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CLIMATIC FACTORS AFFECTING WHEAT YIELDS IN AEGEAN COASTAL REGION AND ADAPTATION OF VARIETIES

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ABSTRACT: *Wheat yield can reach up to 10000 kg/ha under favorable years and good management in Aegean coastal region in which rainfall ranges between 550-1100 mm. But, unusual weather conditions prevailing in the region like other parts of the globe during recent years have become major factor limiting wheat production. Climatic conditions badly affecting wheat yield in Aegean Region are erratic rainfall, high air temperature in May, drought stress, and late frost damage following mild autumn. The fact that wheat yields are very much dependant on environment and climatic conditions changing year to year makes it important to determine stabile and high yielding varieties and to introduce them to producers. The outcome of yield trials carried out at nine locations between the years of 2001-2004 by Aegean Agricultural Research Institute showed that Ziyabey 98, Basribey 95, Karacabey 97 and Golia were found to be stabile varieties. Varieties to be advised were Seyhan 95, Izmir 85, Bandırma 97 and Kasifbey 95 for low and average yielding parts and Adana 99, Ceyhan 99 and Doğankent for high yielding parts of the region.*

Keywords: *Wheat,* ***Triticum aestivum*** *L., stability, adaptation, climatic factors.*

EGE BÖLGESİ SAHİL KUŞAĞINDA BUĞDAY VERİMİNİ ETKİLEYEN İKLİM FAKTÖRLERİ VE ÇEŞİTLERİN ADAPTASYONLARI

ÖZ: *Yağışın 550–1100 mm arasında değiştiği Ege sahil kuşağında, uygun yıllarda iyi bakım koşullarında hektara buğday verimi 10000 kg'a kadar çıkabilmektedir. Ancak son yıllarda tüm dünyada olduğu gibi bölgede de hüküm süren alışılmadık iklim koşulları, üretimi sınırlayan faktörlerin başında gelmektedir. Ege bölgesinde buğday verimini olumsuz etkileyen en önemli iklim faktörleri; yağışların düzensizliği, Mayıs ayında oluşan yüksek sıcaklık ve yetersiz yağışla oluşan kurak stresi, ılık geçen sonbaharın ardından erken ilkbaharda oluşan soğuk zararıdır. Buğday verimlerinin çevre ve yıllara göre değişen iklim şartlarına çok bağımlı olması; kararlı ve yüksek bir verim için çevre faktörlerinin etkisini azaltıcı, çeşitlerin saptanarak üreticilere aktarılması önem arz etmektedir. Ege Tarımsal Araştırma Enstitüsü tarafından 2001-2004 yılları arasında 4 yıl ve 9 lokasyonda yürütülen bir çalışmada verim değerlendirmeleri sonucunda tavsiye edilebilecek stabil çeşitler olarak; Ziyabey 98, Basribey 95 Karacabey 97 ve Golia çeşitleri görülmektedir. Bölgenin kötü ve orta verimleri bölgeleri için Seyhan 95, İzmir 85, Bandırma 97 ve Kaşifbey 95 çeşitleri, iyi verimli koşularına verim potansiyeli yüksek olan Adana 99, Ceyhan 99, Doğankent çeşitleri önerilebilir.*

Anahtar Sözcükler: *Buğday,* ***Triticum aestivum*** *L., stabilite, adaptasyon, iklim faktörleri.*

INTRODUCTION

Wheat plays a major role in human nutrition, being main ingredient of bread. Wheat is also used as feed at animal nutrition and energy source for bioetanol production.

Although wheat has large adaptation ability, it does not like high temperature and humidity. At early stages of growth, it is enough that temperature is 8-10 ^{o}C and humidity is 60 % percent. It does not require much temperature during tillering and booting stage. 10-15 ^{o}C temperature, 65 % humidity and partly cloudy weather are favorable. Temperature and humidity requirement increase with booting. High relative humidity just before heading positively affects yield. Low humidity and high temperature at fertilization increase seed quality. 500 mm uniform rainfall during growing period is enough for maximum yield (Kün, 1988).

Wheat crop grown almost every part of Turkey comes first in field crops in terms of both area and production. Wheat growing areas range between 9-9.5 million hectares of which 1.8 million ha is for durum and the rest is for bread wheat (Anonymous, 2006). It interests 2.9 million farms in terms of production which is about 15 million people and whole nation in terms of consumption. Moreover wheat is used as row material industry. Wheat is only crop for certain areas.

