

EFFECT OF THE LOCATION ON SOME BIOTIC STRESS AND AGRONOMIC CHARACTERS IN BARLEY (*Hordeum vulgare* L.) GENOTYPES

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Abstract

Because of the various environmental conditions biotic and abiotic stress factors varies in Trakya region, Turkey, and negatively affect some agronomic traits of the barley cultivars. This research was carried out to investigate location effect on yield, quality and leaf disease and correlation among these characters in developed advance genotypes. Experiment was conducted at three locations during 2015-2016 growing year in Trakya region, Turkey. Experiment was set up with 25 advanced genotypes in randomized completely blocks design with four replications. Grain yield, days of heading, plant height, 1000-kernel weight, test weight, protein ratio, net blotch, and leaf rust diseases and relationship among these characters were investigated. There were significant differences among genotypes and location for examined characters. Sixty genotypes were tolerant to net blotch and leaf rust in three locations. The correlation coefficient varied according to level of the disease infection. Grain yield was negatively correlated with net blotch in three locations. Net blotch disease of barley negatively affected and decreased in TKW at three locations. Also, in Edirne location net blotch highly affected and decreased test weight. The grain yield was positively correlated with TKW at three locations and negatively significant correlated with protein ratio in Edirne and slightly correlated in Keşan location. These results showed that genotypes x environment interaction were highly significant for biotic and abiotic stress factor.

Key words: Barley, genotypes, location effect, agronomic characters, biotic stress

1. INTRODUCTION

Barley (*Hordeum vulgare* L.) is one of the oldest cereal crops known to be cultivated since about 10.000 years in a region located between the Nile (Egypt) and Southern Turkey. It has a natural tolerance to drought, salinity, and fungal diseases, thus making it a model organism in stress biology research. Indeed, a barley plant was shown to complete its life-cycle before using all the available soil water, even in high salt concentrations and defined as the most salt-tolerant cereal (Munns et al., 2006). Grain yield in barley is a complex economically important trait resulting from the effect of genotype and the environment throughout the life cycle of a plant. It is particularly difficult to develop cultivars that would carry positive traits under different growing conditions and show resistance to biotic and abiotic stress factors (Przulj et al., 1998; Knezevic et al., 2007). Success of a wheat breeding program depends on the regional adaptability of the cultivars improved and adaptability of such cultivars in the target environments determined by its tolerance to biotic and abiotic stresses (Altay, 2012). The impact of diseases on barley yields and grain size, and identified the most economically important diseases nationally (scald, net blotch, yellow and leaf rusts, and BYDV). Grain yield in barley, like other crops, is very complex trait that is a function of genetic and environmental factors. In different environmental conditions, different characteristics effect on increasing the seed yield, the affect rate of these characteristics can be different depending on the barely kind. The correlation between the characteristics and the seed yield in barley showed that seed yield has a significant and positive correlation with the agronomical characteristics (Tomer et al., 1999). The optimum development of barley (*Hordeum vulgare* ssp *vulgare* L.) over its life cycle depends on a number of environmental abiotic stress factors that can prevent the plants expressing its maximum genetic potential (Cattivelli and Ceccarelli, 2011). Net blotch (*Pyrenophora teres*), powdery mildev (*Blumeria graminis* f. sp. *hordei*), leaf stripe (*Pyrenophora graminea*), and some root rot are the mainly biotic stress factors affecting grain yield in Trakya region (Öztürk et al., 2014). In this study, grain yield and

some quality components, mainly leaf diseases and correlation among these traits were investigated over location.

2. MATERIALS AND METHODS

This research was carried during 2015-2016 growing cycle at three locations (Edirne, Lüleburgaz, Keşan) in Trakya region, Turkey. Experiment was set up with 25 advanced genotypes in randomized completely blocks design with four replications. Sowings were performed by using a plot drill, parcels area was 6 m² and 500 seeds/m² was used at planting. Five local checks Sladoran, Bolayır, Martı, Harman and Lord Cultivars were used. Grain yield, days of heading, plant height, 1000-kernel weight, test weight, protein ratio, net blotch (*Pyrenophora teres*), and leaf rust diseases and relationship among these characters, based on location were investigated. Also, correlations among these traits were examined. Modified Cobb scale (Prescott et al., 1986; Roelfs et al., 1992; Saari and Prescott, 1975; Peterson et al., 1948) was used for leaf diseases. All data are presented as mean values of four replicates and three locations. Data were analysed statistically for analysis of variance (ANOVA) following the method described by Gomez and Gomez (1984). The significance of differences among means was compared by using Least Significant Difference (LSD at a %5) test. Some climate condition data were collected from main station in Edirne location and was given in Table 1.

