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Araştırma Makalesi (Research Article)

Morphological and Agronomical Characteristics of a Rhizomatous Crested Wheatgrass (*Agropyron cristatum* L. Gaertn.) Collected from Ankara Province

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Abstract

The use of natural material in ongoing breeding programs provides a unique resource and they have vital importance for the improvement of plant production and the rehabilitation of degraded rangelands. The aim of this study was to improve the new rhizomatous crested wheatgrass (*Agropyron cristatum* L. Gaertn.) collections with high adaptation ability for rangeland improvement using national genetic sources. A total of 8 genotypes collected from the region and from other institutions were tested the morphological and phenological characters. After testing one population, G-466, with rhizome was selected to be evaluated further. The mass selection was implemented in this study. Two trials with G-466 and population were conducted during the years of 2007 to 2010 in Yenimahalle and Gölbaşı locations, Ankara. The observed morphological, and agronomical characteristics were main stem height, main stem diameter, internode length, node numbers per main stem, flag leaf length, flag leaf width, forage yield and hay yield. Data were statistically analyzed and measured characteristics of two genotypes were compared by F test. Correlation analysis was performed to determine the relationship among the characters. The morphological characters as main stem height, main stem thickness, internode distance long, node numbers per main stem, flag leaf length and flag leaf width in G-466 were 58.5 cm, 2.1 mm, 13.2 cm, 3.7, 8.4 cm, 4.9 mm, respectively. There was no significant difference between the studied genotypes in fresh forage and hay yields on the two location-averages. Fresh forage and hay yields in G-466 were 482.2 kg/da and 120.6 kg/da, respectively. High correlation (0.893) found between hay yield and main stem length. There were also high correlation length of internode and node numbers in main stem with hay yield. As considered hay quality, the G-466 had higher crude protein content (11.58-11.33%), than population (9.71-10.58%) in 2009 and 2010. But it was lower relative feeding value than population. In conclusion, the G-466 genotype is recommended for grassland improvement and making artificial pasture as using alone or in mixtures.

Keywords: Rhizomatous crested wheatgrass, morphological and agronomical characters

Ankara İlinden Toplanan Rizomlu Otlak Ayrığının (*Agropyron cristatum* L. Gaertn.) Morfolojik ve Agronomik Karakterleri

Öz

Islah programında genetik kaynakların kullanılması bu konuda yürütülen çalışmaları zenginleştirir ve bitki üretiminin geliştirilmesi ve bozuluş mera alanlarının iyileştirilmesi için hayati öneme sahiptirler. Bu çalışmada genetik kaynaklardan mera ıslahına yönelik adaptasyon kabiliyeti yüksek yeni rizomlu otlak ayrığı (*Agropyron cristatum* L. Gaertn.) kolleksiyonlarının geliştirilmesi, amaçlanmıştır. Diğer enstitülerden ve bölgeden sağlanan 8 adet genotip morfolojik ve fenolojik özellikler açısından incelenmiştir. Bu işlemden sonra G-466 rizomlu genotip daha sonra değerlendirmek üzere seçilmiştir. Bu çalışmada toptan seleksiyon metodu uygulanmıştır. Ankara'nın iki ilçesi Yenimahalle ve Gölbaşında 2007-2010 yılları arasında G-466 ile popülasyon materyallerinin yer aldığı iki deneme tesis edilmiştir. Morfolojik ve tarımsal özellikler ana sap uzunluğu, ana sap kalınlığı, ana saptaki boğum sayısı, bayrak yaprağın uzunluğu ve genişliği ile yeşil ve kuru ot verimleridir. Tüm deneme verileri istatistiksel olarak analiz edilmiş ve iki genotipin incelenen özellikleri F testiyle karşılaştırılmıştır. Özelikler arası ilişkiler belirlenmek için korelasyon analizi yapılmıştır. Morfolojik özellikler ana sap uzunluğu ve ana sap kalınlığı, boğum arası uzunluk, ana saptaki boğum sayısı, bayrak yaprağının uzunluğu ve genişliği G-466 genotipinde sırayla 58.5 cm, 2.1 mm, 13.2 cm, 3.7, 8.4 cm, 4.9 mm olmuştur. Her iki lokasyonda yeşil ot ve kuru ot verimleri açısından çalışılan her iki genotip arasında fark bulunmamıştır. Genotip G-466'nın yeşil ot ve kuru ot verimleri sırayla 482.2 kg/da and 120.6 kg/da, olarak tespit edilmiştir. Kuru ot verimi ve ana sap uzunluğu arasında yüksek korelasyon (0.893) bulunmuştur. Boğum arası uzunluk ve ana saptaki boğum sayısı ile kuru ot verimi arasında da yüksek düzeyde korelasyon vardır. Kuru ot kalitesi düşünüldüğünde, 2009 ve 2010 yıllarında genotip G-466 (%11.58 ve %11.33) populasyondan (%9.71 ve %10.58) daha yüksek ham protein oranına sahip olmuştur. Fakat nispi yem değeri popülasyondan daha düşük olmuştur. Sonuç olarak G-466 genotipi mera ıslahı ve suni mera tesisleri için yalın ya da karışımlar halinde kullanılması tavsiye edilir.