Table 1. Wheat production area and average yield in Turkey (Anonymus, 2006; Anonymus-a, 2007).

Year	Area sown Million of ha	Production Million of ton	Yield (kg/ha)
1980	9,020	16,500	1829
1990	9,450	20,000	2116
1995	9,400	18,000	1915
1996	9,350	18,500	1978
1997	9,340	18,650	1997
1998	9,400	21,000	2234
1999	9,380	18,000	1919
2000	9,400	21,000	2234
2001	9,350	19,000	2032
2002	9,300	19,500	2097
2003	9,100	19,000	2099
2004	9,300	21,000	2258
2005	9,250	21,500	2320
2006	8,490	20,010	2360
2007	8,490	17,234	1948

Wheat yields change from year to year depending on climate. Average wheat yield is 1 829-2 360 kg/ha. This shows that wheat yield is dependent on environment and climatic conditions changing from year to year and it is necessary that variety improvement and irrigation practices should be developed in order to decrease effects of environmental factors for stabile and high yield.

WHEAT GROWING IN AEGEAN REGION

In relation to wheat growing, Aegean Region has two distinct regions, coastal stripe and transition zones. The area called coastal stripe consist of İzmir, Aydın counties and low parts of Manisa-Denizli-Muğla, coastal and southern parts of Çanakkale-Bursa and Balıkesir counties where wheat varieties with spring type is grown. Coastal region has Mediterranean climatic condition having mild and rainy winters. Highlands and inner parts called west transition zone of Manisa-Denizli-Muğla-Balıkesir counties and northern and inner parts of Bursa-Çanakkale-and Uşak counties have continental climate with harsh winter conditions. Wheat varieties with winter-facultative type and more vernalization requirement and tolerant to winter cold are grown in these regions (Ünsal, 2004).

Average occupation of wheat growing areas in Aegean region is about 850 000-900 000 ha maintaining 10 % of Turkey's wheat growing areas. Coastal area of the region has nearly 350 000 ha wheat growing area 280 000 ha of which is grown with bread type wheat cultivars and 70 000 ha of which is cultivated with durum type of wheat varieties. Average yield of the region is 3100-3200 kg/ha which is about 1.5 times as high as Turkey's average. But yield of coastal area is higher being 4500-5000 kg/ha (Ünsal, 2004).

Table 2. Wheat production areas and average yields in Aegean Region (Anonymus, 2006).

Province	Area sown (ha)	Production (ton)	Yield (kg/ha)
İzmir	53186	185812	3494
Aydın	30129	129050	3840
Manisa	119974	293071	2443
Denizli	98418	233991	3000
Muğla	50805	153285	3000
Balıkesir	182310	578393	3170
Çanakkale	128305	425351	3315
Bursa	127735	392767	3075
Uşak	55600	147150	3030

Climatic factors limiting wheat yield in Aegean Region

Wheat yield can reach up to 10000 kg/ha under favorable years and good management in Aegean coastal region in which rainfall ranges between 550-1100 mm. But, unusual weather conditions prevailing in the region like other parts of the globe during recent years have become major factor limiting wheat production.

Amoung the factors limiting wheat yield, erratic rainfall comes first. Particularly, excessive and late autumn rainfall reaching up to 100 mm a day experienced recent year's results in delay in sowing time and crop lost some years. In addition to this, winds cause lodging. Flooding and lodging also decrease yield and quality.

The importance of the rainfall distribution during the growing season cannot be overstated. Even for rainfall amounts of 200-330 mm, any additional rainfall affects the yield both positively and negatively depending on climate and the crop phenelogical stage (Lomas and Shashoua, 1970). The effect of rainfall distribution on wheat yields in the Aegean Region of Turkey showed positive effects during the months of March to May when the average amount of rainfall is 139 mm and the potential rate of evapotranspiration in 392 (Anonymus, 2002).

Inadequate rainfall during mid-February and mid-March when spikelet primordial initiation occurs limits the yield significantly. Apart from this, drought stress happening in May and afterwards because of lack of rainfall also decrease the yield as well as quality. In order to decrease losses, crop should be irrigated at flowering time. Another choice to escape from drought stress is to use early varieties.

The most significant variables, which explained wheat yield variability, are rainfall (during December, May and June) and soil moisture stress (following the reproductive stage of wheat) (Anonymus, 2002).

