). Evaluation of genotypes across diverse environments and over several years is needed in order to identify spatially and temporally stable genotypes that could be recommended for release as new cultivars and/or for use in the breeding programs (Sharma *et al*. 2010).

In Trakya region winter and facultative type of bread wheat cultivars are grown. The amount of the precipitation during growing season (from October to June) is enough for wheat production, but the distribution of this precipitation is not regular especially in April, May and June. In this period, less amount and fluctuation of precipitation could cause lower grain yield and quality. Therefore, development of the stable genotypes for grain quality under various environmental conditions is very important issue in the region. This study was carried out to assess some quality parameters of some genotypes under various drought stress condition and, also to determine stability parameters of the bread wheat genotypes.

Materials and Methods

The research carried out at experimental field of Trakya Agricultural Research Institution in Edirne (Turkey), during 2008-2009 and 2009-2010 growing seasons. In this experiment, a total of 15 bread wheat genotypes viz., Kate A-1, Gelibolu, Pehlivan, Tekirdağ, Selimiye, Aldane, Bereket, Flamura-85 and Golia and 6 advanced lines (BBVD7, ÖVD26-07, ÖVD2/21-07, ÖVD2/27-07, EBVD24-07, BBVD21-07) were used. The experiment was set up in a randomized complete block design (RCBD) in split block design with 3 replicated. Each plot was 5 meter long with 6 rows, spaced 0.17 meters apart. A seed rate of 500 seeds per m^2 was used, and sowing was done by an experimental drill. The plots were fertilized with 40 kg P_2O_5 ha^{-1} at planting and 150 kg N ha^{-1} in three splits i.e. at planting, tillering and stem elongation phase. For weed control chemical was used. Drought applications and genotypes were main plot and sub-plot, respectively. The Zadoks Decimal Code (GS) was used to describe plant growth stages (Zadoks *et al*. 1974). The described plant development stages are; DS1: Drought stress applied from GS31 (stem starts to elongate) to GS51 (10% of spikes visible), DS2: Drought stress applied from GS51 (10% of spikes visible) to GS94 (over-ripe, straw brittle), DS3: Non-stress treatment (irrigation at three times; shooting, heading and grain filling phase), DS4: Non-treatment, and DS5: Drought stress applied from GS31 (stem starts to elongate) to GS94 (over-ripe, straw brittle).

In the research; thousand kernel weights, test weight (Blakeney *et al.* 2009; Köksel *et al.* 2000), protein content (Perten, 1990; % NIR AACC 39-10), sedimentation, hardness, wet gluten and gluten index (Atlı *et al.* 1993; Elgün *et al.* 2001; Köksel *et al.* 2000; Pena 2008) were investigated. The quality analysis of zeleny sedimentation test and wet gluten content were determined according to ICC standard methods No. 116/1 and 106/2, respectively (Anonymous, 1972; Anonymous, 1984). Several methods have been developed to analyse genotype x environment interaction (Lin *et al*. 1986). For stability of the genotypes the mean yield (x), determinations coefficient (R^2), deviation from regression (S^2d), intercept value (a), regression coefficient (b) were calculated (Finlay and Wilkinson, 1963; Eberhart and Russell, 1966; Tai, 1971; Teich, 1983). In the study, regression graphs are used to predict adaptability of genotypes. The analysis of variance for each character was measured followed by LSD to test significance difference between means (Steel and Torrie 1980), and simple correlation coefficient and path analysis, which is the direct and indirect effects of each character was performed as per method of Dewey and Lu (1959). Regression analysis was done to determine relation between investigated characters. Correlations between all characteristics were calculated. Data variance analyses were performed by using J.M.P. 5.0.1. The significance of differences among means was compared by using Least Significant Difference (L.S.D. at a 5%) test (Gomez and Gomez, 1984; Kalaycı, 2005).

Some climate parameters for research field are provided in Table 1. The average temperature in 2008-09 growing years is 12.2°C, and 2009-10 is 11.3°C. The average temperatures during the first and second growing years of the study were lower than the long-term average (13.6°C). Annual average relative humidity of the 2008-09 growing year is 75.2% and of the 2009-10 growing year is 81.5%. Distribution of the precipitation within the year also significantly varied between the years. Especially, the amount of precipitation during the booting and heading growth stages of the first and second year (April and May) were relatively lower than the long-term average. In 2008-09, the total rainfall was 327.1 mm, whereas the total rainfall for the second years of the study was 536.5 mm. The long-term average monthly rainfall is 573.1 mm. During the first years of the study, the average rainfall was lower than the long-term and second year of the study average (Table 1).

Results and Discussion

The analysis variance for quality parameters were performed and given in Table 2 and 3. The results of variance analyses showed that there were significant differences ($p<0.01$) among genotypes, treatments and genotypes x treatments interaction (Table 2 and 3). The results of variance analyses showed that there were significant differences ($P<0.01$) among genotypes and treatments for investigated quality parameters under both stress and non-stress environments. Bereket had higher grain yield with 658.8 kg da^{-1} and, followed by BBVD7 and Kate A-1. The mean values of the genotypes varied between 29.7-43.5 g for 1000-kernel weight, 73.6-83.2 kg hl^{-1} for test weight, 11.1-13.3% for protein content, 28.5-37.0% for gluten value, 34.3-56.0% for sedimentation, 68.9-95.3% for gluten index, 47.0-58.6 for hardness (Table 4). Analysis of variance showed that there was higher genetic variability among the genotypes. According to results mean test weight of the genotypes was 79.7 kg. Limited water conditions decreased test weight and mean test weight was 81.2 kg under non-stress conditions, and 77.6 kg under fully-stress condition. Cultivar Selimiye had higher test weight with 83.19 kg followed by cv. Pehlivan with 81.63 kg. Cultivar Pehlivan had higher 1000-kernel weight with 43.56 g. Protein content varied from 11.3% to 12.5% among treatment. Based on genotypes BBVD21-07 had the highest protein content with 13.3% in and followed by cv. Aldane with 12.7%. Protein content of the genotypes decreased under fully-stress and non-stress conditions.

The mean gluten value was 31.8% in genotypes, and the highest gluten content was determined in BBVD21-07 with 37.0%, followed by ÖVD2/27-07 and Pehlivan. The highest protein content and wet gluten content was determined under drought stress conditions which drought stress were applied from heading to physiological maturity stage (GS51-94). The highest sedimentation value was obtained with 56.0 ml in cultivar Aldane. Highly significant differences for drought application indicated their influences on protein content at different environments. Protein quality and quantity have received more attention than other quality attributes, partly owing to the significant influence imparted by protein on end-use product quality of both common wheat and durum wheat. Environmental factors, such as nitrogen fertilization, water and temperature, influence protein content (Sissons *et al.* 2005; Arya *et al.* 2014). In contrast, protein quality is largely under genetic control (Lerner *et al.* 2006; Rogers *et al.* 2006).

A genotype having stable grain quality across the environment condition is very important in wheat production. Genotype x environment interaction is a mainly issue for plant breeders in improving high-quality, stable genotypes across variable environments. Stability parameters based on test weight showed that all the genotypes were significantly different. Tekirdağ and Pehlivan were very stable cultivar for test weight due to their highest coefficient of determinations (R^2). There was high variation in regression coefficients (b) values and optimum b value was determined in cultivars Pehlivan and Tekirdağ. The highest intercept values (a) were determined in cultivars Golia, Aldane and Selimiye. The highest intercept value indicated that these cultivars were higher in grain quality both under fertile and less fertile environment condition. According to all stability parameters, it could be seen that cultivar Pehlivan was very stable for the test weight with higher determinations coefficient (R^2), positive intercept value (a) and suitable regression coefficient (b) with close to 1 (Table 5).

Regression coefficient for test weight and thousand kernel weights were determined and given in Table 5 and Figure 1. For test weight, it was determined that genotypes Pehlivan, Gelibolu, Kate A-1 and G11 (ÖVD26-07) were well adaptable to all environmental conditions. Cultivar Selimiye and Aldane had higher test weight under unfavourable environment conditions. Cultivars Tekirdağ, Bereket, G13 and Flamura-85 were medium adaptable to all environment conditions. For 1000-kernel weight, it was determined that cultivar Selimiye well adaptable to favorable environmental conditions. Cultivars Aldane, Pehlivan and G9 (BBVD7) had higher test weight under all environment condition. Tekirdağ, Gelibolu and G11 (ÖVD26-07) were medium adaptable into favorable environment conditions (Fig.1).

Stability parameters of the protein content and wet gluten of the genotypes showed that all stability parameters were significantly different. For protein content Gelibolu, Pehlivan, Tekirdağ, Bereket and, BBVD24-07 were very stable genotypes due to higher determinations coefficient (R^2). There was highly variation in regression coefficients (b) values varied from 0.48 to 1.60, and cultivars Pehlivan and Gelibolu had optimum b value. The highest intercept values (a) were determined in cultivars Golia, Selimiye, Aldane and Tekirdağ. The highest intercept value indicates that these cultivars had higher protein content under both fertile and less fertile environment conditions (Table 6).

For wet gluten content, cultivars Bereket, Gelibolu, and Pehlivan were very stable due to higher determinations coefficient (R^2). There was highly variation in regression coefficients (b) values varied from 0.27 to 1.81, and optimum b value was determined in G13 (ÖVD2/27-07) and Kate A-1. The highest intercept values (a) were determined in genotypes Aldane, BBVD7, G12 (ÖVD2/21-07) and Tekirdağ (Table 6).

Regression coefficient for protein content and gluten value were determined and given in Figure 2 and Table 6. It was determined that cultivar Flamura-85 had higher protein content under all environmental conditions. Cultivars Aldane, Tekirdağ, and Golia had higher protein content under unfertile environment conditions. For gluten content cultivar Pehlivan, Kate A-1, G13 (ÖVD2/27-07) and G9 (BBVD7) had higher gluten value. Aldanewas, the best performing variety according to its gluten value under unfertile environment conditions. Genotypes Flamura-85, Selimiye and G11 (ÖVD26-07) were medium adaptable in terms of their gluten value under all environment conditions. Stability parameters based on sedimentation and hardness of the genotypes showed that all stability parameters were significantly different (Table 7). For sedimentation genotypes EBVD24-07, ÖVD2/21-07 and Gelibolu was very stable for their highest determinations coefficient (R^2). Cultivars Pehlivan, Bereket and Golia had optimum b value. The highest intercept values (a) were determined in cultivars Tekirdağ, Selimiye, ÖVD2/27-07, and Kate A-1.Regression coefficients for sedimentation and grain hardness were determined and given in Figure 3 and Table 7. It was determined that Flamura-85 was well adapted to all environmental conditions. Cultivars Bereket, Gelibolu and Pehlivan were medium adaptable to all environment conditions. Selimiye and Tekirdağ cultivar had higher sedimentation under unfavourable environment conditions.

Correlation analysis was done in order to determine relationships among quality parameters based on stability parameters. Using Pearson's correlation analysis, a significant ($P<0.05$) and negatively correlation was found between mean test weightwith deviation from regression (S^2d) (R^2=-0.573*), regression coefficient (b) (R^2=-0.573*), and positively associated with intercept value (a) (R^2=0.865**). Based on protein content correlation was negative between determination coefficient (R^2) with deviation from regression (S^2d), and intercept value (a). Correlations coefficient of the stability parameters showed that mean of grain hardness was statistically significant ($P<0.05$) with deviation from regression (S^2d) (R^2=0.515). Based on TKW, gluten value and sedimentation determination coefficient (R^2) was negatively correlated with S^2d and intercept value (a). Furthermore, mean sedimentation value was statistically significant and positively correlated with deviation from regression (R^2=0.578*), and negatively non-significant correlated with determinations coefficient (Table 8).

Conclusion

Environment conditions had a significant effect in quality of winter wheat genotypes. Non-stress condition or additional irrigation during grain filling phase negatively affected and reduced grain protein content, wet gluten content, hardness and sedimentation value of the genotypes. Non-irrigation condition from heading up to maturity stage had had positively effect on protein and gluten content. As expected the highest test weight and thousand kernels weight was determined under fully non-stress conditions from shooting up to maturity. The highest sedimentation was determined under non-treatment condition. According to stability of genotypes, Pehlivan, Aldane and BBVD7 well adapted to overall environmental condition for 1000-kernel weight. For test weight, cultivars Gelibolu, Kate A-1, and Pehlivan were suitable to overall environmental conditions. Under overall environmental conditions cultivar Flamura-85 had higher protein content. According to sedimentation Aldane was very suitable to fertile environmental conditions and, for wet gluten value cv. Selimiye and Flamura-85 were medium adapted to overall environmental conditions. According to result of the research based on quality parameters and drought application Aldane was the best performing cultivar and limitation of the irrigation during grain filling period resulted in positive effect and increased quality parameters except thousand kernel weight and test weight.

Table 1. Precipitation, humidity and temperature in 2008-2009 and 2009-2010 growing season

Months	2008-2009 growing season				2009-2010 growing season			
	Rainfall (mm)	Humidity (%)	Max. temp. (°C)	Average temp. (°C)	Rainfall (mm)	Humidity (%)	Max. temp. (°C)	Average temp. (°C)
October	17.0	72.6	26.5	14.9	112.6	82.3	28.9	15.1
November	29.2	77.8	18.3	15.3	51.7	89.7	22.7	9.7
December	35.6	82.2	20.4	6.4	93.4	89.7	19.6	7.3
January	48.6	87.8	17.5	6.5	59.6	85.2	20.3	2.5
February	83.2	81.3	13.5	5.2	107.0	88.1	20.3	5.9
March	44.1	77.5	17.9	7.8	47.6	81.9	22.2	7.7
April	15.8	68.8	25.9	12.3	17.8	76.0	24.9	12.7
May	27.7	66.1	32.1	19.1	16.0	68.6	33.6	18.1
June	25.9	62.5	36.4	22.6	30.8	72.3	38.7	22.5
Total/Mean	327.1	75.2	23.2	12.2	536.5	81.5	25.7	11.3

Data were obtained from the Turkish State Meteorological Service

Table 2. Combined analysis of variance for 15 wheat genotypes across five environments for quality parameters

Source	DF	TKW		TW		PRT		HARD	
		MS	F	MS	F	MS	F	MS	F
Year (Y)	1	1781.65	615.06**	0.07	0.12	18.93	29.52**	1447.22	1156.31**
Replication (Year)	4	0.85	0.29	0.33	0.55	1.35	2.11	4.41	3.52
Genotype (G)	14	541.38	186.89**	170.64	284.18**	9.89	15.42**	266.24	212.72**
Year*Genotype	14	114.40	39.49**	10.42	17.36**	2.11	3.29**	8.29	6.62**
Error	56	2.89	1.77	0.60	1.92	0.64	1.52	1.25	0.83
Treatment (T)	4	584.31	356.38**	184.37	590.34**	21.22	50.29**	61.92	41.10**
Year*Treatment	4	172.70	105.33**	141.85	454.19**	13.80	32.70**	16.72	11.10**
Genotype*Treatment	56	6.04	3.68**	2.14	6.86**	0.52	1.23	2.37	1.58*
Y*G*T	56	5.91	3.61**	1.37	4.38**	0.48	1.13	2.21	1.47*

Significant at *: $p<0.05$ and **: $p<0.01$. TKW: Thousand kernel weight (g), TW: Test weight (kg), PRT: Protein content (%), HARD: Hardness

Table 3. Combined analysis of variance for 15 wheat genotypes across five environments for quality parameters