Anahtar Kelimeler: Rizomlu otlak ayrığı, morfolojik ve tarımsal özellikler

Introduction

The sown area of forage crops is 1.88 million hectares and the meadow-rangeland area is 14.61 million hectares in Turkey (Anonymous 2015). Moreover, total livestock is 14.19 million large animal units (Anonymous 2015). Turkey, the roughage production, is estimated to be the total 15.90 million tons as mainly generated by both natural pastures (5.84 million tones) and forages crops (10.06 million tones). The amount accounts for only 24.55% of total requirement of good quality forage hay (64.74 million tones).

Therefore, the increasing of forage production and the reducing of shortages would immensely contribute to the improvement of animal husbandry sector.

In the Central Anatolia Region, in addition to widely grown forage crops such as vetches, alfalfa and sainfoin, alternative crops, such as crested wheatgrass (*Agropyron cristatum* L. Gaertn.) should be incorporated mixtures or pure stand for both grazing and forage production.

The crested wheatgrass has good abilities such as a perennial life form, satisfactory production and drought resistance. Moreover, this species possesses some desirable aspects with early growth initiation in spring and good persistence to grazing. For those reasons, native crested wheatgrass cultivars are seeded in rangelands and artificial pastures.

This species is adapted to a wide variety of environmental conditions (Holechek 1981; Rogler and Lorenz 1983) the same authors stated that crested wheatgrass is resistant to heat, drought, cold, and is little damaged by diseases. In addition, crested wheatgrass exhibits palatability, persistence under misuse, good competitive ability, excellent seed production, ease of establishment, and sufficient seedling vigor to volunteer successfully. The crested wheatgrass has good potential for reintroduction of native plants, and follow-up management to ensure persistence of seeded native species for improving native plants of degraded rangeland areas (Fansler and Mangold 2011).

The local genetic resources play important role as the basic material commonly used in breeding programs (Prosperi et al. 1996). The crested wheatgrass is native to Central Asia, Afghanistan, Turkey and Iran (Nevski 1934; Bor 1970). Turkey is the one of the gene centers of many forage crops, and it is fairly rich in crested wheatgrass diversity as well. It exists in Edirne province in Thrace region (Davis 1970), in Ankara, Çankırı and Kayseri provinces of Central Anatolian Region (Unal et al. 2012a; Unal et al. 2012b; Unal et al. 2013), in provinces of Trabzon and Gümüshane in Eastern-Blacksea Region, and East Anatolia and Kahramanmaraş province in Mediterranean region (Davis 1970).

The surveys for collection of local materials were carried out in 1999 and 2000 throughout the Central Anatolian Region of Turkey. Crested wheatgrasses with rhizomes were collected from the Polatlı, Ankara.

There are a few rhizomatous varieties in USA called Ephraim, RoadCrest (Asay et al. 1999). Rhizomatous varieties, not weedy or invasive species, spread very slow (Anonymous 2000).

So far many studies on crested wheatgrass were performed and completed by numerous researchers, some of which are related to its morphology (Hull 1972), phenology (Schuster and Ricardo 1973), genetic diversity (Prosperi et al. 1996) and agronomy (Smoliak et al. 1967; Ünal and Eraç 2000).

In this study, the morphologic and agronomic characteristics in the rhizomatous material G-466 crested wheatgrass were studied for adaptation ability, hay yield and quality for the variety development.

Material and Method

Study materials were collected from the natural flora of Central Anatolian region. Additional materials were provided from Gene Banks of İzmir, Ankara and Erzurum Agricultural Research Institutes.

The soil of the experimental site in Yenimahalle was clay of texture, neutral, poor in organic matter, but moderate in lime content. The soil of Gölbaşı had clay textured, slightly alkaline, poor in organic matter, but high in lime content. Soil features of two sites were detected to be different in pH and lime content (Anonymous 2007; Anonymous 2008).

During the experimental seasons of 2006-2007, 2007-2008, and 2008-2009 in Yenimahalle; 2007-2008, 2008-2009 and 2009-2010 in Gölbaşı total precipitation, average temperatures and average relative humidity were given in Table 1.