Another important factor limiting the yield is sudden air temperature changes. On coastal area summer varieties with no vernalization requirement are grown. Wheat excessively growing under warm autumn conditions is more prone to temperature changes happening in January and March. At this cold period if wheat is at tillering stage, damage is low, but if it is at booting or heading stage damage is high. Sowing time is important to reduce cold damage. Sudden air temperature increase in second part of May also causes yield and quality losses.

Table 3. Long term rainfall (mm) and average air temperature (ºC) data in Aegean Region (Anonymus, 2008).

Months	Denizli		Balıkesir		Çanakkale		Aydın	
	(mm)	ºC	(mm)	ºC	(mm)	ºC	(mm)	ºC
October	32	16,3	44	15,7	45	16	48	17,9
November	50	11,4	78	10,1	85	11,4	74	13,6
December	86	7,4	100	6,6	105	8,1	135	9,5
January	83	5,5	92	5,0	97	6,4	121	7,8
February	70	6,7	74	5,6	71	6,4	54	9,0
March	63	9,8	61	8,1	66	8,3	69	11,2
April	49	14,1	49	13,3	39	12,5	46	15,7
May	46	19,2	44	17,8	28	17,4	30	20,6
June	22	23,8	24	22,6	23	22,3	14	25,4
July	10	26,6	8	24,4	11	25,0	4	28,0
August	5	26,0	8	24,0	8	24,7	2	27,4
September	14	21,5	21	20,6	23	20,8	15	23,3
Total	535		607		606		656	

Months	İzmir		Manisa		Muğla	
	(mm)	ºC	(mm)	ºC	(mm)	ºC
October	43	18,4	49	17,6	68	15,8
November	86	14	91	12,3	125	10,7
December	146	10,4	148	8,4	284	7
January	136	8,6	129	6,8	262	5,4
February	102	9,4	111	8,0	179	6
March	71	11,3	77	10,4	117	8,3
April	43	15,6	55	15,1	62	12,5
May	34	20,5	42	20,1	44	17,4
June	9	25,1	16	25,0	22	22,4
July	2	27,6	6	27,6	6	26
August	2	27,1	4	27,2	6	25,6
September	13	23,4	18	23,1	15	21,6
Total	691		751		1195	

Yields and adaptation of wheat cultivars grown in Aegean Region

Acreage of cultivated areas are steadily decreasing like allover the world. Consequently, to develop cultivars getting highest yield per unit area is the purpose of the breeding studies. It is important that varieties show stabile performance against environment conditions in terms of sustainability of the yield. Since climatic

conditions are not intervened it is more important to improve stabile varieties to climatic changes.

Genotype x environment interaction is important to breeders. Yıldırım at all. (1979), described adaptation as ability of genotype to adapt to different environmental conditions and stability as measure of probability of changes to be done at environmental condition on genotype. It is accepted that varieties with high stability value have higher yield than average yield and varieties that show superior yield at certain environments have good specific adaptation ability.

Yields values maintained at study carried out by Aegean Agricultural Research Institute using registered bread wheat varieties during the years of 2001-2004 are given in Table 4. Irrigations were applied at different places and years where facilities were suitable. Experiments were irrigated once at Menemen and twice in Salihli locations and there was no irrigation at Bandırma location in 2001. There was no irrigation in the years of 2002-2003. Experiment at Menemen location was irrigated once at heading stage in 2004 when rainfall was only 252 mm.

Yields of Adana 99 were 9544 kg/ha at Salihli, 6356 kg/ha at Menemen, and 3845 kg/ha Bandırma location where there was no irrigation in 2001. Yields of Basribey 95 were 7789 kg/ha at Menemen, 8338 kg/ha at Salihli, and 5724 at Bandırma location. Particularly inadequate rainfall in May which wheat was at seed filling stage caused yield losses at later heading varieties. This shows how important irrigation is.

The yields of varieties ranged from 7410 kg/ha (Basribey 95) to 3687 kg/ha (Momthcil) in 2002-2003. Low rainfall in April and May, lack of irrigation decreased the yield of alternative and late varieties.

The year 2004 was very dry. Total rainfall was 252.75 mm of which 134.25 mm was in January. Irrigation applied at heading stage and cool spring put late varieties with high vernalization requirement first (Katea-1 8882 kg/ha). Temperature decrease in February, May and April caused significant cold damage in fields sown early.