Source	DF	SED		GLT		IND	
		MS	F	MS	F	MS	F
Year (Y)	1	12335.0	1303.01**	449.8	72.56**	21498.1	1070.92**
Replication (Year)	4	8.14	0.86	18.71	3.02	83.13	4.14
Genotype (G)	14	1050.45	110.96**	327.96	52.91**	4486.37	223.48**
Year*Genotype	14	88.11	9.31**	46.61	7.52**	437.89	21.81**
Error	56	9.47	1.59	6.20	1.26	20.07	1.32
Treatment (T)	4	348.31	58.48**	205.0	41.80**	187.16	12.35**
Year*Treatment	4	372.41	62.53**	182.82	37.28**	159.59	10.53**
Genotype*Treatment	56	17.65	2.96**	7.76	1.58**	37.77	2.49**
Y*G*T	56	19.03	3.20**	9.17	1.87**	46.66	3.08**

Significant at *: p<0.05 and **: p<0.01; SED: Sedimentation (ml), GLT: Wet Gluten (%), IND: Gluten index (%)

Table 4. Mean of yield and quality parameters and standard deviation of fifteen genotypes at five various environments

No	Genotype	GY	TKW	TW	PRT	HARD	SED	GLT	IND
1	Kate A-1	631.5±132.0	34.5±3.11	81.2±1.35	11.4±0.53	55.3± 0.78	41.2±2.24	33.8±1.87	72.9±3.68
2	Gelibolu	613.0±111.8	37.7±3.14	80.8±1.37	11.1±0.54	47.0± 0.88	41.3±2.27	24.6±1.86	95.3±1.19
3	Pehlivan	587.7±113.1	43.5±2.51	81.6±1.48	11.7±0.50	53.5± 0.82	41.6±2.39	34.7±1.75	72.6±2.01
4	Tekirdağ	594.5±102.7	38.8±3.13	78.9±1.59	11.9±0.33	53.7± 0.61	45.3±1.70	32.8±1.42	83.3±3.38
5	Selimiye	608.9±116.4	41.5±2.92	83.2±1.32	11.6±0.34	55.1± 0.33	45.1±1.71	31.9±1.66	90.3±1.92
6	Aldane	551.1±105.5	42.1±2.86	81.3±1.27	12.8±0.41	55.2± 0.86	56.0±3.65	34.4±0.67	94.1±0.70
7	Flamura-85	518.9±103.8	37.3±2.45	80.6±1.32	12.1±0.54	53.3± 0.69	47.8±3.62	30.4±2.22	94.4±1.93
8	Golia	610.4±95.7	31.9±1.56	79.9±1.03	11.9±0.29	57.8± 0.92	35.0±2.01	28.7±1.64	94.2±2.16
9	BBVD7	651.0 ±152.2	42.7±2.80	78.9±1.32	12.3±0.69	51.1± 1.38	37.2±2.01	34.6±1.50	64.8±5.11
10	Bereket	658.3±121.5	37.9±2.04	80.6±1.40	11.4±0.80	52.8±1.24	44.7±2.90	28.7±2.83	94.5±2.19
11	ÖVD26-07	579.1±115.7	35.6±2.94	81.2±1.45	11.8±0.58	58.6± 1.50	36.6±1.84	31.6±2.15	88.2±2.13
12	ÖVD2/21-07	563.0±90.9	37.2±3.19	76.9±2.24	11.5±0.67	50.4±1.43	47.8±3.50	28.5±1.35	93.9±3.58
13	ÖVD2/27-07	617.8±96.4	34.6±1.91	79.9±1.36	11.4±0.48	55.7± 1.19	36.9±2.54	35.2±1.73	60.8±3.29
14	EBVD24-07	577.4±150.7	31.2±3.25	77.1±2.27	11.7±0.68	54.3± 1.16	38.7±3.09	30.2±2.13	83.6±3.55
15	BBVD21-07	383.0±89.4	29.7±2.30	73.6±2.34	13.3±0.68	57.0± 0.84	34.3±2.71	37.0±2.21	68.9±2.06
Mean		583.0	37.1	79.7	11.9	54.1	42.0	31.8	83.4
LSD (0.05)		21.94**	0.88 **	0.40**	0.41**	0.58**	1.59**	1.29**	2.32**

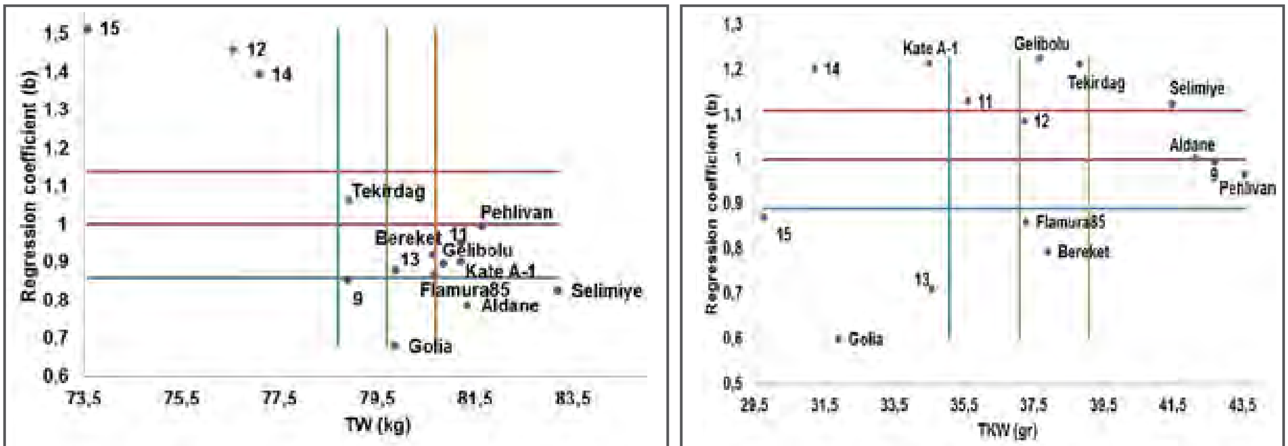
Note: *: p<0.05, **: p<0.01, GY: Grain yield (kg da-1), TKW: Thousand kernel weight (g), TW: Test weight (kg), PRT: Protein content (%), HARD: Hardness, SED: Sedimentation (ml), GLT: Wet Gluten (%), IND: Gluten index (%)

Table 5. Stability parameters for test weight and 1000-kernel weight of the genotypes

No	Genotype	Stability parameters for TW					Stability parameters for TKW				
		X	R^2	S^2d	a	b	X	R^2	S^2d	a	b
1	Kate A-1	81.20	0.97	0.016	9.32	0.90	34.49	0.99	0.46	-10.54	1.21
2	Gelibolu	80.85	0.93	0.038	9.48	0.90	37.67	0.99	0.54	-7.77	1.23
3	Pehlivan	81.63	0.98	0.012	2.36	0.99	43.54	0.96	1.09	7.69	0.97
4	Tekirdağ	78.91	0.98	0.017	-5.84	1.06	38.83	0.97	1.21	-6.14	1.21
5	Selimiye	83.19	0.86	0.068	17.18	0.83	41.47	0.96	1.52	-0.18	1.12
6	Aldane	81.34	0.83	0.078	18.56	0.79	42.15	0.80	6.66	4.93	1.00
7	Flamura-85	80.65	0.94	0.029	11.60	0.87	37.28	0.80	4.86	5.32	0.86
8	Golia	79.86	0.96	0.013	25.46	0.68	31.90	0.95	0.50	9.65	0.60
9	BBVD7	78.89	0.92	0.042	10.74	0.86	42.70	0.82	5.68	5.75	1.00
10	Bereket	80.63	0.94	0.036	7.28	0.92	37.91	0.98	0.29	8.40	0.80
11	ÖVD26-07	81.21	0.94	0.035	5.13	0.95	35.61	0.95	1.61	-6.30	1.13
12	ÖVD2/21-07	76.55	0.93	0.098	-39.95	1.46	37.24	0.75	10.25	-3.04	1.09
13	ÖVD2/27-07	79.87	0.90	0.051	9.85	0.88	34.56	0.90	1.47	8.14	0.71
14	EBVD24-07	77.08	0.82	0.260	-34.05	1.39	31.21	0.89	4.78	-13.39	1.20
15	BBVD21-07	73.56	0.92	0.130	-47.12	1.51	29.75	0.93	1.55	-2.52	0.87

Note: X: mean, R^2: determinations coefficient, S^2d: deviation from regression, a: intercept value, b: regression coefficient

Figure 1. According to the regression coefficient and adaptability of varieties for the test weight and 1000-kernel weight



Regression coefficient for test weight

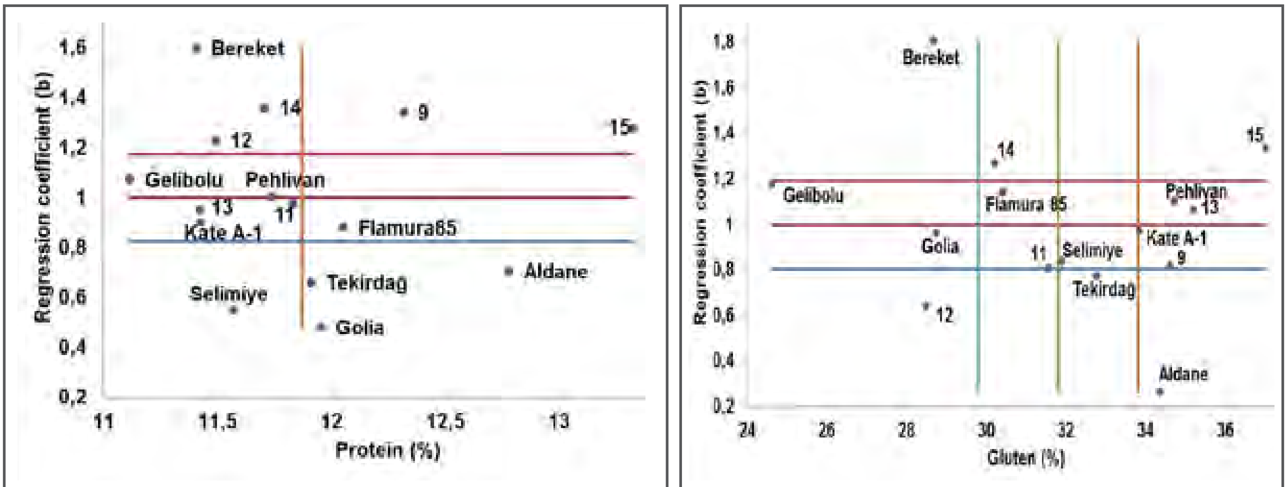
Regression coefficient for 1000-kernel weight

Table 6. Stability parameters for protein content and wet gluten of the genotypes

No	Genotype	Stability parameters for protein content					Stability parameters for wet gluten				
		X	R^2	S^2d	a	b	X	R^2	S^2d	a	b
1	Kate A-1	11.43	0.68	2.612	0.73	0.90	33.83	0.61	0.394	2.93	0.97
2	Gelibolu	11.11	0.93	0.627	-1.62	1.07	24.61	0.91	0.087	-12.99	1.18
3	Pehlivan	11.73	0.92	0.609	-0.18	1.00	34.70	0.90	0.088	-0.47	1.11
4	Tekirdağ	11.91	0.92	0.249	4.06	0.66	32.76	0.68	0.187	8.00	0.78
5	Selimiye	11.57	0.62	1.266	5.04	0.55	31.91	0.58	0.328	5.18	0.84
6	Aldane	12.78	0.68	1.601	4.40	0.71	34.36	0.36	0.084	25.87	0.27
7	Flamura-85	12.05	0.62	3.158	1.58	0.88	30.40	0.60	0.568	-5.94	1.14
8	Golia	11.95	0.64	0.871	6.25	0.48	28.74	0.78	0.167	-1.94	0.96
9	BBVD7	12.32	0.87	1.752	-3.62	1.34	34.60	0.68	0.206	8.57	0.82
10	Bereket	11.41	0.92	1.431	-7.59	1.60	28.67	0.92	0.174	-28.84	1.81
11	ÖVD26-07	11.83	0.65	3.499	0.23	0.98	31.56	0.32	0.902	5.78	0.81
12	ÖVD2/21-07	11.49	0.78	2.908	-3.12	1.23	28.47	0.52	0.253	8.02	0.64
13	ÖVD2/27-07	11.42	0.90	0.646	0.14	0.95	35.20	0.85	0.125	1.36	1.06
14	EBVD24-07	11.71	0.92	1.052	-4.44	1.36	30.21	0.80	0.254	-10.05	1.27
15	BBVD21-07	13.32	0.81	2.583	-1.84	1.28	37.01	0.83	0.242	-5.48	1.34

Note: X: mean, R^2: determinations coefficient, S^2d: deviation from regression, a: intercept value, b: regression coefficient

Figure 2. According to the regression coefficient and adaptability of varieties for the protein content and sedimentation



Regression coefficient for protein content

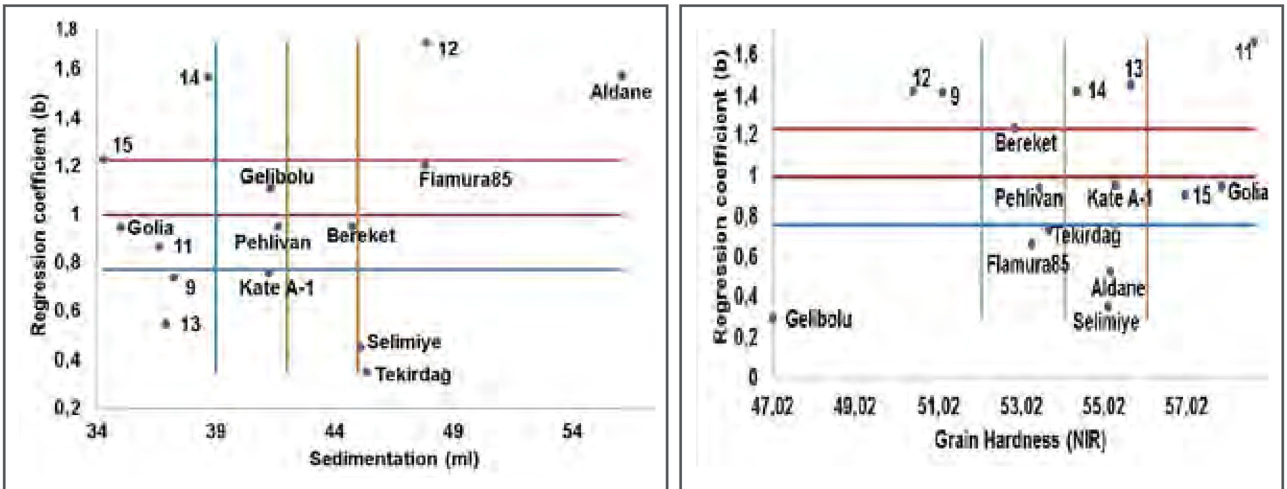
Regression coefficient for gluten value

Table 7. Stability parameters for sedimentation and hardness of the genotypes

No	Genotype	Stability parameters for sedimentation					Stability parameters for hardness				
		X	R^2	S^2d	a	b	X	R^2	S^2d	a	b
1	Kate A-1	41.23	0.44	0.806	9.32	0.76	55.3	0.93	0.07	3.48	0.96
2	Gelibolu	41.30	0.92	0.121	-5.33	1.11	47.0	0.07	0.01	30.92	0.30
3	Pehlivan	41.63	0.61	0.635	1.59	0.95	53.5	0.83	0.06	2.28	0.95
4	Tekirdağ	45.33	0.16	0.692	30.61	0.35	53.7	0.91	0.07	13.62	0.74
5	Selimiye	45.10	0.27	0.613	26.03	0.45	55.1	0.69	0.05	35.81	0.36
6	Aldane	56.03	0.72	1.070	-10.21	1.58	55.2	0.24	0.02	26.45	0.53
7	Flamura-85	47.77	0.43	2.152	-2.92	1.21	53.3	0.58	0.04	17.24	0.67
8	Golia	35.03	0.85	0.169	-4.82	0.95	57.8	0.67	0.05	6.54	0.95
9	BBVD7	37.23	0.53	0.547	6.12	0.74	51.1	0.66	0.05	-25.74	1.42
10	Bereket	44.73	0.42	1.402	4.65	0.95	52.8	0.62	0.04	-14.34	1.24
11	ÖVD26-07	36.63	0.86	0.135	0.09	0.87	58.6	0.77	0.05	-31.51	1.67
12	ÖVD2/21-07	47.80	0.93	0.255	-24.26	1.72	50.4	0.62	0.04	-26.76	1.43
13	ÖVD2/27-07	36.90	0.74	0.115	13.79	0.55	55.7	0.93	0.07	-23.00	1.46
14	EBVD24-07	38.67	0.99	0.014	-27.32	1.57	54.3	0.94	0.07	-22.81	1.43
15	BBVD21-07	34.27	0.79	0.439	-17.35	1.23	57.0	0.73	0.05	7.82	0.91