Total precipitation and average relative humidity in Yenimahalle location were lower than Gölbaşı location. But its temperature was higher than Gölbaşı. Long term average precipitation and temperatures are 396.1 mm and 11.8°C at Yenimahalle (1975-2006), and 395.5 mm and 10.1°C at Gölbaşı (1990-2006). Two locations received less precipitation to long term averages (Anonymous 2009; Anonymous 2010).

A nursery was found to screen the genotypes morphological and phenological properties. After screening one population, G-447 with rhizomatous (ecotype collected near Ankara province) was selected to characterize further. Mass selection method was applied for choosing 7 promising lines (accession number G-466).

Latter yield experiments with one promising material and check variety, local population, were sown in a randomized complete block design with 8 replications. Seeds were sown by hand. The plot size was 3.2 m x 5.0 m = 16.0 m^2, consisting of 8 rows spaced at 40 cm for fresh forage. The harvested plot size was 9.6 m^2. The experiments at the both locations (Yenimahalle and Gölbaşı, Ankara) were established in a fallow field during the years of 2007 to 2010 of The Central Research Institute for the Field Crops.

After seeding (19 October 2007 in Yenimahalle and, 17 April 2008 in Gölbaşı), 18 kg N, and 46 kg P_2O_5 ha^1 were broadcasted, mixed into the soil and its surface was pressed with plowing roller.

Weed control was made by hoeing when necessary.

Cutting dates for fresh forage at Yenimahalle and Gölbaşı were at the dates of 27 May 2008-01 June 2009 and 27-29 May 2009 -30 May-01 June 2010. At the blooming period of each accession, randomly selected 5 and 10 plants were sampled and measured from each plot for the plant traits.

Morphological properties such as main stem length, main stem diameter, the length of internode, node numbers in main stem, flag leaf length, and flag leaf width and phenological properties such as heading date, agronomic properties as fresh forage and hay yields were measured.

The 9.6 m^2 of each plot was harvested for green herbage and sampling (each 500 g). The samples were dried at 70°C for 48 h.

All data were analyzed in excel software program of Microsoft office 2010. Variance analysis was performed and averages were compared by the F test.

Results and Discussions

Morphological properties

Main stem length (MSL)

Significant differences observed between G-466 and population two years averages in Yenimahalle (YM), but no differences in Gölbaşı (GB) (Table 2).

MSL in GB had higher than that of YM. High variation occurred over years at two locations. No difference appeared in overall at two location averages.

The results for MSL were similar to the previously reported results. Plant height was found as 55.78 cm by Gökkuş et al. (2001). Besides it was measured as 79.28 cm (77.80-81.09 cm) (Unal and Eraç 2000), and 57.54 cm (40.50-72.66 cm) (Unal and Fırıncıoğlu 2009) in the previous studies. Moreover its plant heights were found as 87-97 cm and 54-65 cm in 1999 and 2000, respectively (Mellish and Coulman 2002). The given values above were similar or higher than this trial's.

Main stem diameter (MSD)

G-466 had wider MSD in GB than base population in 2009, 2010 and overall average (Table 2). Two genotypes had similar MSD in YM. Variation in years, was highly significant in GB. High difference (P<0.01) observed in overall at two location averages ($F_{(0.05)}$=33.0).

MSD ranged between 2.1 and 2.7 mm (Açıkgöz 1982); 2.15 mm (Unal and Eraç 2000), and 2.39 mm (1.60-3.16 mm) (Unal and Fırıncıoğlu 2009) in the past trials.

Table 1. Total precipitation, average temperatures and average relative humidity for the experimental seasons and long term in Yenimahalle and Gölbaşı

Çizelge 1. Yenimahalle ve Gölbaşında deneme süresince ve uzun dönem toplam yağış, ortalama sıcaklık ve nispi nem değerleri

	Yenimahalle					Gölbaşı				
	2006-07	2007-08	2008-09	Averages	Long term	2007-08	2008-09	2009-10	Averages	Long term
Precipitation (mm)	315.7	295.8	370.8	327.4	396.1	316.6	417.6	360.3	364.8	395.5
Temperatures (˚C)	12.90	12.80	9.80	11.80	11.8	10.00	10.00	11.80	10.60	10.1
Relative humidity(%)	55.6	54.8	64.6	58.3	61.3	58.9	70.4	66.2	65.2	73.4

Table 2. Some morphological properties data in main stem length (MSL) (cm) and main stem diameter (MSD) (mm) at two locations in 2008, 2009, 2010 and two year averages

Çizelge 2. İki lokasyondaki 2008, 2009, 2010 ve iki yıl ortalama ana sap uzunluğu (ASU) (cm) ve ana sap kalınlığı (ASK) (mm) gibi bazı morfolojik özellik değerleri