Table 1. Some climate conditions in Edirne location in 2015-2016 growing year

Months	Precipitation (mm)	Days to rain	Moisture (%)	Temperature (°C)		
				Min.	Max.	Mean
September 2015	29.5	5	68.7	12.2	39.9	24.0
October 2015	52.6	9	81.7	3.6	26.2	15.6
November 2015	26.2	7	81.7	1.1	25.1	13.5
December 2015	0.3	1	83.6	-5.7	14.9	5.5
January 2016	114.8	14	84.5	-11.4	18.4	2.8
February 2016	91.4	15	85.5	-3.5	22.2	9.2
March 2016	54.8	10	77.5	-1.1	23.3	10.2
April 2016	116.1	7	66.6	2.3	31.8	15.5
May 2016	81.4	20	71.8	5.7	32.2	17.4
June 2016	10.2	7	61.8	8.3	38.4	23.9
Total/Mean	577.3	95	76.3	-11.4	39.9	13.8

3. RESULTS AND DISCUSSION

Grain yield is a complex character depending upon a large number of environmental, agronomical and physiological characters, so it was found significant differences among genotypes and locations based on yield and other investigated traits. Grain yield is a product of an organized interplay of its several components, which are highly susceptible to environmental fluctuations. However, yield can be estimated on the basis of performance of yield components. Enhancement in yield in most situations is more effectively fulfilled on the basis of performance of yield components, which are closely associated with grain yield (Ashfaq et al., 2003). Overall evaluation yield of genotypes and location, grain yield in barley was affected from genetic and environmental factors. There was a significant difference between locations in grain yield and mean yield of the experiment was 624.8 kg da⁻¹. According to mean value of the genotypes the highest grain yield was determined with 746.6 kg da⁻¹ in TEA2324-9 line and followed by TEA2324-11 sister lines (714.2 kg da⁻¹).

Thousand kernel weight studied by the researchers were reported in the literature as a very important yield component (Khan et al., 2004; Hassan et al., 2003). There was a very highly significant variation in 1000-kernel weight of barley genotypes based on their spike types and other genotypic traits. The highest 1000-kernel weight was measured in TEA2324-11 and TEA2324-9 sister lines which they have two rows spike types. TKW ranged from 27.3 g to 47.4 g among genotypes and mean was 40.8 g. The results of present study were in accordance with the previous findings. Test weight was measured in all genotypes and location and mean value was 71.7 kg. Based on mean value of the test weight was ranged from 64.2 kg to 74.5 kg among genotypes and the highest test weight scaled in TEA2275-14 (74.5 kg) and TEA2363-16 (74.4 kg) genotypes (Table 2).

Barley grain is used primarily as an energy and protein source for animal feed. High protein content is desirable for feed production. Variation in weather condition in the regions, year effect, soil fertility and pest management can affect barley grain quality significantly. Protein quantity in grain varies depending on weather conditions and amount of the nitrogen fertilizer in the region. In this study, protein ratio ranged based on genotypes x environment interaction and the lowest protein was 8.8% and highest 11.7% and mean protein was 10.62%. The highest protein value was obtained in Sladoran and Bolayır cultivars (Table 2). Earliness is other important and favourable characters in barley in the region, due to farmers need to produce second crops especially for animal feed in same growing cycle. Days of heading ranged from 94.0 (TEA2370-7) to 109.3 days (TEA 2168-12) among genotypes and mean was 100.3 days, it means that there was significant differences among genotypes.