Note: X: mean, R^2: determinations coefficient, S^2d: deviation from regression, a: intercept value, b: regression coefficient

Figure 3. According to the regression coefficient and adaptability of varieties for the amount of sedimentation and hardness



Regression coefficient for sedimentation

Regression coefficient for grain hardness

Table 8. Correlation coefficients among stability parameters based on quality parameters

	Test weight					Thousand-kernel weight				
	X	R^2	S^2d	CV	a	X	R^2	S^2d	CV	a
R^2	0.077					-0.180				
S^2d	-0.573*	-0.735**				0.201	-0.944**			
CV	-0.573*	-0.735**	1.000**			1.000**	-0.180	0.201		
a	0.865**	0.130	-0.689**	-0.689**		0.355	-0.202	-0.022	0.355	
b	-0.834**	-0.134	0.690**	0.690**	-0.998**	0.209	0.107	0.140	0.209	-0.840**
	Protein content					**Wet gluten value**				
R^2	-0.207					-0.133				
S^2d	0.262	-0.582*				-0.020	-0.597*			
CV	0.262	-0.582*	1.000**			-0.020	-0.597*	1.000**		
a	0.174	-0.611*	-0.162	-0.162		0.466	-0.730**	0.052	0.052	
b	-0.026	0.589*	0.204	0.204	-0.989*	-0.217	0.766**	-0.063	-0.063	-0.965**
	Hardness					**Sedimentation value**				
R^2	0.515*					-0.320				
S^2d	0.515*	1.000**				0.578*	-0.606*			
CV	-0.506	-0.692**	-0.692**			0.578*	-0.606*	1.000**		
a	-0.122	-0.491	-0.491	-0.233		0.036	-0.818**	0.183	0.183	
b	0.248	0.546**	0.546*	0.162	-0.992**	0.309	0.668**	0.025	0.025	-0.939**

Note: *: $p<0.05$, **: $p<0.01$, X: mean, R^2: determinations coefficient, S^2d: deviation from regression, a: intercept value, b: regression coefficient, CV: variation of coefficient

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Studies on DUS Testing in Durum Wheat (*Triticum durum* Desf.)

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ABSTRACT

Present investigation was carried out at CCS Haryana Agricultural University, Hisar to examine the different morphological characters for distinctness, uniformity and stability of durum wheat varieties. Nine genotypes were studied over two years and observations on thirty-seven morphological characters were recorded. The study revealed that morphological characters of wheat plant viz. plant growth habit, coleoptile anthocyanin colouration, flag leaf anthocyanin colouration of auricle, time of ear emergence, ear waxiness, waxiness of peduncle, flag leaf length, peduncle attitude, flag leaf width, plant height, lower glume shoulder width, lower glume shoulder shape, outer glume pubescence, and awns attitude were the most important characters which could easily distinguish the durum wheat varieties. The characters like foliage colour, flag leaf attitude, flag leaf waxiness of sheath, ear length, lower glume beak length, lower glume beak shape, flag leaf waxiness of blade, ear colour, awns colour, are also found useful in distinguishing durum wheat varieties. The seed morphological characteristics such as grain hardness, grain germ width and grain shape are found to be useful in discriminating durum wheat varieties. But some characters like ear density, awn length and 1000 seed weight are not found to be so useful in distinguishing durum wheat varieties in the present investigation. The study also revealed that the characters viz. flag leaf hairs on auricle, brush hairs, peduncle length, straw pith in cross section, ear shape in profile easily distinguished bread wheat variety 'PBW 343' from rest of the durum wheat varieties. But these characters could not distinguish among durum wheat varieties. The grain colouration with phenol also could not distinguish among durum wheat varieties but it strongly distinguished bread wheat variety 'PBW 343' from all the durum wheat varieties in the study.

***Keywords*:** DUS, characterization, identification, durum wheat

Introduction

Globally, wheat is one of the most important cereal crop which is widely adapted to different agro-climatic conditions and unique property of its flour allows us to make a range of products (Kant *et al*. 2014; Guin *et al.* 2019). In India, wheat is the major crop, which is mainly cultivated for grain production (Preeti *et al*. 2016). But, the changing food habits have created additional demand for durum wheat because it has potential to produce value added marketable products. Infact, the food basket of Indian consumer is gradually diversifying towards value added commodities. Therefore, the durum wheat is emerging as an important food commodity as it contains 1.5 to 2.0% higher protein than bread wheat. In addition, it contains higher β-carotene (precursor of vitamin A) too, required to solve the problem of malnutrition among children and rural population (Sethi and Arya, 2012). Europe, West Asia, Mediterranean countries, North Africa and Russia are in heavy demand of durum wheat. Due to these reasons, India would need more varieties of durum wheat for cultivation.

In recent decades, a large number of new candidate varieties are generated for testing every year, thus, underlining the need for establishing their clear cut diagnostic features. India ratified the agreement on Trade Related aspects of Intellectual Property Rights (TRIPs) under General Agreements on Tariffs and Trade (GATT) and adopted *sui generis* system of protection of plant varieties. The "Protection of Plant Varieties and Farmers' Rights Act 2001" enacted by our Government prevents unlawful exploitation of plant varieties developed by plant breeders, farmers and communities and also encourages for the development of new varieties. Under this act the varieties will be registered which confirms to the criteria of Distinctness, Uniformity and Stability (DUS). As DUS testing data is essential for grant of protection to new plant varieties to compare the candidate varieties with varieties of common knowledge at the time of filling application (Yadav *et al.* 2013).

Hence, studies on DUS testing to acquaint with the procedures involved are needed in various field crops. To reduce the time required for DUS testing after release of variety, it will be appropriate if this information can be generated during final year testing of varieties. Obviously the standardization of DUS testing procedure in durum wheat will help in registration of varieties under PPV and FR act (2001) and shall be very beneficial in harnessing the market and trade benefits. Accordingly study was planned with the objective to examine the different morphological characters for distinctness, uniformity and stability of durum wheat varieties.

Materials and Methods

Present investigation was carried out to examine the different morphological characters for distinctness, uniformity and stability of durum wheat varieties. Eight durum wheat varieties *viz.* PDW 291, HD 4717, PDW 308, WH 896, DDW 11, PDW 233, UAS 415, PDW 307 and one bread wheat variety PBW 343 (used as check) grown in AVT-D-TSI at CCSHAU Hisar in North Western Plain Zone was taken as experimental material. Same set of varieties were grown in the next year at CCSHAU Hisar and similar observations were taken. Observations on morphological characters were recorded on five plants in metric scale for each cultivar, while the qualitative characters were recorded in different classes on population basis. Each character was characterized with the help of descriptors provided in the National Test Guidelines for DUS testing of bread wheat (*Triticum aestivum*) developed by Directorate of Wheat Research, Indian Council of Agricultural Research, Karnal (Kundu *et al*. 2006). Observations were recorded on 37 morphological characters viz. coleoptile anthocyanin colouration, plant growth habit, foliage colour, flag leaf hairs on auricle, flag leaf anthocyanin colouration of auricle, flag leaf attitude, time of ear emergence, flag leaf waxiness of sheath, flag leaf waxiness of blade, ear waxiness, culm waxiness of neck (peduncle), flag leaf length (cm), flag leaf width (cm), plant height (cm), straw pith in cross section, ear shape in profile, ear density, awns presence, ear length (cm), awn length (cm), awn colour, awns attitude, outer glume pubescence, ear colour, lower glume shoulder width, lower glume shoulder shape, lower glume beak length, lower glume beak shape, peduncle length (cm), peduncle attitude, grain colour, grain shape, grain germ width, brush hairs, seed size (1000 seed weight), grain hardness and grain colouration with phenol as suggested by Fraser and Gieller (1935).

Results and Discussion

DUS testing of crop varieties is becoming exceedingly important in today's era of Intellectual Property Rights (IPR), as it guarantees farmers and other stakeholders that the new cultivar is distinct from other released cultivars, uniform, stable as well as assures that it is the genotype which has been specified by the breeder. Moreover, DUS testing provides basic information which is used to protect plant varieties under Protection of Plant Varieties and Farmers' Rights Act (2001). It is important that the characters used in DUS testing of crop varieties should be able to distinguish the varieties of that crop. Further, the characters of varieties under study should be stable over repeated propagations of that variety. Generally, no single morphological trait can be used to distinguish a cultivar, so a combination of various characters can be used for DUS testing. In this study an attempt was made to characterize the eight durum wheat varieties along with a bread wheat variety used as check. Thirty-seven morphological characters were studied to examine their utility for DUS testing of durum wheat varieties (Table 1).

Morphological characteristics of varieties such as coleoptile colouration, plant growth habit, foliage colour, flag leaf hairs on auricle, auricle colour, flag leaf attitude, time of ear emergence, waxiness of flag leaf sheath, waxiness of flag leaf blade, ear waxiness, peduncle waxiness, flag leaf length, flag leaf width, plant length, straw pith in cross section, ear shape, ear density, awns presence, ear length, awns length, awn colour, awn attitude, outer glume pubescence, ear colour, lower glume shoulder width, shoulder shape, beak length, beak shape, peduncle length, peduncle attitude, grain colour grain shape, grain germ width, brush hair length, seed size, grain hardness and phenol colouration of grains were recorded over two years (Table 1).

These characters have been included in the guidelines for DUS testing of bread wheat (Kundu *et al*. 2006). It was observed that the results of both the years were almost same for all the characters and based on these results, varieties were classified for each character into different groups. Schematic diagrams were made for identification of wheat varieties on the basis of plant morphological characters, flag leaf characters (Fig. 1), ear head characters (Fig. 2) and grain characters (Fig. 3).

On the basis of coleoptile colour, wheat varieties were classified into two groups as absent or present. Only two varieties (PDW 233, WH 896) were characterized as present while remaining varieties as absent. This trait is considered as a useful trait in distinguishing wheat varieties. Dhesi *et al*. (1969) and Kochetova (1971) had also reported the usefulness of this trait in differentiating genotypes of wheat. The study of plant growth habit made it possible to divide the wheat varieties into three groups as erect (DDW 11, HD 4717 and UAS 415), semi-erect (PDW 307, PDW 308, PDW 291 and PBW 343) and intermediate (WH 896 and PDW 233). This trait was proved to be a diagnostic characteristic for characterizing and distinguishing wheat varieties. Kumar *et al*. (2002) also reported the utility of this trait for cultivar identification in oat.

On the basis of foliage colour varieties showed two groups viz. green and dark green. Only two varieties (DDW 11 and UAS 415) green foliage whereas other varieties were observed as dark green. But, this character has been reported to have positive response to high doses of nitrogenous fertilizers (Milan and Hossain, 1973). Therefore, results are likely to vary over different environments. The present investigation revealed that all the durum wheat varieties didn't have hairs on their flag leaf auricle. Only the bread wheat variety 'PBW 343' showed hairs on auricle. Hence this trait failed to distinguish between present set of durum wheat varieties. On the basis of flag leaf anthocyanin colouration of auricle, four varieties are categorized as having medium colouration (PDW 307, PDW 291, PDW 233 and WH 896) and others as absent (PBW 343, PDW 308, HD 4717, DDW11 and UAS 415). The utility of this character for DUS testing of wheat cultivars was reported by Haljak (2005).

Some more characters of plant were studied such as flag leaf attitude, flag leaf length and flag leaf width. Variation was observed for flag leaf length and flag leaf width. Varieties were classified into different groups such as long, medium, short and narrow, medium, broad for flag leaf length and flag leaf width respectively. Almost same results were obtained during second year also. These characters are proved to be useful characters in distinguishing and identification of wheat varieties and their usefulness was also reported by Wel and Lin (1989) in rice varieties. Based on flag leaf attitude varieties were classified into two groups such as erect and semi-erect. Two varieties (PDW 307 and PDW 291) were having semi-erect flag leaf attitude and remaining varieties were having erect flag leaf attitude. Utility of flag leaf attitude was reported by Sharief *et al*. (2005) for identifying rice cultivars and by Kumar *et al*. (2002) for characterization of oat cultivars. This character is also useful for characterization and identification of wheat varieties.

The present study revealed that varieties differed with respect to waxiness of different plant parts such as waxiness of flag leaf sheath, flag leaf blade, ear waxiness and peduncle waxiness. These characters are not measurable but visually observed and so their accuracy depends upon the skill of observer to correctly assess the intensity of waxiness of different plant parts. Therefore, it was also used by Panwar *et al*. (2013) to characterize WH 1105. Further, weather should be clear for observing these characters. These difficulties make these characters less important in DUS testing and variety identification programmes.

Time of ear emergence was recorded as the number of days required for 50% flowering and the present set of varieties varied from 94 days (PBW 343) to 105 (PDW 291) days. Little variation was observed for this character as varieties could be classified into only two groups viz. medium (91-100 days) and late (101-110 days). Plant height was also found useful in characterization of durum wheat varieties. Wide variation 86.3 cm (PBW 343) to 104.9 cm (WH 896) during first year and 86 cm (PDW 233) to 106.2 cm (WH 896) during second year) was observed in the present investigation. Based on this data varieties were classified into three groups as short (81-90 cm), medium (91-100 cm) and long (101-110 cm). Plant height is highly heritable character and has been used before for identification purpose. Significant differences among durum genotypes for characters days to heading and plant height were reported (Singh and Sharma, 2007).

It was observed that the character straw pith in cross section could not discriminate between durum wheat varieties, as all the durum wheat varieties in the present investigation expressed same size (medium) of straw pith in cross section. Only bread wheat variety PBW 343 expressed different state i.e. thin from those of durum wheat varieties. Similarly character ear shape also could not distinguish the present set of durum wheat varieties as these were having same state of ear shape i.e. parallel sided while bread wheat variety PBW 343 used as check was having tapering ear shape. But as these characters are stable and highly heritable, they may be useful while testing for large number of varieties.