	MSL+									MSD								
	Gölbaşı			Yenimahalle			Two location averages			Gölbaşı			Yenimahalle			Two location averages		
	2009	2010	Ave.	2008	2009	Ave.	First	Second	Overall	2009	2010	Ave.	2008	2009	Ave.	First	Second	Overall
G-466	73.8	50.1	62.0	35.7	67.4	51.5	61.1	55.8	58.5	2.3	2.0	2.1	1,8	2.1	2.0	2.1	2.0	2.1
Population	72.9	50.8	61.8	34.7	55.6	45.2	60.2	52.4	56.3	2.0	1.5	1.8	1,9	2.1	2.0	2.0	1.7	1.8
$F_{(var)\ (0.05)}$	0.2	0.1	0.0	0.9	16.6*	15.0**	0.0	0.9	2.7	9.5*	70.5**	68.3**	0.2	0.0	0.2	1.6	10.8	33.0**
$LSD_{(0.05)}$	4.5	6.6	3.3	3.2	9.2	3.7	17.5	7.6	2.7	0.2	0.1	0.1	0.4	0.1	0.2	0.2	0.2	0.1
$F_{Year\ (0.05)}$			208.6**			256.6**			23.7**			96.1**			11.2			25.1**
$F_{loc\ (0.05)}$									60.9**									0.1
$F_{var*year\ (0.05)}$			0.3			10.9**			0.9			8.6**			0.2			5.6*
$F_{var*loc\ (0.05)}$									4.8*									21.0**
$F_{year*loc(0.05)}$									299.5**									63.4**
$F_{var*year*loc(0.05)}$									4.7*									1.3
CV (%)	5.1	11.0	7.3	4.0	6.6	6.7	33.2	16.2	8.1	6.8	6.5	6.1	9.5	2.7	7.3	12.4	12.7	6.9

*, **Significant at 5 an 1 % probability levels, respectively, *(*) % 5 ve (**) % 1 düzeyinde önemli farklılık göstermektedir.*

LSD: least significant difference, *LSD: en küçük önemli farklılık;*

CV (%): coefficient of variation (%), *CV (%): varyasyon katsayısı*

+ Abbreviations were explained in headline above

Blooming period in Yenimahalle, 27.05.2008, *Yenimahalle'deki Başaklanma tarihi, 27.05.2008* Blooming period in Yenimahalle, 01.06.2009, *Yenimahalle'deki Başaklanma tarihi, 01.06.2009*

Blooming period in Gölbaşı, 27-29.05.2009, *Gölbaş'ndaki başaklanma tarihi 27-29.05.2009* Blooming period in Gölbaşı, 31.05-01.06.2010, *Gölbaş'ndaki başaklanma tarihi, 31.05-01.06.2010*

MSL: Main stem length (cm), *MSL: Ana sap uzunluğu (cm)*,

MSD: main stem diameter (mm), *MSD: Ana sap kalınlığı (mm)*

Table 3. Some morphological properties data in length of internode (LI) (cm) and node numbers in main stem (NNMS) (number) at two locations in 2008, 2009, 2010 and two year averages

Çizelge 3. İki lokasyondaki 2008, 2009, 2010 ve iki yıl ortalama boğum arası uzunluk (LI) *(cm), ana saptaki boğum sayısı (*NNMS*) (adet) gibi bazı morfolojik özellik değerleri*

	LI									NNMS								
	Gölbaşı			Yenimahalle			Two location averages			Gölbaşı			Yenimahalle			Two location averages		
	2009	2010	Ave.	2008	2009	Ave.	First	Second	Overall	2009	2010	Ave.	2008	2009	Ave.	First	Second	Overall
G-466	17.6	10.4	14.0	9.3	14.0	11.6	14.9	11.55	13.2	3.9	3.6	3.8	3.3	3.7	3.5	3.7	3.6	3.7
Population	15.0	9.2	12.1	8.8	11.2	10.0	12.9	9.87	11.4	4.2	4.5	4.4	3.0	3.5	3.2	3.8	4.2	4.0
$F_{(var)\ (0.05)}$	28.5**	4.4	18.1**	0.8	4.3	5.4*	1.4	4.1	23.7**	32.0**	47.2 **	29.7**	5.4	1.2	2.3	0.2	8.3**	13.5**
$LSD_{(0.05)}$	1.2	1.3	0.9	1.9	4.3	1.6	3.4	1.8	0.8	0.1	0.3	0.2	0.4	0.5	0.4	0.6	0.4	0.2
$F_{Year\ (0.05)}$			217.3**			23.9**			72.9**			0.0			7.0*			2.7
$F_{loc\ (0.05)}$									21.1**									59.7**
$F_{var*year\ (0.05)}$			2.9			2.4			0.1			6.1*			0.2			5.3*
$F_{var*loc\ (0.05)}$									0.1									19.9**
$F_{year*loc(0.05)}$									161.3**									4.2*
$F_{var*year*loc(0.05)}$									5.7*									1.3
CV(%)	6.1	11.0	9.5	9.5	15.2	13.3	28.6	18.9	10.5	2.9	6.4	7.9	5.8	6.4	9.3	18.7	11.8	8.2