At breeding studies, it is important to determine stability parameters and adaptation as well as increase in yield. In general, it is accepted that genotypes with high mean yield, regression coefficient (b) 1 or close to 1, deviation value from regression zero are ideal (Eberhart and Russel, 1996). Moreover, varieties with regression coefficient higher than 1 adapt to good environment conditions, and lower than 1 to bad environment conditions.

Stability parameters obtained from experiments carried out at 9 locations and for 4 years are summarized in Table 5. Stability graph containing regression coefficient of varieties is given in Figure 1.

Regression coefficient (b) of varieties ranged from 0.541 to 1.941 (Table 5) at this study. In terms of regression coefficient stability of Basribey 95 (0.982), Golia (0.916), Karacabey 97 (1.051) and Ziyabey 98 (1.048) are seen to be good. It may be misleading that to get in conclusion about cultivars stability by taking into consideration only regression coefficient. Therefore, it is wise to use all parameters while justification. Mean square error (s^2d) value should be targeted low and theoretically 0.

Table 4. Yield of wheat varieties (2001-2004, 9 Locations) (Anonymus-b, 2007).

Varieties	Menemen 2001(kg/ha)	Bandırma 2001(kg/ha)	Salihli 2001(kg/ha)	Menemen 2002(kg/ha)	Menemen 2003(kg/ha)	Dalaman 2003(kg/ha)	Menemen 2004(kg/ha)	Bandırma 2004(kg/ha)	Dalaman 2004(kg/ha)
Adana 99	6356	3845	9544	6436	5260	4658	7515	6188	6458
Bandırma 97	6650	4761	6887	6438	7022	5961	7400	6471	6106
Basribey 95	7789	5724	8338	7410	6649	5884	8564	6551	6397
Ceyhan 99	6801	4243	9263	6401	5688	5409	7689	6913	7048
Cumhuriyet 75	7124	4732	5929	6116	5620	3393	7753	6328	4893
Doğankent	6974	4944	9159	6120	5943	5376	8339	6790	5663
Golia	6825	5633	8048	6488	5352	5458	7806	6591	7353
Gönen 98	6897	4755	6960	6783	6417	4635	7068	6309	6093
İzmir 85	6929	6092	7168	6496	6524	5650	8735	7431	6254
Karacabey 97	6750	4838	7985	5967	6398	5384	7713	6698	4673
Karacadağ 98	6250	3660	5532	6260	6241	5580	6483	5525	5031
Kaşıfbey 95	7837	5284	5003	4793	5458	5464	7870	6982	6629
Katea -1					4872	4730	8882	6914	6478
Momtchıl	5442	4128	6213	3687	3983	4298	6213	6150	5724
Nurkent	6279	3898	8747	6490	6131	5757	7421	7052	5896
Pamukova 97	6280	4436	7329	5322	5527	4902	7134	5522	4827
Panda	5785	3630	7686	5419	5987	5223	5920	6238	5934
Sakin					4704	3934	6293	7110	5976
Seri 82	7050	4823	6349	4379	5937	4653	6981	6599	5900
Seyhan 95	6838	5247	8633	6304	6377	6655	7175	6473	6195
Tahirova 2000	5613	4628	6371	5180	4789	5110	7705	6807	7123
Yüreğir 89	5814	3232	7916	6357	5384	5599	7139	6447	6160
Ziyabey 98	7379	4948	8694	6614	6800	6758	8373	6512	6655
CV	7,3	13,5	10,0	10,4	8,9	12,7	6,9	5,6	7,3
LSD(%5)	68,7	88,4	106,6	88,3	73,03	94,24	73,03	51,92	63,02

Table 5. Stabilities parameter of wheat varieties (2001-04, 9 Locations) (Anonymus-b, 2007).