Varieties could be classified on the basis of ear density. On the basis of this attribute varieties were classified into two groups viz. dense and very dense. Most of the durum varieties in the present study were observed to have dense ears (Fig. 1). Though this attribute could not distinguish among the present set of durum varieties, this character has been used by many workers for characterization and identification of wheat varieties and may be used for DUS testing of *durum* wheat varieties also.

All the varieties in the present investigation were awned like most of the present day varieties and among durums most of the varieties were observed to have long awns. So the durum varieties in the present study could not be distinguished on the basis of awns presence and awns length but Reeves and Boyd (1984) used awn length along with other spike characters to establish the distinctness of rye cultivars and on the basis of this they suggested their inclusion in the standard character set for use in DUS testing. Awn length has been also reported to have positive effect on grain yield (Motzo and Giunta, 2002).

Little variation was observed for ear length of wheat varieties. Average ear length varied from 5.8 cm (PDW 291) to 10.4 cm (PBW 343) and almost same range was observed during second year also. Most of the durum varieties had short ears and so ear length could not distinguish among these varieties. The characters like ear colour and awn colour were studied and it was observed that most of the varieties were having white coloured ears and awns. But these characters are highly stable and may be useful for DUS testing of durum wheat varieties.

On the basis of awns attitude, varieties were classified into three distinct groups viz. appressed (DDW 11, PDW 233 and PDW 308), medium (PDW 307, HD 4717, UAS 415 and WH 896) and spreading (PBW 343 and PDW 291). This character can be easily observed on the field and has importance in distinguishing durum wheat varieties. On the basis of outer glume pubescence varieties were categorized into those having medium pubescence (PDW 307, PDW 308 and DDW 11) and no pubescence i.e. absent (UAS 415, PDW 291, WH 896, PDW 233, HD 4717 and PBW 343). Glume pubescence was also used by Galussi *et al.* (1999) for characterizing the varieties of oat, wheat and rice. The study of lower glume in respect to its shoulder width and shoulder shape made it possible to divide the varieties into distinct groups. Glume beak length and glume beak shape were also observed to be helpful for categorization of wheat varieties into different groups. Mor *et al*. (2006) reported the importance of beak characteristics in identification of rice cultivars. Little variation was observed for peduncle length of varieties and this character failed to discriminate the present set of durum wheat varieties. On the basis of peduncle attitude two distinct groups were observed as straight and bent. Most of the varieties were having straight peduncle attitude.

All the varieties in the present investigation were found to be amber coloured like most of the present day cultivars. But due to its high heritability and stability it has been used in varietal identification (Nethra *et al*. 2007) and DUS testing of wheat varieties. A number of other grain characters viz. grain shape, grain germ width and grain size were studied. Grain shape and grain germ width were able to differentiate the varieties into few distinct classes and hence are important for DUS testing of durum wheat varieties. But in case of grain size all the varieties (except UAS 415) were found to be bold. The grain size and shape are the major identifying traits in wheat. Mor *et al*. (2006) also reported the usefulness of seed characters viz. seed length, seed shape, seed colour and beak characteristics for varietal identification of rice cultivars. The character brush hairs was also failed to distinguish the present set of durum wheat varieties as brush hairs were absent in all of them. Only bread wheat variety PBW 343 was having brush hairs. Wheat varieties also differed in their grain hardness and two categories were made on the basis of this character viz. semi-hard and hard. Wrigley (1976) also observed that grain hardness and texture of the grains in wheat as important parameters for identification of varieties. In case of grain colouration with phenol, it was observed that all the durum wheat varieties in the present study remained unstained and so the durum varieties could not be distinguished on the basis of grain colouration with phenol. These results were in accordance with those reported by Gupta *et al.* (2007) for durum wheat cultivars.

With the help of results obtained in the present study it is concluded that the characters *viz.* plant growth habit, coleoptile anthocyanin colouration, flag leaf anthocyanin colouration of auricle, time of ear emergence, ear waxiness, waxiness of peduncle, flag leaf length, peduncle attitude, flag leaf width, plant height, lower glume shoulder width, lower glume shoulder shape, outer glume pubescence, and awns attitude were the most important characters which could easily distinguish the durum wheat varieties. The characters like foliage colour, flag leaf attitude, flag leaf waxiness of sheath, ear length, lower glume beak length, lower glume beak shape, flag leaf waxiness of blade, ear colour, awns colour, are also found useful in distinguishing durum wheat varieties.

The study also revealed that seed morphological characteristics such as grain hardness, grain germ width and grain shape are found to be useful in discriminating *durum* wheat varieties. But some characters like ear density, awn length and 1000 seed weight are not found to be so useful in distinguishing durum wheat varieties in the present investigation The characters *viz.* flag leaf hairs on auricle, brush hairs, peduncle length, straw pith in cross section, ear shape in profile easily distinguished bread wheat variety 'PBW 343' from rest of the durum wheat varieties. But these characters could not distinguish among durum wheat varieties. Similar result was obtained for the character grain colouration with phenol.

Table 1. Classification of wheat varieties on the basis of plant morphological characters

Plant Descriptors	Range	No. of Variety	Classification of Varieties
Coleoptile Anthocyanin Colouration	Absent	7	PBW 343, PDW 291, DDW 11, HD 4717, PDW 308, UAS 415, PDW 307
	Present	2	PDW233, WH 896
Plant Growth Habit	Erect	3	DDW 11, HD 4717, UAS 415,
	Semi-erect	4	PDW 307, PDW 308, PDW 291, PBW 343
	Intermediate	2	WH 896, PDW 233
	Semi Prostrate	0	Nil
	Prostrate	0	Nil
Foliage Colour	Pale green	0	Nil
	Green	2	DDW 11, UAS 415
	Dark green	7	PBW 343, PDW 307, PDW 233, PDW 308, PDW 291, HD 4717, WH 896
Straw Pith in Cross Section	Thin	1	PBW 343
	Medium	8	PDW 233, HD4717, PDW 291, DDW 11, UAS 415, PDW 307, PDW 291, WH 896
	Thick	0	Nil
Plant Height	Short	2	PBW 343, PDW 291
	Medium	4	HD4717, PDW 233, PDW 307, DDW 11
	Long	3	UAS 415, PDW 308, WH 896
Flag Leaf Length	Short	4	PBW 343, PDW 291, DDW 11, UAS 415
	Medium	5	PDW 307, PDW 291, PDW 233, HD 4717, WH 896
	Long	0	Nil

Continuing table 1

Plant Descriptors	Range	No. of Variety	Classification of Varieties
Flag Leaf Waxiness of Blade	Absent	7	HD 4717, PDW 233, PDW307, DDW11, PBW 343, UAS 415
	Weak	2	PDW 291, PDW 308
	Medium	0	Nil
	Strong	0	Nil
Flag Leaf Hairs on Auricle	Absent	8	PDW 307, PDW 233, PDW 308, PDW 291, HD 4717, WH 896, DDW 11, UAS 415
	Medium	1	PBW 343
	Strong	0	Nil
Flag Leaf Anthocyanin Colouration of Auricle	Absent	0	Nil
	Medium	5	PBW 343, PDW 308, HD 4717, DDW 11, UAS 415
	Very strong	4	PDW 307, PDW 291, PDW 233, WH 896
Flag Leaf Width	Narrow	6	PDW 291, DDW 11, UAS 415, PDW 307, PDW 291, WH 896
	Medium	3	PDW 233, HD 4717, PBW 343
	Broad	0	Nil
Ear Shape in Profile	Tapering	1	PBW 343
	Parallel sided	9	PDW 233, HD 4717, PDW 291, DDW 11, UAS 415, PDW 307, PDW 291, WH 896
	Clavate	0	Nil
	Fusiform	0	Nil
Ear Density	Very lax	0	Nil
	Lax	0	Nil
	Medium	0	Nil
	Dense	2	PBW 343, PDW 291
	Very Dense	7	HD4717, PDW 308, PDW233, WH 896, PDW 307, UAS 415, DDW 11
Awn Length	Long	7	HD 4717, PDW 291, DDW 11, UAS 415, PDW 307, PDW 291, WH 896
	Medium	2	PDW 233, PBW 343
	Short	0	Nil

Continuing table 1

Plant Descriptors	Range	No. of Variety	Classification of Varieties
Lower Glume Beak Length	Short	0	Nil
	Medium	8	PDW 308, PDW233, WH 896, PDW 307, UAS 415, DDW 11, PBW 343, PDW 291
	Long	1	HD 4717
Lower Glume Shoulder Shape	Sloping	0	Nil
	Round	5	DDW 11, WH 896, PDW 307, PDW 308, PDW233
	Straight	3	PBW 343, HD4717, PDW 291
	Elevated	1	UAS 415
Outer Glume Pubescence	Absent	6	UAS 415, PDW 291, WH 896, PDW 233, HD 4717, PBW 343
	Medium	3	DDW 11, PDW 307, PDW 308
	Strong	0	Nil
Awns Attitude	Appressed	3	DDW 11, PDW 233, PDW 308
	Medium	4	PDW 307, HD 4717, UAS 415, WH 896
	Spreading	2	PBW 343, PDW 291
Ear Colour	White	7	UAS 415, PDW 291, WH 896, DDW 11, PDW 233, HD 4717, PBW 343
	Light brown	2	PDW 307, PDW 308
	Dark brown	0	-
Brush Hairs	Medium	1	PBW 343
	Absent	8	PDW 308, WH 896, DDW 11, PDW 233, HD 4717, PDW 291, PDW 307, UAS 415
Seed Size	Small	0	-
	Medium	1	UAS 415
	Bold	8	PDW 308, WH 896, DDW 11, PDW 233, HD 4717, PDW 291, PDW 307, PBW 343
Grain Hardness	Soft	0	-
	Semi hard	3	PDW 307, PBW 343, HD 4717
	Hard	6	PDW 308, WH 896, DDW 11, PDW 233, PDW 291, UAS 415

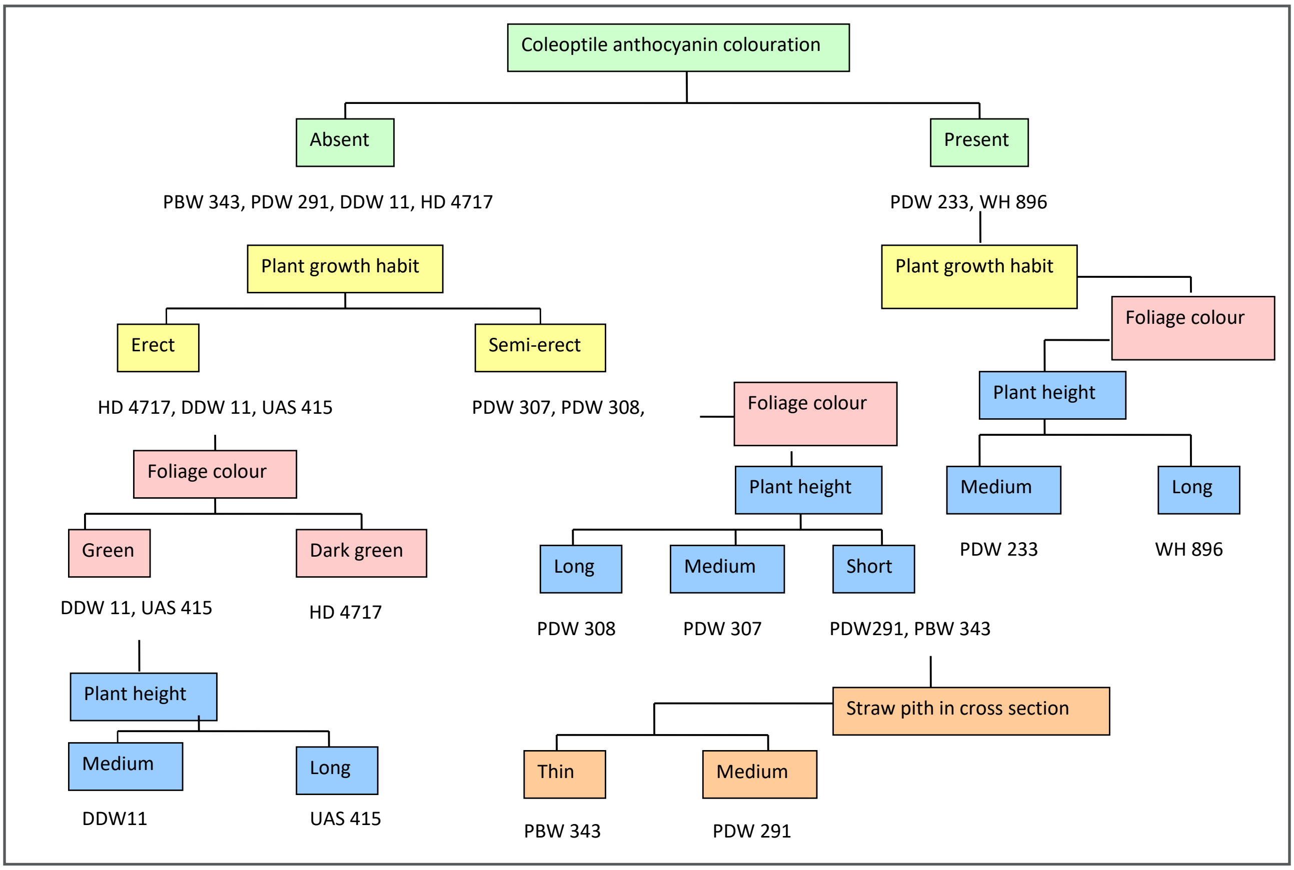
Continuing table 1

Plant Descriptors	Range	No. of Variety	Classification of Varieties
Grain Germ Width	Narrow	0	-
	Medium	4	PDW 233, HD 4717, PBW 343, UAS 415
	Wide	5	PDW 308, WH 896, DDW 11, PDW 291, PDW 307
Grain Shape	Round	0	-
	Ovate	1	PDW 308
	Oblong	5	WH 896, UAS 415, PDW 233, PBW 343, PDW 307
	Elliptical	3	DDW 11, PDW 291, HD 4717
Flag Leaf Waxiness of Sheath	Weak	0	-
	Medium	3	DDW11, PBW 343, UAS 415
	Strong	6	HD 4717, WH 896, PDW 233, PDW307, PDW 291, PDW 308
Ear Waxiness	Weak	3	PBW 343, UAS 415, DDW11
	Medium	4	HD4717, PDW 233, WH 896, PDW 307
	Strong	2	PDW 291, PDW 308
Culm Waxiness of Neck (Peduncle)	Weak	2	PBW 343, DDW11
	Medium	4	PDW233, WH 896, PDW 307, UAS 415
	Strong	2	HD4717, PDW 291
Time of Ear Emergence	Early	0	-
	Medium	5	PBW 343, HD 4717, PDW 308, PDW 307, UAS 415
	Late	4	WH 896, PDW 233, PDW 291, DDW11
Awns Presence	Absent	0	-
	Present	9	All varieties
Awn Colour	White	7	HD 4717, DDW 11, UAS 415, PDW 291, WH 896, PDW 233, PBW 343
	Light brown	2	PDW 307, PDW 308