*, **Significant at 5 an 1 % probability levels, respectively, *(*) % 5 ve (**) % 1 düzeyinde önemli farklılık göstermektedir.*
LSD: least significant difference, *LSD: en küçük önemli farklılık;* CV (%): coefficient of variation (%), *CV (%): varyasyon katsayısı (%)*
LI: length of internode (cm), *LI: boğum arası uzunluk (cm),* NNMS: node numbers in main stem ((number), *NNMS: ana saptaki boğum sayısı (adet)*

Table 4. Some morphological properties data in flag leaf length (FLL) (cm) and flag leaf width (FLW) (mm) at two locations in 2008, 2009, 2010 and two year averages

Çizelge 4. İki lokasyondaki 2008, 2009, 2010 ve iki yıl ortalama bayrak yaprağının uzunluğu (cm) ve genişliği (mm) gibi bazı morfolojik özellik değerleri

	FLL									FLW								
	Gölbaşı			Yenimahalle			Two location averages			Gölbaşı			Yenimahalle			Two location averages		
	2009	2010	Ave.	2008	2009	Ave.	First	Second	Overall	2009	2010	Ave.	2008	2009	Ave.	First	Second	Overal
G-466	11.3	7.1	9.2	4.9	9.1	7.0	9.2	7.7	8.4	5.5	4.5	5.0	3.8	5.8	4.8	4.9	4.9	4.9
Population	10.9	6.6	8.7	9.1	12.5	10.8	10.3	8. 6	9.4	6.1	4.8	5.4	7.0	7.6	7.3	6.4	5.7	6.0
$F_{(var)\ (0.05)}$	1.0	0.7	1.6	10.98*	93.63**	42.5**	1.4	4.1	9.4**	4.1	4.3	4.0	14.48*	29.8*	36.5**	9.0	3.3	33.8**
$LSD_{(0.05)}$	1.1	1.3	0.8	4.0	1.1	1.3	3.5	1.8	0.6	0.6	0.4	0.5	2.7	1.1	0.9	1.0	1.0	0.6
$F_{Year\ (0.05)}$			139.7**			42.0**			25.3**			28.4**			10.1*			2.9
$F_{loc\ (0.05)}$									0.1									14.5**
$F_{var*year\ (0.05)}$			0.0			0.4			0.1			0.2			3.0			2.5
$F_{var*loc\ (0.05)}$									41.4**									25.4**
$F_{year*loc(0.05)}$									147.1**									36.4**
$F_{var*year*loc(0.05)}$									0.3									2.2
CV(%)	8.1	15.9	11.4	25.5	4.7	13.2	28.7	18.9	12.2	9.4	7.0	11.9	22.5	7.0	13.8	20.5	20.9	12.3

*, **Significant at 5 an 1 % probability levels, respectively, *(*) % 5 ve (**) % 1 düzeyinde önemli farklılık göstermektedir.*
LSD: least significant difference, *LSD: en küçük önemli farklılık;* CV (%): coefficient of variation (%), *CV (%): varyasyon katsayısı (%)*
FLL: Flag leaf length (cm), *FLL: Bayrak yaprağının uzunluğu (cm),* FLW: Flag leaf width (mm), *FLW: Bayrak yaprağının genişliği (mm)*

Length of internode (LI)

G-466 had longer LI than base population at two locations (Table 3). Significant differences found in 2009 in GB and two-year-averages between them in GB and YM. High variability (P<0.01) was measured over year averages at two locations.

Significant difference (P<0.01) observed in overall variety, year, location and year*location interaction at two locations.

Node numbers in main stem (NNMS)

Significant differences observed in NNMS in GB between two genotypes, base population had more NNMS than G-466 (Table 3). Conversely, no differences was found between them but G-466 had more NNMS than population.

Significant difference (P<0.01 and P<0.05) found in overall variety, location, and interactions (variety*location and year*location) at two locations.

Flag leaf length (FLL)

No significant differences found in FLL between two genotypes in YM but significant differences (P<0.01) observed on year effects (Table 4). G-466 had longer FLL than base population in GB location.