Varieties	Yield (kg/ha)	%	b	a	R^2	Deviation from Regression (S^2d)
Adana 99	6251	100,6	1,590	-362,526	0,844	4870,659
Bandırma 97	6411	103,2	0,660	231,287	0,681	2120,434
Basribey 95	7034	113,2	0,982	92,496	0,819	2213,152
Ceyhan 99	6606	106,3	1,409	-214,543	0,879	2840,474
Cumhuriyet 75	5765	92,80	1,038	-68,408	0,572	8401,047
Golia	6576	105,8	0,916	88,590	0,747	2960,127
Gönen 98	6180	99,4	0,834	99,761	0,780	2040,390
İzmir 85	6841	110,1	0,774	203,043	0,675	3007,770
Karacabey 97	6326	101,8	1,051	-20,127	0,741	4015,417
Karacadağ 98	5585	89,9	0,560	210,948	0,391	5085,782
Kaşifbey 95	6310	101,5	0,541	295,028	0,224	10556,366
Momtchil	5093	81,9	0,877	-35,402	0,629	4730,293
Nurkent	6407	103,1	1,267	-146,378	0,836	3269,606
Pamukova 97	5697	91,7	0,987	-43,070	0,861	1643,313
Panda	5758	92,6	0,920	4,648	0,686	4032,847
Seri 82	5852	94,2	0,816	78,335	0,593	4764,348
Seyhan 95	6655	107,1	0,786	177,067	0,679	3050,607
Tahirova 2000	5926	95,3	0,865	55,517	0,554	6274,878
Yüreğir 89	6005	96,6	1,221	-157,718	0,801	3846,959
Ziyabey 98	6970	112,2	1,048	46,303	0,824	2434,206
Doğankent	6648	107	1,379	-195,985	0,900	2547,665
Kate-A-I	6375	102,6	1,941	-570,305	0,941	2265,423
Sakin	5603	90,2	1,156	159,478	0,596	8729,217
Average yield	6212	100				

The stability chart shown that, Ziyabey 98 (yield: 6970 kg/ha, b: 1048, a: 46,303) and Karacabey 97 (yield: 6326 kg/ha, b: 1,051, a: -20,127) have very good adaptation capability on favorable conditions. Because Nurkent, Ceyhan 99, Doğankent, and Adana 99 have >1 calculated b score and higher yield then average, these varieties may grown in good conditions.

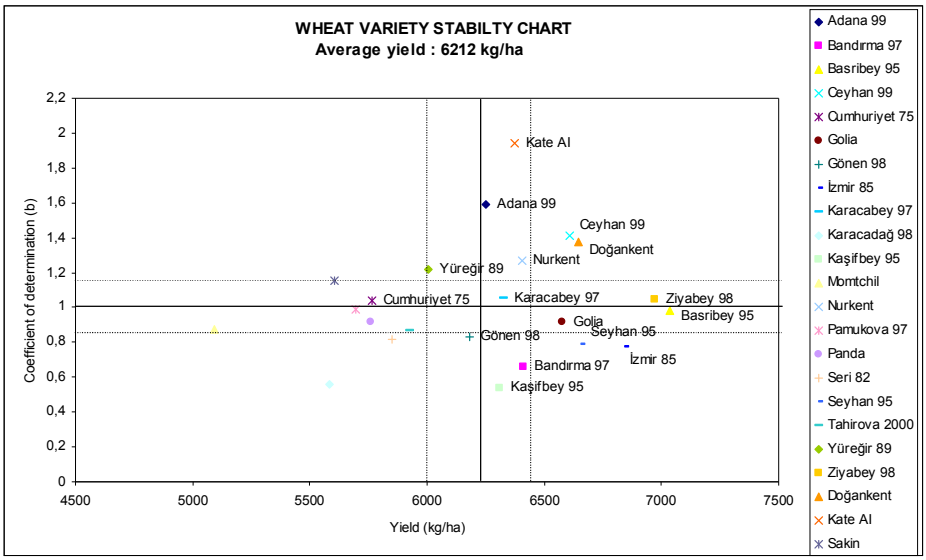

Figure 1. Stability chart of varieties (Anonymus, 2004).

It is said that Golia (yield: 6576 kg/ha, b: 0,916, a: 88,590), Basribey (yield:7034 kg/ha, b: 0,982, a: 93,496) have very good adaptation capability and stability on poor conditions. These varieties may show good performance on the favorable conditions. Izmir 85, Bandırma 97 and Kaşifbey 95 may be grown in poor conditions, because these varieties have <1 calculated b score and higher yield then average.

RESULT

Wheat yields are very much dependent on growing conditions and year on year climatic changes, therefore it is important to release high yielded and stabile varieties.

Ziyabey 98, Basribey 95, Karacabey 97 and Golia show very good adaptation capability and stability in all location of the region. Seyhan 95, İzmir 85, Bandırma 97 and Kaşifbey 95 may be grown weak and poor conditions. Adana 99, Ceyhan 99, Doğankent and Nurkent may be preferred in favorable growing conditions because of high yield. On the other hand, quality parameters are also important to advise varieties to the region, therefore quality factors should be studied.

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