Table 2. Average value of grain yield, quality and agronomic characters of the genotypes

No	Genotypes	GY	TKW	TW	PRT	DH	PH
1	Sladoran	586.1 hij	37.2 fgh	70.7 c-f	11.7 a	101.0 b-g	89.7 i
2	TEA1619-2	617.4 fgh	39.3 efg	71.2 b-e	11.0 a-e	100.0 c-h	92.3 f-i
3	TEA2312-3	598.2 ghi	44.7 abc	70.7 c-f	10.9 a-e	105.0 ab	101.7 a-f
4	TEA1980-4	635.4 def	29.5 ij	68.6 fg	10.6 b-f	103.0 b-e	91.7 ghi
5	Bolayır	549.3 kl	35.1 gh	73.1 ab	11.5 ab	100.7 b-h	103.3 a-d
6	TEA1980-6	684.5 bc	33.9 hi	71.3 b-e	10.6 b-f	103.3 bcd	94.7 d-i
7	TEA2370-7	656.5 cde	40.3 c-f	71.3 b-e	10.6 b-f	94.0 i	95.7 d-i
8	TEA2312-8	599.1 ghi	45.9 ab	73.6 ab	10.9 a-e	98.7 d-i	102.0 a-e
9	TEA2324-9	746.6 a	47.3 a	73.4 ab	10.2 ef	100.3 b-h	93.0 e-i
10	Martı	562.7 jkl	35.3 gh	68.2 g	10.0 ef	97.3 f-i	100.7 a-g
11	TEA2324-11	714.2 ab	47.4 a	72.6 a-d	10.1 ef	101.0 b-g	91.0 hi
12	TEA2168-12	570.8 i-l	43.2 a-e	73.7 a	11.2 a-d	109.3 a	100.0 a-h
13	TEA1814-13	689.1 bc	46.1 ab	73.0 abc	10.9 a-e	101.3 b-f	99.0 c-i
14	TEA2275-14	676.9 c	42.9 a-e	74.5 a	10.8 a-f	101.0 b-g	93.3 e-i
15	Harman	660.6 cd	42.8 a-e	72.8 abc	10.9 a-e	96.3 ghi	102.3 a-e
16	TEA2363-16	682.8 bc	44.4 a-d	74.4 a	10.5 c-f	98.3 e-i	97.0 c-i
17	TEA1752-17	621.8 efg	46.0 ab	73.2 ab	10.4 def	101.0 b-g	96.0 c-i
18	TEA2370-18	638.6 def	42.9 a-e	72.9 abc	10.0 ef	100.3 b-h	91.7 ghi
19	TEA2312-19	597.3 g-j	46.4 ab	72.8 abc	10.6 b-f	100.0 c-h	96.7 c-i
20	Hasat	599.2 ghi	42.0 b-e	72.7 a-d	10.9 a-e	101.3 b-f	104.0 a-d
21	TEA2417-21	588.8 g-j	40.1 c-f	72.4 a-d	10.7 b-f	99.3 c-h	105.3 abc
22	TEA2423-22	564.6 i-l	45.0 ab	70.3 d-g	11.4 abc	96.7 f-i	100.7 a-g
23	TEA2349-23	576.9 ijk	39.6 d-g	73.0 abc	10.9 a-e	99.7 c-h	99.7 b-h

24	TEA2403-24	541.1 l	27.3 j	69.2 efg	9.9 f	104.0 bc	108.7 ab
25	IBYT-HI-16-25	660.9 cd	36.5 fgh	64.2 h	8.8 g	96.0 h ₁	109.3 a
Average		624.8	40.8	71.7	10.6	100.3	98.4
C.V (%)		6.9	7.1	2.0	5.4	2.9	5.8
L.S.D (0.05)		34.9	4.7	2.4	0.9	4.7	9.4
F		**	**	**	**	**	**

Note: Significance at **: P<0.01 and *: P<0.05; GY: Grain yield (kg da⁻¹), TKW: Thousand kernel weight (g), TW: Test weight (kg), PRT: Protein ratio (%), DH: Days of heading, PH: Plant height (cm).

Stem long is one of the most important initial selection criteria in barley breeding works, being a direct component of lodging resistance and an indirect component of both yield and quality (Madic et al., 2012). Short and strong stem is an important morphological character directly linked with lodging resistance the productive potential of plant in terms of grain yield. For lodging resistance plant height and stem structure are highly considerable traits in the region. In this experiment short plant height was measured in Sladoran (89.7 cm) cultivar, followed by TEA2324-11, TEA2370-18 and TEA1980-4 genotypes (Table 2).