High differences measured in FLL in 2008, 2009 and two-year- averages in YM location. Base population had longer FLL than G-466.

Significant difference (P<0.01) observed in overall variety, year, and interactions (variety*location and year*location) at two locations.

Flag leaf width (FLW)

No significant differences found in FLW between two genotypes in GB but significant differences (P<0.01) observed on year effects (Table 4). Base population had wider FLW than G-466 in GB location.

Significant differences observed in FLW between two genotypes in 2008, 2009 and two-year-average in YM (Table 4).

At the two location averages, significant differences measured in FLW between two genotypes. Moreover, significant difference (P<0.01) recorded in locations and interactions (variety*location and year*location).

Environmental factors influences leaf growth (including in FLL and FLW) especially higher temperatures resulted in greater leaf mass and leaf surface area for all species (Leffler et al. 2011). Moreover, increasing the photoperiod usually increased leaf length and sometimes leaf width, but decreased rate of production of leaves (Ryle 1966). The same author added that rate of leaf appearance, number of live leaves, number of actively-elongating leaves and leaf length were increased by a high level of N and high temperature, but high temperature reduced leaf width and, in some instances, tiller numbers.

G-466 in Gölbaşı had higher FLL than that of Yenimahalle due to higher precipitation, and relative humidity. But population in Yenimahalle was higher FLL than population in Gölbaşı because of higher temperature. As a result, genotypes are differently influenced by environmental factors.

Fresh forage yield (FFY)

No difference in fresh forage yield was detected between G-466 genotype and the population in 2009 and 2010 years in Gölbaşı location (Table 5), but significant difference found in two year-averages (P<0.05). The G-466

Table 5. Fresh forage yields (kg/da) at the two locations in 2008, 2009 and 2010 years
Çizelge 5. İki lokasyonun 2008, 2009 ve 2010 yılları yeşil ot verimleri (kg/da)

Materials	Gölbaşı location			Yenimahalle location			Two locations		
Numbers of replication 8	2009	2010	Averages	2008	2009	Averages	First season	Second season	Overall
G-466	871.1	253.7	562.4	102.0	541.7	321.8	614.7	349.7	482.2
Population	1044.9	354.9	699.9	139.3	336.0	237.6	743.1	348.6	545.8
$F_{(var)\ (0.05)}$	2.2	3.3	5.9*	2.9	25.0*	5.4*	0.5	0.0	2.2
$LSD_{(0.05)}$	277.9	131.3	117.6	69.4	130.0	81.1	93.0	38.1	
$F_{Year\ (0.05)}$			133.6**			78.0**			59.9**
$F_{loc\ (0.05)}$									42.5**
$F_{var*year\ (0.05)}$			0.4			11.4**			2.3
$F_{var*loc\ (0.05)}$									6.0*
$F_{year*loc(0.05)}$									115.8*
$F_{var*year*loc(0.05)}$									0.9
CV(%)	24.5	36.5	25.3	25.6	13.3	25.7	66.5	45.5	28. x 7

*, **Significant at 5 an 1% probability levels, respectively. *(*) %5 ve (**) %1 düzeyinde önemli farklılık göstermektedir.*

LSD: least significant difference, *LSD: en küçük önemli farklılık;*

CV (%): coefficient of variation (%), *CV (%): varyasyon katsayısı (%)*

yielded lower than population. Two year averages in FFY of G-466 genotype and population were 562.4 and 699.9 kg/da in Gölbaşı location, respectively. Significant difference in year effect observed.

In Yenimahalle, significant differences observed in 2009 ($P<0.05$), two year averages ($P<0.05$), year effect ($P<0.01$) and variety*year interaction ($P<0.01$) and moreover G-466 had greater yield than population. In Yenimahalle location, averages in FFY of G-466 genotype and population became 321.8 and 237.6 kg/da, respectively.

No difference appeared in FFY of G-466 and population over two location averages (Table 5).

Significant differences in yield appeared in between years ($P<0.01$), locations ($P<0.01$), year*location interaction ($P<0.05$) and variety* location interaction ($P<0.05$).

The FFY in Gölbaşı gave two fold higher yield than that in Yenimahalle. For this reason Gölbaşı location had higher total precipitation, and average relative humidity than Yenimahalle. At the same time it was lower temperature than Yenimahalle.

Unal and Eraç (2000) reported 1485.25 kg/da yield in FFY in Gölbaşı location. This trial values were much lower than study value mentioned above. Specific precipitation patterns accounted for 87% or more of the variation in forage yields of crested wheatgrass grazed at different seasons (Currie and Peterson 1966).