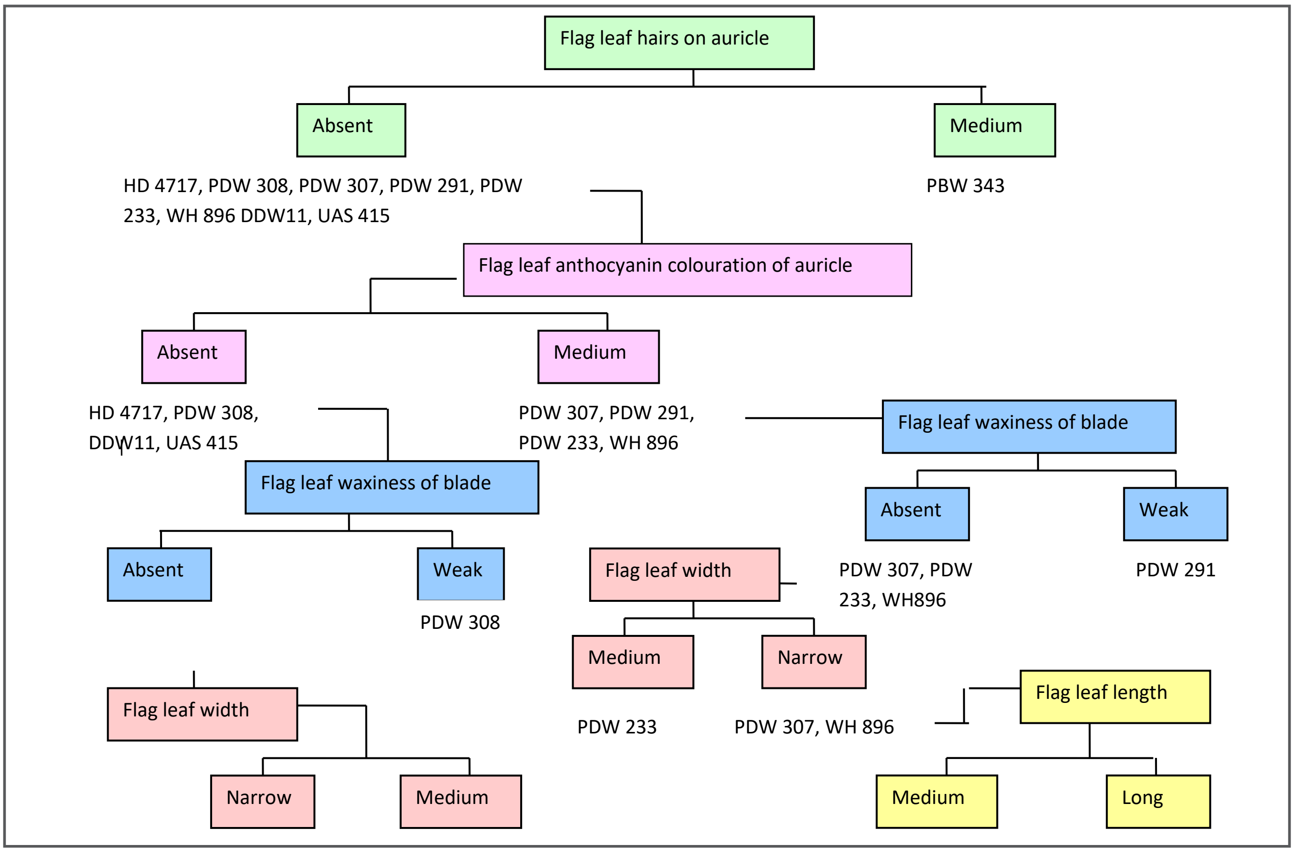
Continuing table 1

Plant Descriptors	Range	No. of Variety	Classification of Varieties
Flag Leaf Attitude	Erect	7	PBW 343, PDW 308, HD 4717, DDW 11, UAS 415,PDW 233, WH 896
	Semi Erect	2	PDW 307, PDW 291
	Drooping	0	-
Lower Glume Shoulder Width	Narrow	7	DDW 11, WH 896, PDW 307, UAS 415, PDW 308, HD4717, PDW 291
	Medium	0	Nil
	Broad	2	PDW233, PBW 343
Lower Glume Beak Shape	Straight	2	PBW 343, HD4717
	Moderately Curved	7	DDW 11, WH 896, PDW 307, UAS 415, PDW 308, PDW 291, PDW233
	Strongly Curved	0	-
	Geniculate	0	-
Peduncle Length	Short	1	PBW 343
	Medium	8	PDW 308, WH 896, DDW 11, UAS 415, PDW 291, PDW 233, HD 4717, PDW 307
	Long	0	-
Peduncle Attitude	Straight	6	UAS 415, PDW 291, PDW 233, HD 4717, PBW 343, PDW 307
	Bent	3	PDW 308, WH 896, DDW 11
	Crooked	0	-
Grain Colour	White	0	-
	Amber	9	PDW 308, WH 896, DDW 11, UAS 415, PDW 291, PDW 233, HD 4717, PBW 343, PDW 307
	Red	0	-
Grain Colouration With Phenol	None	8	PDW 308, WH 896, DDW 11, PDW 307, HD 4717, PDW 233, PDW 291, UAS 415
	Very dark	1	PBW 343
Ear Length	Very short	1	PDW 291
	Short	6	HD 4717, PDW 233, PDW 307, DDW 11, PDW 308, WH 896
	Medium	2	PBW 343, UAS 415
	Long	0	-

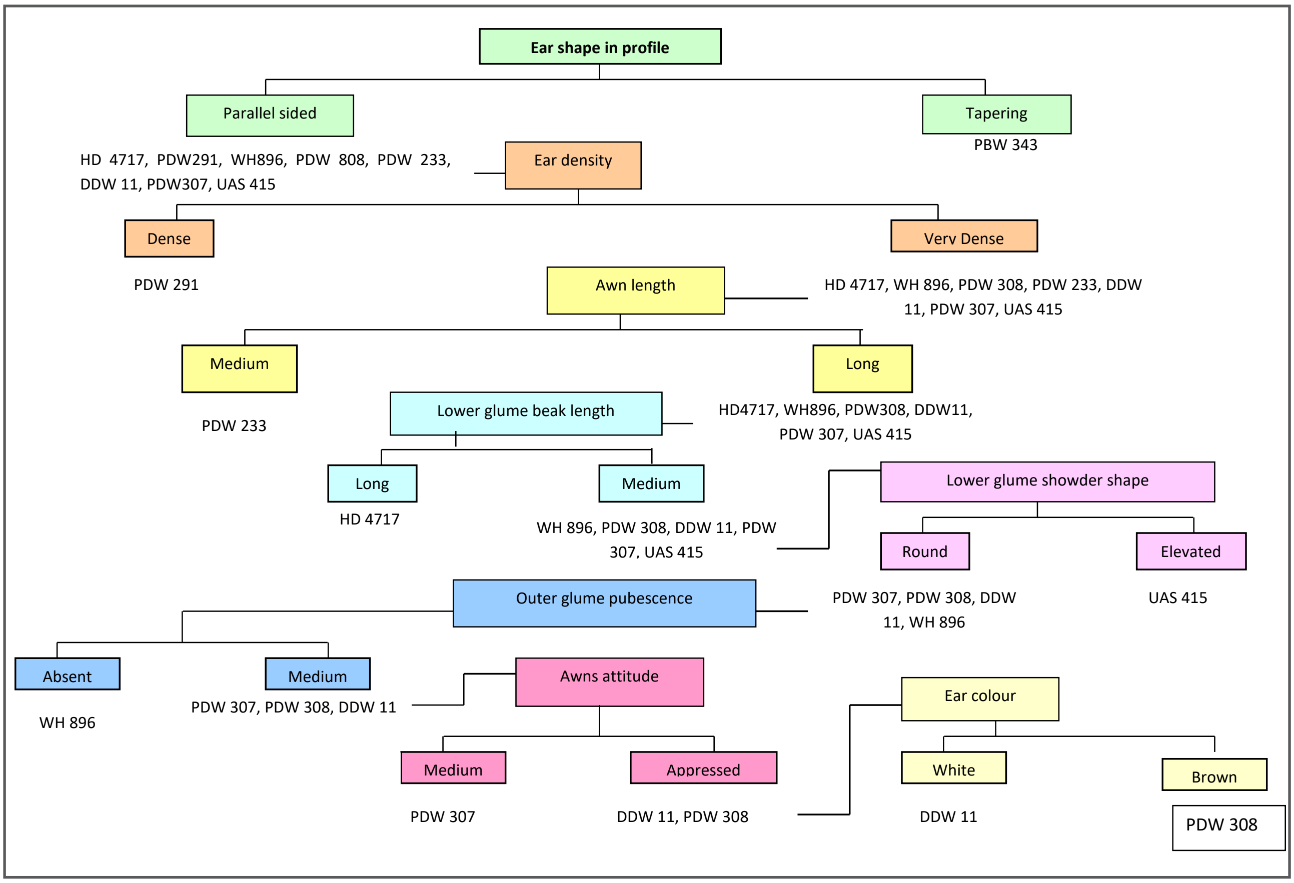
Figures 1. Schematic diagram for cultivar identification of wheat varieties on the basis of plant morphological characters



Figures 2. Schematic diagram for cultivar identification of wheat varieties on the basis of flag leaf characters



Figures 3. Schematic diagram for cultivar identification of wheat varieties on the basis of ear shape characters



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Comparative Evaluation of Hexaploid Triticale Genotypes Under Irrigation with Saline Water

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ABSTRACT

A field experiment was conducted in randomized block design in 3 replications at agriculture research farm, Jagan Nath University, Bahadurgarh, Haryana, to evaluate the production potential of 7 triticale genotypes namely TL2942, TL2969, TL3004, TL3001, TL3003, TL3002 and TL3005 under irrigation with saline water. The soil is clay loam with EC 118 µS/cm and water from nearby bidhro canal having pH 7.6 to 8.4 depending upon rainfall. The observations were recorded on five randomly selected plants in each replication for each genotype and the mean data for grain yield and its attributes: plant height, number of tillers per plant, number of ears per plant, number of spikelet's per spike, dry weight of 100 grains, grain yield per plant and test weight were subjected to analysis of variance. The results revealed significant differences among 7 triticale genotypes for grain yield and its attributes. Among seven triticale varieties TL3002 was found superior for grain yield (7.5g/plant), number of spikelets per spike (16.88) whereas TL3001 scored highest number of tillers per plant (6.2), number of ears per plant (6.21), test weight (15.79) and TL2969 scored highest plant height (88.2 cm) and number of spikelets per spike (16.88). These genotypes may possess genes for salinity tolerance as evidenced by their performance in predominantly saline soil and water used. They should be included in direct cultivation in such environment as well as hybridization programme to develop recombinants possessing high grain yield and tolerance to salinity.

Keywords: *6x triticosecale*, grain yield, salinity

Introduction

Triticale (6x *triticosecale, AABBRR*) is a first man made cereal obtain from cross between tetraiploid wheat (AABB) and diploid rye (RR) (Conrado *et al.* 1993). It posses attributes of both parents that is grain quality from wheat and stress tolerance from rye (Blum, 2014). Triticale can be grown in marginal soils with low to medium fertility and soils possessing salinity/acidity problems (Bona, 2004). Initially triticales wear suffering from grain shrivelling and low grain yield. However broadening of genetic base in secondary 6x triticale lines through recombination breeding have paid dividends (Blum, 2014). Triticale lines now available have well filled long grains possessing comparative yield to wheat (Arya *et al.* 2016) with better grain quality particularly for protein, lysine and mineral matters (Mergoum *et al.* 2009). A set of seven such lines has been evaluated under field condition using saline water from drain canal (Bidro) at the research farm, Jagan Nath University Bahadurgarh, Haryana, India. This paper deals with comparative evaluation of seven Triticale genotypes for grain yield and its components and other morphological characters.

Materials and Methods

Experiment location: All the experiments were conducted in research farm of the Department of Agriculture, Jagan Nath University during Rabi season 2018-19. This location has latitude 28062’80’’N and longitude 76075’34’’E.

Soil: The district Jhajjar is a part of Eastern Haryana plain which forms a part of the Indo-Gangetic Plain. The soil at the location is clayey loam with Organic Carbon 0.69%, Total Nitrogen 0.16% and available P_2O_5 (5.0 kg/ha).

Irrigation Water: This experimental field was irrigated with bidhro water. Water samples were collected from bidhro before sowing and were analyzed for various physico-chemical parameters (Table 1).

Plant material and experimental design: Seven triticale genotypes (TL2942, TL2969, TL3004, TL3001, TL3003, TL3002 and TL3005) obtained from CCS HAU Hisar (Table 2) were sown in a randomized block design with three replicates. Recommended doses of 120 kg N, 60 kg P, and 60 kg K/ha through Urea, Di-ammonium phosphate and Muriate of Potash, respectively were applied. Half of the N and full of P and K were applied at sowing while remaining half N was top dressed in two equal parts each at tillering and heading stages of crop. Fertilizer application preceed with irrigation with saline water from bidhro as flood irrigation. Plants were allowed to grow up to maturity. Yield and yield components plant height, number of tillers per plant, number of ears per plant, number of spikelet’s per spike, dry weight of 100 grains, grain yield per plant and test weight *etc.*) were recorded after harvesting the plants at maturity.

Statistical analysis: The mean data for each trait was subjected to Analysis of Variance to ascertain significant differences among genotypes. Also the standard errors for mean difference for each trait were calculated. Based on statistical analysis superior genotypes were identified.

Results and Discussion

Analysis of Variance revealed that significant differences among triticale genotypes for all the traits (data not given for brevity). It indicated that each genotype reacted differently to saline irrigation water. The comparison of means for each trait (Table 3) revealed that genotype TL2942 recorded highest plant height (88.2 cm) while the lowest being in TL3005 (84.1 cm). Highest number of tillers per plant was observed in TL3001 (6.2) while lowest in TL2942 (4.7). Maximum number of ears per plant was recorded for TL3001 (6.2) while minimum in TL2942 (4.44). TL2969 and TL3002 recorded highest number of spikelet’s per spike (16.88) while TL2942 recorded the lowest (14.88). Dry weight of 100 grains was observed maximum in TL3004 (3.72 g) while minimum in TL2942 (3.27 g). TL3002 scored maximum grains yield per plant (7.50 g) while TL3005 recorded minimum grain yield (5.68 g). Highest test weight was observed in TL3001 (15.79 g/cm^3) while lowest in TL3003 (9.75 g/cm^3). The standard error or difference of mean for various traits was almost within acceptable range which revealed that the experiment was properly conducted and the sampling was effectively done. Some genotypes figured superior for two or more characters. In this context genotype TL3002 figured important for its superior performance for number of spikelets per spike and grain yield per plant coupled with second highest performance for number of tillers per plant and number of ears per plant. Coincidentally these are principle components of grain yield. It’s seems that the genetic makeup of this genotype offers tolerance to salinity of irrigation water as well as soil. Also, TL3001 exhibited superior performance for grain yield at second ranked coupled with relatively high number of tillers per plant, number of ears per plant and test weight. Likewise, genotype TL2969 revealed considerably high yield coupled with superior performance for plant height, number of spikelet’s per spike and test weight. Thus it is evident that the genotypes found superior for grain yield also had superior performance for at least one or more yield components contributing towards grain yield (Dumbrava *et al.* 2016). Salt tolerance in plant is mainly determine by mechanisms including salt exclusion by root (Munns and Tester, 2008), deposition of salts in vacuoles, exclusion of salts from leaf margins and maintenance of turgor and osmotic potential under saline condition. On the other hand, the salt injuries are caused either by osmotic stress or ionic injury (Tang *et al.* 2015). The performance of agronomic traits have been used to identify relative tolerance of triticale genotypes for salt stress. A genotype performing better under salinity stress as well as no stress condition is expected to possess mechanism of homeostasis (Bartels and Sunkar, 2005). Such genotypes are worthwhile to insure survival under salt stress and yield potential under optimal condition. Involvement of such genotype in hybridization program may yield recombinants exhibiting higher performance for grain yield as well as its components especially in the environment where soil salinity is predominant.