Hay yield (HY)

No statistically differences between two genotypes in Gölbaşı (GB)location in 2009, 2010 years, but significant differences ($P<0.05$) found between them in two year averages (Table 6). HYs of G-466 and population were 217.8 and 261.2 kg/da; 63.4 and 88.7 kg/da in 2009 and 2010, respectively in Gölbaşı location. Two-year averages in GB of G-466 genotype and population were 140.6 and 174.9 kg/da, respectively.

Statistically differences ($P<0.05$) between two genotypes in Yenimahalle (YM) location in 2009, and two year averages, but no difference seemed between them in 2008 (Table 6). Year effect became significant differences ($P<0.01$) in both locations. G-466 and population were 25.5 and 34.8 kg/da; 135.4 and 83.9 kg/da in HYs during the years of 2008 and 2009, respectively in YM location. Their averages were 80.4 and 59.4 kg/da, respectively.

No difference was observed in HY over two location averages (Table 6).

High significant differences seemed in between years ($P<0.01$), locations ($P<0.01$), variety*location interaction ($P<0.05$) and year*location interaction ($P<0.05$).

Crested wheat grass gave 306.6 kg/da in hay yield (Altın 1982a). Hay yield was 137.4 kg/da in perennial grass mixture (Hull 1971), later hay yields ranged from 42.0 to 213.6 kg/da in crested wheat grass (Hull 1972). Hay yields were obtained as 304.8 kg/da (195.5-406.1 kg/da) (Serin 1991) and 627.41 kg/da (Unal and Eraç 2000). Stem yield was found as 388.03 kg/da by Gökkuş et al. (2001). Moreover, HY showed a broad variation depending on variety, year and location effects.

White and Wight (1981) emphasized that crested wheat grass had the highest competitive ability. This feature or ability is highly important for its alone and mixture sowing.

Table 6. Hay yields (kg/da) at the two locations in 2008, 2009 and 2010 years

Çizelge 6. İki lokasyonun 2008, 2009 ve 2010 yılları kuru ot verimleri (kg/da)

Materials	Gölbaşı location			Yenimahalle location			Two locations		
Numbers of replication 8	2009	2010	Averages	2008	2009	Averages	First season	Second season	Overall
G-466	217.8	63.4	140.6	25.5	135.4	80.4	153.7	87.4	120.6
Population	261.2	88.7	174.9	34.8	83.9	59.4	185.8	87.2	136.5
$F_{(var)\ (0.05)}$	2.2	3.3	5.9*	2.9	25.0*	5.4*	0.3	0.0	2.2
$LSD_{(0.05)}$	69.5	32.8	29.4	17.4	32.7	20.3	104.2	34.5	21.6
$F_{Year\ (0.05)}$			133.6**			78.0**			59.9**
$F_{loc\ (0.05)}$									42.5**
$F_{var*year\ (0.05)}$			0.4			11.4			2.3
$F_{var*loc\ (0.05)}$									6.0*
$F_{year*loc(0.05)}$									115.8*
$F_{var*year*loc(0.05)}$									0.9
CV(%)	24.5	36.5	25.3	25,6	13,3	25.7	70.2	45.4	28.7

*, **Significant at 5 an 1% probability levels, respectively. *(*) %5 ve (**) %1 düzeyinde önemli farklılık göstermektedir.*
LSD: least significant difference, *LSD: en küçük önemli farklılık;* CV (%): coefficient of variation (%), *CV (%): varyasyon katsayısı (%)*

Table 7. The correlation coefficients among measured characters
Çizelge 7. İncelenen özellikler arası korelasyon değerleri

	MSL	MSD	LI	NNMS	FLL	FLW	FFY	HY
MSL	1	-0.036	0.798**	0.654**	-0.144	-0.585**	0.893**	0.893**
MSD		1	0.34	-0.404	0.243	-0.05	-0.221	-0.221
LI			1	0.328	-0.037	-0.609**	0.566**	0.566**
NNMS				1	-0.18	-0.359	0.712**	0.712**
FLL					1	0.735**	-0.053	-0.053
FLW						1	-0.407*	-0.407*
FFY							1	1**
HY								1

*, **Significant at 5 an 1% probability levels, respectively. *(*) %5 ve (**) %1 düzeyinde önemli farklılık göstermektedir.*
MSL: main stem length, *MSL: ana sap uzunluğu*; MSD: main stem diameter, *MSD: ana sap kalınlığı,* LI: length of internode, *LI: boğum arası uzunluk*; NNMS: node numbers in main stem, *NNMS: ana saptaki boğum sayısı*; FLL: flag leaf length, *FLL: bayrak yaprağının uzunluğu;* FLW: flag leaf width, *FLW: bayrak yaprağının genişliği;* FFY: fresh forage yield, *FFY: yeşil ot verimi;* HY: hay yield, *HY: kuru ot verimi*

Results from this study obtained in 2008-2010 were also similar and lower to those previously discussed. This condition may be occurred from different genotypes and various ecological conditions.