Triticale is a relatively new crop for Indian farmers. Its lower grain quality for leavened bread (*Chapatti)* compare to wheat and its high nutritional value and production potential in marginal soils make it as an attractive crop for animal husbandry particularly for monogastic animals like swine and poultry (Farrell *et al.* 1983). We shall take up the feeding trials for poultry industry prevalent in Jhajjar district around the university.

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Table 1. Various physico-chemical parameters of water used for irrigation

pH	7.26
TDS (ppm)	1737.47
EC (µS/cm)	3393.43
ORP (mV)	202.08
F^- (ppm)	1.25
Cl^- (ppm)	1472.42
NO_3^- (ppm)	22.98
SO_4^{2-} (ppm)	329.39
PO_4^{3-} (ppm)	0.16
Total Hardness (ppm)	1025.70
Ca Hardness (ppm)	200.21
Mg Hardness (ppm)	832.79
Total Alkalinity (ppm)	147.49

Table 2. Pedigree of seven triticale genotypes utilized in experimentation

Sr. No.	Variety	Pedigree
1.	TL2942	TL 2732/DT 54
2.	TL2969	JNIT 141/TL1210//JNIT141
3.	TL3004	TL2969/2987
4.	TL3001	UPT79362/DT962//JNIT128
5.	TL3003	T2396/DT78/JNIT128//TL1241
6.	TL3002	T2938/T2969
7.	TL3005	TL2969/2987

Table 3. Performance of various agronomical parameters in seven triticale genotypes

Variety	Plant Height	No. of Tillers Per Plant	No. of Ears Per Plant	No. of Spikelets Per Spike	Dry Wt. of 100 Grains (g)	Grains Yield Per Plant (g)	Test Wt. (g/cm^3)
TL2942	85.6 ±5.33	4.7 ±1.38	4.44 ±1.07	14.88 ±2.0	3.27 ±0.21	5.82 ±0.59	12.63 ±2.34
TL2969	88.2 ±3.29	5.1 ±0.84	4.88 ±1.01	16.88 ±1.6	3.25 ±0.21	6.38 ±1.22	14.57 ±3.67
TL3004	85.2 ±7.39	5.6 ±0.87	5.44 ±1.07	16.22 ±1.5	3.72 ±0.38	5.96 ±0.19	14.54 ±4.18
TL3001	87.3 ±4.72	6.2 ±1.26	6.21 ±1.26	15.99 ±1.1	3.52 ±0.21	7.04 ±1.16	15.79 ±4.21
TL3003	85.59 ±6.83	4.8 ±0.19	5.88 ±1.83	15.10 ±2.1	3.49 ±0.13	6.63 ±1.99	9.75 ±2.05
TL3002	84.69 ±9.63	5.8 ±0.76	5.88 ±0.76	16.88 ±0.7	3.64 ±0.10	7.50 ±1.80	14.14 ±3.16
TL3005	84.1 ±8.72	5.4 ±1.89	5.11 ±2.01	15.77 ±3.2	3.65 ±0.76	5.68 ±2.85	10.78 ±2.85

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Comparison of Some Triticale and Wheat Varieties in Terms of Yield Over the Locations and Years in Erzurum Conditions

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ABSTRACT

This study was conducted to determine triticale varieties suitable for the ecological conditions of Erzurum and to compare them with wheat varieties developed for the region in Pasinler and Aziziye locations for a period of ten years (2006-2015) in randomized block design with 3 replications. In this study, 3 bread wheat varieties (Doğu 88, Palandöken 97, Alparslan) and 1 triticale (Ümranhanım) variety and 3 triticale varieties developed by Bahri Dağdaş International Agricultural Research Institute (Tatlıcak 97, Mikham and Melez 2001) for the East Anatolian Region were used as study material. Wheat and triticale varieties were compared with each other in terms of grain yield over the locations and years. There were statistically significant differences ($p<0.01$) between years, locations and varieties. While the average yield of 4403 kg ha^{-1} was obtained from the Pasinler location, 2896 kg ha^{-1} yield was obtained from the Aziziye location on average. According to the results of the ten-year trial, the Ümranhanım triticale variety developed especially for the Eastern Anatolia Region had the highest grain yield (4189 kg ha^{-1}). This was followed by Tatlıcak 97 (4062 kg ha^{-1}), Doğu 88 (3712 kg ha^{-1}), Alparslan (3655 kg ha^{-1}), Palandöken 97 (3575 kg ha^{-1}), Mikham (3389 kg ha^{-1}) and Melez 2001 (2967 kg ha^{-1}) varieties. Therefore, it is concluded that the Ümranhanım and Tatlıcak 97 cultivars can be used as an alternative to wheat varieties grown in the region and higher grain yield can be obtained.

Keywords**:** Triticale, bread wheat, yield, adaptation

Introduction

About 73% (1.03 million ha) of the agricultural lands of Eastern Anatolia Region which holds an important place in the agriculture of Turkey is comprised of grain planting areas. Approximately 730 thousand ha of this area has been planted with wheat and the yield per hectare is 1500-1700 kg (Anonymous, 2012). Only 25% of the agricultural land in the region can be irrigated. Therefore, agriculture in the region is based on plant species that can be cultivated in dry conditions. The compensatory abilities of cereals as well as their ability to eliminate grower errors and negative conditions to a certain extent earn them a different place among crop plants (Akkaya, 1994). The dry farming system dominates in Eastern Anatolia as well as overall Turkey and therefore cereals have an important place in this system. Furthermore, 539,174 ha of the 13,621,000 ha of land is unsuitable for the agriculture of many crops grown in the region (Anonim, 1996). That is, 20.4% of the total land in the region cannot be used at present. On the other hand, the yield from the unit area in the region is quite low. Therefore, there is a significant gap both in the balanced nutrition of humans and in the provision of feed for animal husbandry. Under the circumstances cereals have a great potential to close the gap in terms of both food grains and animal feed in the world as well as in Turkey. As the winter pre-winter development is good for both cultivated and cold-resistant varieties planted at the appropriate time, both cold resistance and yield increase. Triticale is less damaged by winter and cold compared to other grain types. The varieties developed especially as a result of breeding studies provide maximum adaptation to the regions where their use is recommended and deliver very high yields. The aim of this study is to examine and compare the long year average yield performance of some triticale and wheat varieties which have high adaptation to the region.

Materials and Methods

Materials

In this study, Doğu 88, Palandöken 97, Alparslan wheat varieties with a significant cultivation area in the region and Ümranhanım triticale variety and 3 triticale varieties developed by Bahri Dağdaş International Agricultural Research Institute, namely Tatlıcak 97, Mikham and Melez 2001 for the East Anatolian Research Institute were used as trial material.

Methods

The research was carried out in Erzurum, Eastern Anatolia Agricultural Research Institute, at two locations viz., Pasinler experimental station at an altitude of 1760 m and Aziziye experimental station at an altitude of 1812 m in Randomized Complete Block Design with 3 replications. In the planting with the parcel seeder, each parcel was composed of 6 rows with a width of 1.2 m and a length of 6 m. Each parcel was arranged in 6 rows with a row spacing of 20 cm and the planting frequency was adjusted to 475 plants per m^2 (Akkaya, 1993). Planting was carried out between September 1 and October 1, which is the most suitable date for winter planting (Akkaya and Akten 1989; Özcan and Acar 1990). Phosphorus and nitrogen fertilizer was used as the source of fertilizer in the trial; half of the nitrogen fertilizer was used with the planting, the other half during the bolting period while all the phosphorus fertilizer was spread with the planting at a rate of 60 kg N and 60 kg P_2O_5 per hectare (Akkaya, 1993; Kıral and Özcan, 1990). When the varieties reached harvest maturity, the remaining parts were harvested and blended with the parcel harvester after 50 cm of the parcel heads were disposed of as edge effect. The methods applied by Akkaya (1993), Kıral and Özcan (1990), Akkaya and Akten (1989), Özcan and Acar (1990) were used for planting, maintenance and harvesting. Grain yield was investigated based on the methods of Uluöz (1965), Genç (1972), Köycü (1974 and 1979) and in this trial.

The data obtained from the trial were analyzed statistically using JUMP 5.0 package programs and compared according to the LSD test.

Climate and Soil Properties of the Test Site:

Total rainfall and temperature data of the locations where the trials were established are given in Tables 1, 2, 3 and 4 for the years 2006-2015.

Among the locations, Aziziye location has a montmorillonite clay type soil structure and the soil properties of both locations are given in Table 5. Penetration resistance in Pasinler location is between 0.5 and 1.5 MPa and in Aziziye location it is 8 MPa. Root development stops at 2.5 MPa penetration resistance. Therefore, yields obtained from Aziziye location are lower than those for the Pasinler location.

Results and Discussion

When the total rainfall and average temperature values of the growing season between October (1-15 September) and harvest (1-15 August) are examined, there are differences between the total rainfall and average temperatures in both locations. Although the yield is directly related to precipitation and temperature, it is more important that the desired climatic conditions occur in the developmental stages of the plants. Differences were determined between years, varieties, locations and interactions at $P<0.01$ level (Table 6). When the yields on the basis of locations and the climate data of the relevant years are analyzed, the highest yields were obtained in Aziziye in 2008 (7098 kg ha^{-1}) and in Pasinler in 2011 (4120 kg ha^{-1}). The highest yields were obtained in 2008 (5054 kg ha^{-1}) and the lowest yields in 2013 (3332 kg ha^{-1}) (Table 7).

In order to obtain high yields, temperature and precipitation must be regular throughout the vegetation period. Negative climatic conditions that occur at any stage of plant development cause significant reductions in yield. Autumn rainfall and temperatures are very important in the Eastern Anatolia Region. In winter planting, if the plants can make a good start, they will be less affected by winter damage. When the rainfall data is analyzed for a long time, it is noted that 23% of the annual rainfall occurs in autumn and 19% during winter months. When plants planted in winter reappear in spring, they benefit from about 40% of total annual precipitation. This is very important for plant development. High yields were obtained in the years when the plants made a good start before winter and thus started winter with a strong root structure. As a matter of fact, Erekul and Köhn (2006) emphasized the importance of a good start of the plants before winter and the thickness of snow during winter months for high yield.

The yield values for the years in which the trial was conducted are presented in Table 7. The differences between genotypes in terms of yield were insignificant in 2007, significant in 2006 and 2008 ($P<0.05$) and very significant during other years ($P<0.01$). When the data obtained over the years are examined, the average yields of triticale varieties were higher than the average yields of wheat varieties during 5 years (2006, 2008, 2009, 2013 and 2014) while the average yields of wheat varieties was higher during the other 5 years. However, it was noted that the annual average yields of triticale varieties were lowered by Mikham and Melez 2001 varieties (Table 7).

Table 8 shows that there is no statistically significant difference between the locations in 2006, 2011, 2013 and 2014, however during the other years there are significant differences ($P<0.01$). It is very important for plants to make a good start before winter in Eastern Anatolia Region in terms of winter durability. Although there was no statistical difference between the locations in 2006 because there was no climatic negativity in 2007, significant yield losses were incurred in Pasinler location because there was only 3.5 mm precipitation in June during the flowering and pollination period (Table 1). Therefore, the yield from the Pasinler location (3650 kg ha^{-1}) was close to the yield from the Aziziye location (3164 kg ha^{-1}) (Table 8). As there were no climatic problems in 2007, 2008 and 2011, the yields were high, namely 4098 kg ha^{-1}, 3010 kg ha^{-1}, 4120 kg ha^{-1} in Aziziye and 5291 kg ha^{-1}, 7098 kg ha^{-1}, 4181 kg ha^{-1} in Pasinler, respectively. In 2009, low yields affected the Aziziye location which was subjected to hail before harvest in August which caused yield loss (1722 kg ha^{-1}) (Table 8).

In 2012, the lack of sufficient rainfall after planting and very low night temperatures caused insufficient output before winter and low temperatures in spring (-6°C in March) had an adverse impact on plant growth causing yields to decrease to an average of 1527 kg ha^{-1} in Aziziye and 3238 kg ha^{-1} in Pasinler. Low temperature is one of the most important abiotic stresses affecting wheat planting and production. Frost resistance in winter wheat is one of the elements of winter durability (Sutka 1994). Winter wheat and other cereal species must be winter-resistant. The ability to sustain vitality during winter and spring frosts is an important factor in defining the success of winter wheat. Climatic data and winter damage findings have been compared in many locations in Finland, and it was manifested that climate data are related to winter damage levels and that there is an important link between winter damage and yield (Olesen *et al*. 2011). Greer *et al*. (2001) reported that winter wheat developed adaptation mechanisms that compensate for temperature and cold acclimatization processes to increase the viability of seeds while Kovács *et al*. (2011) reported that cold resistance mechanisms were activated during the cold acclimation process. Küçüközdemir and Tosun (2014) determined that registered varieties were more cold resistant in a study under controlled conditions carried out with 180 local and 6 registered varieties and the most resistant genotype was Alparslan which can withstand a temperature of -19°C.

Again in 2014, insufficient rainfall and very low temperatures prevented plants from having a good pre-winter start after planting in the Aziziye location. At the same time, inadequate precipitation for a snow cover in both locations had a negative impact on yield. Rainfall occurred locally in the spring and low temperatures as well as drought adversely affected plant growth. In 2014, 2155 kg ha^{-1} yield was obtained in Aziziye and 2289 kg ha^{-1} yield in the Pasinler location. Tosun *et al*. (2000) carried out a study in Erzurum conditions and obtained grain yields of 1441-2245 kg ha^{-1} while Atak and Çiftçi (2005) carried out a study in Ankara conditions and determined a yield of 2833-3833 kg ha^{-1}. Again Ünsal (2005) reported a grain yield of 200-250 kg ha^{-1} for wheat and barley planted in problematic areas while the grain yield of triticale was 400 to 500 kg ha^{-1}.

When the wheat varieties used in the experiment were evaluated separately, it was seen that there were very important ($P<0.01$) differences between the years. (Table 9). However, since the varieties were developed for the Eastern Anatolia Region, there was no difference between the location averages. When the locations were evaluated separately, the difference between wheat varieties in Aziziye location was found to be insignificant while the difference in Pasinler location was found to be significant ($P<0.05$). As shown in Table 10, Pasinler location (Average 4057 kg ha^{-1}) has a higher yield than Aziziye location (3234 kg ha^{-1}). The highest yield of wheat varieties belong to Eastern 88 varieties (3712 kg ha^{-1}) followed by Alparslan (3655 kg ha^{-1}) and Palandöken (3571 kg ha^{-1}), respectively. In fact, Kaydan and Yağmur (2008) carried out a study for two years with 15 registered varieties under Van ecological conditions and the local genotype Tir, which is widely cultivated in Van, and determined that the highest yield was obtained from Doğu 88 (23836 kg ha^{-1}) cultivars while genotype Tir had the lowest yield (16707 kg ha^{-1}). Çağlar *et al*. (2006) investigated the adaptation of 25 bread wheats in Erzurum conditions. The Doğu 88 cultivar developed for the Eastern Anatolia Region had the highest yield (4607 kg ha^{-1}), while the lowest yield was obtained from Kırkpınar 79 cultivars (3024 kg ha^{-1}).

When the triticale varieties used in the experiment were evaluated separately, it was seen that there were very important ($P<0.01$) differences between the years, varieties, locations and their interactions (Table 11). Since only Ümranhanım variety, which was one of the triticale varieties used as material, was developed for the Eastern Anatolia Region, very important differences were determined between the varieties in both locations and locations averages. As shown in Table 12, Pasinler location (average 4286 kg ha^{-1}) has a higher yield than Aziziye location (3017 kg ha^{-1}).

The cold-resistant Ümranhanım variety developed for the region had the highest yield (4189 kg ha^{-1}) in terms of both location as well as location average of the ten-year, followed by Tatlıcak 97 varieties which has adapted well to the region with 4062 kg ha^{-1}. When the locations were evaluated separately, it was discovered that Ümranhanım and Tatlıcak 97 varieties had higher yields than Mikham (3389 kg ha^{-1}) and Melez 2001 (2967 kg ha^{-1}) varieties and location averages in both locations (Table 12). As can be seen in the same table, the average of the locations is decreased by Melez 2001 and Mikham varieties. In Erzurum conditions, Tosun *et al*. (2000) carried out a study carried and obtained grain yields of 1441-2245 kg ha^{-1} while a study conducted by Atak and Çiftçi (2005) under the conditions of Ankara, they determined yields between 2833-3833 kg ha^{-1}. Küçükbayram and Azkan (2002) emphasized that high grain yield can be achieved with triticales not withstanding sudden arid and hot weather. In 2002, Geren *et al*. reported that seed yields decreased significantly as a result of low and irregular rainfall recorded in parallel with the high temperature in May in the first year and planting 40 days later in the first year than in the second year. In a study conducted in the Republic of South Africa in 2006-07, Du Pisani (2009) emphasized the importance of the effect of years and varieties on grain yield. 6 triticale lines and Doğu 88 varieties in the ecological conditions of Erzurum, Muş, Erzincan and Van provinces were compared in terms of yield and yield components, and one triticale line had higher yields than Doğu 88 (Küçüközdemir, 2002)

Conclusion

According to the results obtained from the study, significant differences were determined among all varieties on the basis of years and locations. Ümranhanım variety, which is resistant to cold and drought, has been identified as having the highest yield among all varieties. This is due to the fact that this variety was developed for the Eastern Anatolia Region. It has been concluded that Ümranhanım and Tatlıcak 97 varieties can be used as an alternative in areas with low yield from wheat due to cold, arid climate conditions and land structure in Eastern Anatolia Region and it is necessary to expand the production of these varieties in order to increase the average yield of cereal in the region.

Table 1. Total monthly precipitation (mm) of the Pasinler Location for 2005-2015

Years	MONTHS												
	9	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
2005-06	23	26	60	31	41	35	21	118.9	38.9	3.5	21.7	6	426
2006-07	14	69.5	10.5	5	22	25	113	104	78	54	33	39	567
2007-08	0	28	72.5	36.5	19.5	41	18	20.1	47.7	31.5	3.8	32.5	351.1
2008-09	2	74.4	12	28	18	45	66.3	49.7	33.7	78.8	52.5	14.5	474.9
2009-10	31	44.1	49.4	25	45.6	20.2	71.5	47.9	58.5	32	58.3	4.5	488
2010-11	12	52	0	8.6	20.4	42.5	16	152	56.7	24	20	7.5	411.7
2011-12	16	30	38	27.5	34.5	63	11.5	16	47.5	29	10	15	338
2012-13	72	45.5	29	43	43	41	39	45	32	26.5	7.5	6	429.5
2013-14	20	45.5	29	43	18	10	36	21.5	94	27	13	13	370
2014-15	22.5	25	30.5	26.5	41	46	42	66	23	21	8	28.5	380
Average	21.25	44	33.09	27.41	30.3	36.87	43.43	64.11	51	32.73	22.78	16.65	423.62
Long Years	19	46	42	29	27	32	41	59	69	49	26	19	458

Data were obtained from the Turkish State Meteorological Service

Table 2. Monthly total precipitation (mm) of Aziziye Location between 2005-2015

Years	MONTHS												
	9	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
2005-06	25.8	81.5	6.5	18.7	11.5	4.4	12.2	76.4	46.1	22.8	14.7	8.1	328.7
2006-07	24.2	72.7	27.2	9.6	10.7	18	3.5	103.9	83.3	43.8	40	29.2	466.1
2007-08	1	33.5	82.8	18.7	16.9	4.6	4.5	50.5	57.7	58.7	7.6	19.4	355.9
2008-09	27.4	44.1	31.8	16.7	3.4	17.5	39	43.8	48.9	64.5	45.1	38	420.2
2009-10	40.3	60.3	16.5	9.2	39.9	10.9	86.9	45	72.4	27.9	85.8	13.4	508.5
2010-11	14.2	52.2	0	6	31.6	21.7	11.4	153.8	97.4	54.6	16	32.2	491.1
2011-12	21.1	19.9	3.1	18	17	31	7.6	30.8	82.8	5.8	18.5	1.2	256.8
2012-13	20.7	45.9	34.6	21.4	20.2	40.6	31.2	27.8	27.1	30.2	6	5	310.7
2013-14	13.5	22.1	17.1	3	8	4	38.7	31.2	109.2	7.2	17.7	0	271.7
2014-15	67.8	46.9	11	11.2	21.3	28.3	28.9	69.2	72.2	83.6	9.5	38.4	488.3
Average	25.6	47.91	23.06	13.25	18.05	18.1	26.39	63.24	69.71	39.91	26.09	18.49	389.8
Long Years	20	47	43	31	28	30	38	60	74	47	22	16	456

Data were obtained from the Turkish State Meteorological Service

Table 3. Monthly average temperature for Pasinler Location between 2005-2015 (°C)

Years	MONTHS												
	9	10	11	12	1	2	3	4	5	6	7	8	Total
2005-06	20.4	14.9	1.2	0.5	-15.1	-9.4	0.1	7.1	10.9	16.8	19.4	20.5	7.3
2006-07	14.2	9.3	0.8	-7.8	-12.8	-10.6	-2.1	2.5	12.7	14.9	18.2	18.3	4.8
2007-08	15.7	9.5	0.4	-8.2	-18.2	-14.5	-5.5	7.6	9.5	17.2	19.5	20.1	4.4
2008-09	15.6	9.0	2.4	-9.0	-11.6	-3.8	-0.7	4.6	10.3	14.3	17.3	16.7	5.4
2009-10	12.8	9.6	2.5	-0.6	-4.3	-1.5	3.7	6.3	10.7	16.2	33.0	32.0	10.0
2010-11	32.1	9.8	2.9	-1.0	-7.9	-5.6	-0.5	5.9	10.1	15.0	19.4	19.0	8.3
2011-12	13.9	7.5	-3.8	-11.0	-8.8	-14.3	-6.9	7.2	11.6	16.0	18.8	20.4	4.2
2012-13	15.1	9.7	4.5	-5.1	-8.9	-7.7	-0.1	7.8	11.9	15.0	19.6	19.2	6.8
2013-14	14.3	6.6	2.9	-13.8	-8.7	-6.6	2.7	7.2	11.6	15.7	20.5	21.5	6.2
2014-15	15.5	8.9	0.2	-0.9	-7.3	-6.5	-0.8	5.8	10.7	16.0	21.1	21.4	7.0
Average	17.0	9.5	1.4	-5.7	-10.4	-8.1	-1.0	6.2	11.0	15.7	20.7	20.9	6.4
Long Years	15.5	9.3	3	-2.9	-6.3	-4.7	0	6.8	11.6	15.6	19.7	19.6	7.3

Data were obtained from the Turkish State Meteorological Service

Table 4. Monthly average temperature for Aziziye Location between 2005-2015 (°C)

Years	MONTHS												
	9	10	11	12	1	2	3	4	5	6	7	8	Total
2005-06	13.6	6.3	0.5	-4.5	-13.1	-6.4	0.8	7.0	10.4	3.6	19.0	19.4	4.7
2006-07	13.8	8.2	0.2	-9.0	-13.5	6.3	-1.9	1.6	12.6	14.6	18.0	18.7	5.8
2007-08	15.2	8.6	-1.3	-7.8	-17.8	-15.0	1.5	7.6	7.2	13.7	18.8	19.7	4.2
2008-09	14.9	7.1	-1.8	-4.9	-10.9	-8.2	-0.1	4.4	9.9	14.4	16.8	16.6	4.9
2009-10	12.4	8.5	-1.4	-7.4	-12.1	-3.1	-0.7	4.3	10.0	14.7	17.2	17.1	5.0
2010-11	14.8	9.3	1.7	2.5	-1.5	-14.9	-6.1	2.1	11.2	14.4	19.1	14.5	5.6
2011-12	4.3	4.4	4.0	-11.3	-8.5	-14.9	-6.1	6.7	11.2	15.6	18.7	19.4	3.6
2012-13	14.4	9.2	4.0	-5.4	-9.2	-7.4	-0.5	7.2	11.7	14.8	19.3	19.0	6.4
2013-14	13.5	4.4	4.0	-11.3	-8.5	-14.9	-6.1	6.7	11.2	15.6	19.1	14.4	4.0
2014-15	4.3	9.6	2.3	-13.9	-9.9	-6.9	2.4	7.6	5.9	11.2	19.1	20.0	4.3
Average	12.1	7.6	1.2	-7.3	-10.5	-8.5	-1.7	5.5	10.1	13.3	18.5	17.9	4.8
Long Years	15.2	9.1	2.9	-2.9	-6.2	-4.8	-0.2	6.5	11.1	15.1	19.4	19.3	7.0

Data were obtained from the Turkish State Meteorological Service

Table 5. Soil characteristics of the locations where the trial was conducted

Location	Type	pH	EC	Lime	O.M	P	K
Pasinler	Loamy	7.55	3.20	0.32	1.32	10.11	86
Aziziye	Loamy	7.57	2.60	0.32	1.58	8.35	102

Table 6. Variance analysis table of the trial

Source	DF	Sum of Squares	F Ratio	Prob > F	LSD
Year	9	301243620	109.6	<.0001	237
Location [Year]	10	457185340	149.7	<.0001	334
Replication [Year, Location]	40	14063020	1.2	0.2579	578.7
Variety	6	60244470	32.9	<.0001	198.5
Variety* Year	54	87706160	5.3	<.0001	888.2
Variety* Location [Year]	60	54269660	3.0	<.0001	920

C.V: 15%

Table 7. Yield values of varieties by years (kg ha^{-1})

Years	Ümranhanım	Tatlıcak 97	Mikham	Melez 2001	Doğu 88	Palandöken 97	Alparslan	Years United
2006*	3014 bc	4306 a	4029 ab	3757 a-c	3042 bc	3031 bc	2673 c	**3407 e**
2007ns	4400	4521	5361	4352	4553	4826	4847	**4694 b**
2008*	5263 a	5305 a	500 ab	5061 ab	5468 a	4650 b	4632 b	**5054 a**
2009**	4609 a	4615 a	3334 b	2551 c	3772 b	3645 b	3630 b	**3736 d**
2010**	4582 a	4063 b	2881 c	2619 c	4113 ab	4318 ab	4403 ab	**3854 d**
2011**	5348 a	4222 a	3156 d	3270 cd	3884 b	3767 bc	5436 a	**4155 c**
2012**	2273 ab	2537 b	1914 cd	1676 d	3086 a	2450 b	2241 bc	**2382 f**
2013**	4420 a	3837 ab	2840 de	2289 e	3587 bc	3444 b-d	2905 c-e	**3332 e**
2014**	2749 a	2607 ab	2288 a-c	1644 d	2218 a-c	1956 cd	2091 b-d	**2222 f**
2015**	4730 a	4608 a	2088 c	2456 d	3398 bc	3620 b	3689 b	**3656 d**
Average**	**4189 a**	**4062 a**	**3389 c**	**2967 d**	**3712 b**	**3575 bc**	**3655 b**	**3649**

ns: non significant; **: significant at 0.01; *: significant at 0.05

Table 8. Yield values of locations by years (kg ha^{-1})

Location	2006ns	2007**	2008**	2009**	2010**	2011ns	2012**	2013ns	2014ns	2015**
Aziziye	3164	4098 b	3010 b	1722 b	3239 b	4120	1527 b	3316	2155	2598 b
Pasinler	3650	5291 a	7098 a	5751 a	4469 a	4181	3238 a	3347	2289	4714 a
LSD	808.9	721.4	747.6	424.9	322.4	219.7	375.0	269.2	385.8	377.5

ns: non significant; **: significant at 0.01; *: significant at 0.05

Table 9. Variance analysis table of wheat varieties in terms of years and locations

Source	DF	Sum of Squares	F Ratio	Prob > F	LSD
Year	9	142541280	38.9353	<.0001	422.9
Loc [Year]	10	185192030	45.5269	<.0001	598.1
Tek [Year, Loc]	40	23946460	1.4717	0.0719	1036.2
Variety	2	605180	0.7439	0.4785	231.6
Variety* Year	18	18094320	2.4712	0.0031	732.7
Variety* Loc [Year]	20	11616620	1.4279	0.1341	1036.1

Table 10. Annual average yields of wheat varieties

Location	Doğu 88	Palandöken 97	Alparslan	Average	LSD
Aziziye[ns]	3307	3338	3059	3234	3188
Pasinler*	4117 ab	3804 b	4250 a	4057	3486
Average	3712	3571	3655	3646	2316

ns: non significant; **: significant at 0.01; *: significant at 0.05

Table 11. Variance analysis table of triticale varieties based on years and locations

Source	DF	Sum of Squares	F Ratio	Prob > F	LSD
Year	9	176302280	111.5738	<.0001	238.1
Loc [Year]	10	290866230	165.6686	<.0001	336.9
Tek [Year, Loc]	40	9783500	1.3931	0.0875	583.5
Variety	3	59635650	113.2222	<.0001	150.7
Variety* Year	27	52011900	10.9720	<.0001	476.5
Variety* Loc [Year]	30	23780110	4.5148	<.0001	673.9

Table 12. Location yields of triticale varieties in terms of yearly averages (kg ha^{-1})

Location	Ümranhanım	Tatlıcak 97	Mikham	Melez 2001	Average	LSD
Ilıca**	3630 a	3510 a	2650 b	2380 c	3017	213.8
Pasinler**	4848 a	4614 b	4129 c	3555 d	4286	218.8
Average**	4189 a	4062 a	3389 b	2967 c	3652	150.7

ns: non significant; **: significant at 0.01: *: significant at 0.05

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Released Varieties

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Registration of “Meltem” Bread Wheat Variety

Meltem is a spring bread wheat (*Triticum aestivum* L.) variety developed by Aegean Agricultural Research Institute (AARI) and registered in 2018. The pedigree of Meltem involved cross PVN/YACO/3/KAUZ*2/TRAP//KAUZ/4/NESTOR/3/HE1/3*CNO79//2*SERI with SEE02121-0S-0S-0S-3S-3S-2S. crossing was made in 2002.

Meltem is a spring type cultivar. The spike colour of Meltem is white with awn and compact ear. Grain is white colour. Meltem is a medium-tall cultivar, height is 95-100 cm. It is medium early and it has good adaptability. It is resistance to lodging. It has been grown in Aegean region in mediterranean zone.

The yield changes between 7000 kg/ha and 9500 kg/ha depends on air condition and soil fertility. Meltem is moderate resistance to stripe rust (*Puccinia striiformis* f.sp. *tritici*) and stem rust (*Puccinia graminis* f.sp. *tritici*) and moderate susceptible to leaf rust (*Puccinia triticina* f.sp. *tritici*).