Any study needs to be widened by new materials with high genetic variation. Therefore, the wide geographic areas were scanned and collected native species with broad genetic variability in FFYs and HYs. Otherwise, the narrow genetic variability within the native species in forage yields may also reflected from collections of the limited geographic area (May et al. 1998). They advised that this problem was overcome by more diverse areas collections.

Correlation coefficients

The strength of association between characteristics should be known. This point is very important for making a successful selection. Strong relationship between characters were found relevant to high hay yield on wheatgrass.

The observed characters were tested by correlations coefficients (Table 7). High correlation (0.893) found between HY and MSL. Albayrak and Ekiz (2004) stated that main stem length was the one of important characters for high hay yield in crested wheatgrass.

There were also high correlation between LI and NNMS with HY. Significant negative correlation (-0.407) was detected between HY and FLW.

In conclusion the MSL, LI and NNMS properties in crested wheatgrass should be considered as the selection of criteria for high hay yielding varieties in breeding programs.

Hay quality properties

Crude protein is the one of significant hay quality parameters properties.

Crude protein has long been considered a measure of quality in forages (George and Lorenz 1969). They stated that while increased emphasis has been placed in recent years on energy derived from forages, protein content still remains a good measure of the relative nutritive value of various types of pasture and forage. Protein content varies depending on growth stages, locations, and years.

Hay quality properties such as crude protein content, ADF, NDF, and relative feeding values (RFV) were observed and analyzed (Table 8).

No significant differences (P<0.05) found between G-466 genotype and base population on quality properties (Table 8).

The G-466 genotype and base population had the values of 11.6%, and 9.7%; 11.3%, and 10.6%; 39.6%, and 37.7%; 70.1%, and 68.5%; 77.0, and 80.8 on crude protein content in 2009 and 2010, ADF, NDF, and relative feeding values in Gölbaşı location, respectively.

In conclusion, G-466 had higher crude protein content than population in 2009 and 2010. But it had lower RFV than population. ADF and NDF of G-466 were higher than that of base population.

Açıkgöz (1982) found that protein contents in various varieties were 29.59% - 33.78% in grazing period and 8.98% - 11.96% in flowering period, decreasing protein contents during the growing period. Altın (1982b) reported as 8.93% and 6.51% in protein contents of crested wheatgrass in 1975 and 1976, respectively. In addition, protein contents were differently found in various studies as 12.20% (10.28-14.47%) (Serin 1991); 6.08% (Unal and Eraç 2000).

Conclusions

According to two year and two locations results showed that the native crested

Table 8. Variance analysis results and quality properties of G-466 as crude protein content (%), acit detergent fiber (ADF) (%), neutral detergent fiber (NDF) (%) and relative feeding value (RFV) at the Gölbaşı location
Çizelge 8. Gölbaşı lokasyonunda G-466'nın ham protein oranı (%), asit deterjan lif (ADL) (%), nötr deterjan lif (NDL) (%) ve nispi yem değerleri (NYD) gibi kalite özellikleri ve varyans analiz sonuçları

	Crude protein content / 2009	Crude protein content /2010	ADF (%)	NDF (%)	RFV
G-466	11.6	11.3	39.6	70.1	77.0
Population	9.7	10.6	37.7	68.5	80.8
$F_{(0.05)}$	4.1	1.1	5.6	5.4	8.9
$LSD_{(0.05)}$	2.6	1.7	2.6	2.2	4.1
CV(%)	12.5	13.4	3.0	1.4	2.3

*, **Significant at 5 an 1% probability levels, respectively *(*) %5 ve (**) %1 düzeyinde önemli farklılık göstermektedir*
LSD: least significant difference, *LSD: en küçük önemli farklılık;* CV (%): coefficient of variation (%), *CV (%): varyasyon katsayısı (%)* ADF,NDF, and RFV (n=4) in 2010, Crude protein content, *Ham protein oranı*
G-466 (n=4 in 2009, n=8 in 2010), Population (n=6 in 2009, n=8 in 2010)

wheatgrass rhizomatous species (G-466) had a high yield ability. Yield potential of the G-466 genotype was found to be adequate for the first stage of breeding program.

In trials, there were no significant differences between the native grass species and population on quality aspects.

Native genetic resources may be used for enriching and developing of breeding programs.

The collection materials with a greater variation should be used in breeding program for fast improving of new cultivars.

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