Grain quality is good. The values of some bread making qualities of Meltem are; test weight 77.0-82.7 kg hl^{-1}, thousand kernel weight 36.0-42.6 g, protein content 12.0-16.6%, sedimentation 37-59 ml, alveograph energy value (W) 160-300 and water absorption 57-63%.

Figure 1. Spike and grain of the Meltem cultivar (Original)

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Registration of "Poyraz" Durum Wheat Variety

Poyraz is a spring durum wheat (*Triticum durum* Desf.) variety (Figure 1) developed by Aegean Agricultural Research Institute (AARI) and registered in 2019. The pedigree of Poyraz involved cross AVILLO_1/3/ISLOM_1/DUKEM_2//TARRO_3/7/ECO/CMH76A.722//BIT/3/ALTAR84/4/AJAIA_2/5/KJOVE_1/6/MALMUK_1/SERRATOR_1/8/TARRO_1/2* YUAN_1//AJAIA_13/YAZI/3/SOMAT_4/INTER_8/4/ARMENT//SRN_3/NIGRIS_4/3/CANELO_9.1 with CDSS06Y00388S-29Y-0M-10Y-1M-0Y-0S

Poyraz is a spring type cultivar and it is resistance to lodging. The spike color of Poyraz is white with brown awn and compact. Grain is amber colored. Poyraz is a medium-tall cultivar, height is100 cm. It has good adaptability. Tillering is good. It has been grown Aegean region in Mediterranean zone.

The average yield is 6600 kg/ha. Yield potential is high however; high yield can be obtained if environmental conditions and favorable and good agronomic practices are applied. The highest grain yield obtained was 11000 kg/ha. Poyraz is moderate resistance to stripe rust *(Puccinia striiformis* f.sp. *tritici*) and stem rust (*Puccinia graminis* f.sp. *tritici*) and leaf rust (*Puccinia triticina* f.sp. *tritici*).

Grain quality is good. The values of some qualities of Poyraz are; test weight 73.1-80.2 kg hl^{-1}, thousand kernel weight 41.1-54.5 g, protein content 12.0-15.4%, vitreousness 70-98%, yellowness (b value) 27.9-30.3.

Figure 1. Spike and grain of the Poyraz cultivar (Original)

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Registration of "Sümerli" Durum Wheat Variety

Sümerli is spring durum wheat (*Triticum durum* Desf.) variety (Figure 1) developed by GAP International Agricultural Research and Training Center (GAP IARTC) and registered in 2018. Sümerli variety originates from CIMMYT and its pedigree is TRN//D21563/AA/3/BD2080/4/BD2339/5/RASCON_37/TARRO_2//RASCON_37/6/AUK/GUIL//GREEN/11/ALTAR84ALTO_1/RISSA/9/USDA595/3/D67.3/RABI//CRA/4/ALO/5/HUI/YAV_1/6/ARDENTE/7/HUI/YAV79/8/POD_9/10/SHAG_14/ANAD_1//KITTI_1/2/CIRNOC2008.

Sümerli cultivar is spring type and has intermediate growth habit, short-medium plant length, early-medium heading, medium ear glaucosity, fully awned, light brown awn color, short and white spike, medium ear density, amber colored and vitreous grain, absent or very low curved flag leaves. It resembles Artuklu cultivar, but Sümerli variety is shorter in height and spike than Artuklu variety. Plant height is about 100 cm depending on the growing conditions. It has been grown throughout Southeastern Anatolia Region's rainfed and irrigated conditions and Coastal Zones of Turkey. It gives high yield on fertile soils. It has resistance to septoria disease and it shows moderately tolerant reaction against yellow rust.

Yield potential is high however and high yield can be obtained if environmental conditions are favorable and good agronomic practices are applied. The highest grain yield was obtained as 10230 kg ha^{-1} in Diyarbakır location in 2014-15 growing season. Mean yield in the variety registration trials was about 8000 kg ha^{-1} in Southeastern Anatolia Region.Suggested planting rate is 500 seeds/m^2.

The quality of variety is very well. The mean values of some durum wheat quality traits in Sümerli in the variety registration trials (between 2015 and 2017) are as follows. Test weight 80.2 kg/hl^{-1}, thousand kernel weight 41.4 g, protein content 15.7%,vitreousness 97.5%, SDS sedimentation 23.6 ml, semolina color 28.1 and semolina yield 62.6%.

Pre-Basic and Basic seeds of Sümerli cultivar have been produced by GAP International Agricultural Research and Training Center (Gap IARTC). Certified seed of the Sümerli cultivar will be produced by TİGEM.

Figure 1. Spike, grain and plant of the Sümerli cultivar (Original)

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Registration of “Helke” Barley

Helke is six rowed barley (*Hordeum vulgare* L.) variety (Figure 1) developed by Trakya Agricultural Research Institute (TARI) and registered in 2019. Helke cross is Slad/5/Yrm/4/Yky387/3/Api/cm 67//Manch/6/Slad/7/Yky387/3/ Api/Cm67//Manch/5/Yky387/3/Api/Cm67//Manch /4/Dmn/Rhod”S” with TEA1980-0T-0T-0T-3T-0T pedigree. Crossing was made in 2003 and yield test began in 2011-2012 growing year.

Helke cultivar is six rowed cultivar and its spike is moderately long, and compact. It resembles with cultivars Hazar and Martı. Helke is a medium-tall cultivar, similar to Martı. Its plant height is between 79 and 102 cm depending on the growing conditions. It is medium early and it has good adaptation ability, it has been grown throughout Trakya-Marmara region of Turkey. It gives high yield both on fertile and less fertile soils. It has resistance to winter killing and is tolerant to medium drought conditions. Helke is highly tolerant to powdery mildew (*Blumeria graminis* f. sp. *hordei*), net blotch (*Pyrenophora teres*) and scald (Rhynchosporium commune (formerly known as R. secalis) disease.

Yield potential is high; however, high yield can be obtained if environmental conditions are favorable and applied good agronomic practices. The highest grain yield obtained was 8006 kg ha^{-1} in Edirne location in 2016-2017 growing years. Mean yield of the variety testing experiment was 6545 kg ha^{-1} in Trakya growing conditions. Suggested planting rate is between 450-500 seeds/m^2.

Grain feeding quality is good. The mean values of some qualities of the variety testing experiment (2016 and 2018) are; test weight 64.2 kg, thousand kernel weight 31.1 g, protein content 14.5%, sieve value 47.0%, grain uniformity 12.2. The highest quality values in 2016-2018 growing seasons were; 1000-kernel weight 49.9 g, test weight 70.1 kg, protein content 15.1%, sieve value 96.8%

Pre-Basic and Basic seeds of the Helke cultivar have been produced by Trakya Agricultural Research Institute (TARI). Certified seed of the Helke are produced by both private companies and state farms.

Figure 1. Spike and grain of the Helke cultivar (Original)

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Registration of "Anafarta" Bread Wheat

Anafarta is winter bread wheat (*Triticum aestivum* L.) variety (Figure 1) developed by Trakya Agricultural Research Institute (TARI) and registered in 2019. Anafarta cross is 15.99/3/Pehl//Rpb8-68/Chrc/4/ Chatelet with TE6411-2T-0T-9T-5T-3T-0T pedigree. Crossing was made in 2005 and yield test began in 2014-2015 growing year.

The spike of the Anafarta cultivar is moderately long, white, smooth, with awn and compact. It resembles with cultivar Gelibolu and Saban. The flag leaf is dark-green, and with medium glaucousity. Grain is oval, hardand red colour. Anafarta is a medium-tall cultivar, similar to Saban, Gelibolu and Tekirdağ. Its plant height is between 80 and 100 cm depending on the growing conditions. It is medium early and as it has good adaptation ability, it has been grown throughout Trakya-Marmara region and some other parts of Turkey. It gives high yield both on fertile and less fertile soils. It has resistance to winterkilling and is tolerant to medium drought conditions. Anafarta is tolerant to powdery mildew (*Erysiphe graminis* f. sp. *tritici*), stripe rust (*Puccinia striiformis* f. sp. *tritici*) and leaf rust (*Puccinia triticina* Eriks.).

Yield potential is high however, high yield can be obtained if environmental conditions are favorable and applied good agronomic practices. The highest grain yield obtained was 9138 kg ha^{-1} in Edirne location in 2016-2017 growing years. Mean yield of the variety testing experiment was 7135 kg ha^{-1} in Trakya growing conditions. Suggested planting rate is between 450-500 seeds/m^2.

Grain quality is good. The mean values of some bread making qualities of the variety testing experiment (2016 and 2018) are; test weight 75.3 kg, thousand kernel weight 36.9 g, protein content 13.8%, absorpsion 60.6% and sedimentation (Zel) 44.4 ml, gluten index 97.3%, alveograph energy value (W) 184.8. The highest quality values in 2016-2018 growing seasons were; test weight 81.1 kg, protein content 17.2%, gluten value 21.3%, gluten index 97.4% and sedimentation (Zel) 65 ml.

Pre-Basic and Basicseeds of the Anafarta cultivar have been produced by Trakya Agricultural Research Institute (TARI). Certified seed of the Anafarta are producedby both private companies and state farms.

Figure 1. Spike and grain of the Anafarta cultivar (Original)

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Registration of "Aytenabla" Bread Wheat Variety

Aytenabla, moderate hard red winter wheat (*Triticum aestivum* L.) was released (Figure 1) in 2019 by Central Research Institute for Field Crops. Aytenabla, a semi-dwarf cultivar is adapted to Central Anatolia Regions which receives low to intermediate rainfall (300-350 mm average annual precipitation). It is characterized by high grain yield, moderate resistance to yellow rust, and medium grain quality. The pedigree of Aytenabla is ES8-24//KS82W409/SPN/3/AKSEL 2000/4/TOSUNBEY/DEMİR 2000 and YA: 25451 F_1 Double Haploid (DH). The crossing took place in 2011 and yield trails began in the 2013-14 growing seasons. Application for registration of Aytenabla bread wheat variety was submitted to the Seed Registration and Certification Institute in 2016. This project aimed to obtain DH pure lines by using anther culture technique. This technique is utilized to shorten the breeding process. Aytenabla is the first registered bread wheat cultivar developed with this method in Turkey. The named cultivar has been developed in 8 years where it would normally take up to 12 years with traditional breeding techniques.

The average yield of the cultivar varied from 3000-7000 kg ha^{-1} in semi-arid areas of the Central Anatolia and transitional regions without irrigation. It was the top-yielding cultivar with 4950 kg ha^{-1} in yield trails during the registration process. It yielded 16.4% above the mean of the checks. Cv. Aytenabla's bread-making quality values are thousand grain weight: 29.4-35.3 g, hectoliter weight: 76.1-80.7 kg/hl, protein content: 12.3-16.4%, zeleny sedimentation: 32-61 ml, alveograph energy value: 167-280, water absorption: 58.2-60.8%, flour yield: 63.0% 72.4, wet gluten: 34.5-42.9%, dry gluten: 11.4-14.1%, and the gluten index: 58.5-66.7%.

Aytenabla has both better quality characteristics and higher yield than Bayraktar 2000 which is the most produced cultivar in semi-arid areas in Central Anatolia.

Figure 1. Spike and grain of the Aytenabla cultivar

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Online Submission

Author(s)have to submit their manuscripts online using http: http://www.ekinjournal.com. Figures and Tables should be presented at the end of text (after list of references). The submitted manuscript should include the following sections:

Manuscript

Manuscripts should be written in double space and submitted in Word with Times New Roman font as 12 point. The submitted manuscript includes the automatic page number.

Title

The title should be concise and informative, and fallowed by the name(s) of the author(s), the affiliation(s) and address(es) of the author(s), the e-mail address, telephone and fax numbers of the corresponding author

Abstract

Abstract is one of the most important parts of the articles since it is the most published and cited in international databases. Abstract should be started with a sentence that provides an importance and aim of the study. It also contains materials and methods, main findings or results and a conclusion sentence for readers. It is not more than 250 words. Abbreviations or references cannot be written in the abstract.

Keywords

Keywords should be provided between 4 to 6 words for indexing purposes.

Introduction

Introduction should be reviewed of available literature and the similar nature works published before. It should be outlined the reason why the study was performed or the originality of study.

Materials and Methods

Materials and methods could be divided into sub-headings but headings could be used up to three levels. All materials, experiments conducted, conditions and course should be described in details. The whole methodology in the submitted manuscript should be detailed if it is original; in other cases, it is sufficient to cite the relevant reference(s) published before. Statistical methods processed in the submitted manuscript should also be described with the software used.

Results

The results obtained from the materials, experiments, and analyses should be given as figure and tables. The important findings from the results should be outlined but the irrelevant findings should not be given. Statistical evaluation and commentary should also be given without ANOVA table.

Discussion

Results section can be merged with Discussion section. Author(s) should confront own findings and results with data published by the other authors. For different results, scientific questions should be answered and discussed. The surname of the first author(s) and year of publication must be cited in Discussion section directly or indirectly. Some examples;

In Turkey, wheat was produced 10 million tons in 1923 (Gokgol 1939).

This result was in agreement with result of Sahin and Yildirim (2004).

Similar effect has been widely studied prior to this study (Eser 1991; Bagci et al. 1995; Uzun and Yol 2013).

At the end of Discussion section, the conclusion sentence(s) should be presented for readers.

References

The list of references should include cited works in the text. Personal communications (Personal com. with Prof./Dr./Mr./Ms. Ucar, Ankara, Turkey, 2012) should only be mentioned in the text. The works under consideration, submitted and unpublished works should not be listed in the References section. References should be chronologically alphabetized by the surnames of the first author of each work. Some examples;

Journal article:

Toker C (1998). Adaptation of kabuli chickpeas (*Cicer arietinum* L.) to the low and high lands in the West Mediterranean region of Turkey. Turk J Field Crop 3:10-15.

Toker C and Canci H (2003). Selection of chickpea (*Cicer arietinum* L.) genotypes for resistance to ascochyta blight [*Ascochyta rabie*i (Pass.) Labr.], yield and yield criteria. Turk J Agric For27: 277-283.

Toker C, Canci H and Ceylan FO (2006). Estimation of outcrossing rate in chickpea (*Cicer arietinum* L.) sown in autumn.Euphytica 151: 201-205.

Article by Digital Object Identifier (DOI) number:

Yasar M, Ceylan FO, Ikten C and Toker C (2013). Comparison of expressivity and penetrance of the double podding trait and yield components based on reciprocal crosses of kabuli and desi chickpeas (CicerarietinumL.). Euphyticadoi:10.1007/s001090000086

Book:

Toker C (2014). Yemeklik Baklagiller. BISAB, Ankara.

Book chapter:

Toker C, Lluch C, Tejera NA, Serraj R and Siddique KHM (2007) Abiotic stresses. In: Chickpea Breeding and Management,Yadav SS, Redden B, Chen W and Sharma B (eds.),CAB Int. Wallingford, pp: 474-496.

Online document:

FAOSTAT J (2013) http://faostat.fao.org/site/567/default.aspx#anchor. Accessed 15 May 2013.

Dissertation (Thesis):

Yasar M (2012). Penetrance and expressivity of double podding characteristic in chickpea (Cicer arietinum L.). Dissertation, Akdeniz University, Antalya.

Acknowledgments

Acknowledgments of people, grants, funds, etc. could be placed before the reference list. The names of funding organizations should be written.

Abbreviations

Abbreviations should be defined at first mention and used consistently.

bisab
Plant Breeders Union of Turkey
www.bisab.org.tr

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