Net blotch leaf disease is one of the mainly biotic stress factor in barley. An early onset of the disease and rapid development from lower leaves to upper leaves might enable the net blotch disease to be a single dominant disease in both years (seasons). Moreover, the fact that net blotch beginning with low infection and increasing downwards, from F to F-2 leaves positions in time makes clear that the lower leaves remains an important epidemiological factor in barley net blotch (Hundie et al., 2004). Net blotch (*Pyrenophora teres*) is the mainly biotic stress factor in the region and it causes significantly grain yield losses where infection was higher. Harman cultivar and entry number 4, 6, 9, 12, 13 and 14 genotypes were tolerant to net blotch diseases under field condition where level of the disease infection was higher.

Table 3. The correlation coefficient of the investigated characters in Edirne (Turkey) location

Parameters	GY	DH	PH	PYR	LR	TKW	TW
DH	-0.501*						
PH	0.005	-0.172					
PYR	-0.336	-0.154	0.326				
LR	-0.122	-0.042	-0.219	-0.084			
TKW	0.464*	0.003	0.003	-0.529**	0.294		
TW	0.025	0.378	-0.053	-0.435*	-0.016	0.574**	
PRT	-0.463*	0.107	0.225	0.473*	-0.116	-0.212	0.267

Note: Significance at **: P<0.01 and *: P<0.05; GY: Grain yield (kg da⁻¹), DH: Days of heading, PH: Plant height (cm), PYR: *Pyrenophora teres* (0-99), LR: Leaf rust, TKW: Thousand kernel weight (g), TW: Test weight (kg), PRT: Protein ratio (%).

Some relationships between characters were examined and some of the traits were found highly correlated to each other. The correlation coefficient varied according to level of the disease infection. Grain yield was negatively correlated with *Pyrenophora teres* in Keşan (r=-0.608**), Lüleburgaz (r=-0.396*), and Edirne (r=-0.336) location. Net blotch disease of barley negatively affected and decreased in 1000-kernel weight at three locations and the highest correlation coefficient (r=-0.529**) was determined in Edirne location. Also, in Edirne location net blotch highly affected and decreased test weight (r=-0.435*). The grain yield was positively correlated with 1000-kernel weight at three

locations, and negatively significant correlated with protein ratio in Edirne ($r=-0.463^*$), and slightly correlated in Keşan ($r=0.259$) location. These results showed that genotypes x environment interaction were highly significant for biotic and abiotic stress factor.

Table 4. The correlation coefficient of the investigated characters in Keşan (Turkey) location

Parameters	GY	DH	PH	PYR	LR	TKW	TW
DH	-0.273						
PH	-0.463*	-0.247					
PYR	-0.608**	-0.250	0.559**				
LR	-0.220	0.015	-0.122	0.379			
TKW	0.241	0.035	-0.294	-0.129	0.156		
TW	0.006	0.319	-0.176	-0.019	0.181	0.632**	
PRT	-0.259	0.448*	-0.239	-0.137	0.167	0.355	0.359

Also, there was positive relationship between thousand kernel weight and test weight in Edirne ($r=0.574^{**}$), in Keşan ($r=0.632^{**}$), and in Lüleburgaz ($r=0.510^{**}$) locations. Protein ratio was positively correlated with test weight at three locations. Days of heading was negatively slightly correlated with *Pyrenophora teres* in Edirne ($r=-0.154$), in Keşan ($r=-0.250$), and in Lüleburgaz ($r=-0.234$) location. All these results showed that genotypes which have early maturing susceptible to net blotch disease, tested in this experiment.

Table 5. The correlation coefficient of the investigated characters in Lüleburgaz (Turkey) location

Parameters	GY	DH	PH	PYR	LR	TKW	TW
DH	0.165						
PH	-0.120	0.130					
PYR	-0.396*	-0.234	0.030				
LR	0.085	-0.314	0.212	-0.252			
TKW	0.136	-0.395*	-0.161	-0.278	0.364		
TW	0.451*	-0.322	-0.358	0.024	0.146	0.510**	
PRT	0.142	-0.178	-0.173	0.129	-0.099	0.020	0.317

Linear regression was used to investigate between grain yield, quality and net blotch leaf diseases and other characters. Net blotch leaf disease negatively affected and reduced grain yield and some quality parameters. There was a slightly negative relationship between net blotch and grain yield ($R^2=0.112$), 1000-kernel weight ($R^2=0.280$), and test weight ($R^2=0.189$). These results indicated that net blotch negatively affected yield, yield components and quality parameters depending on level of the infection (Figure 1). In Lüleburgaz location infection of the net blotch disease level was slightly or moderate in genotypes so there was slightly relation between grain yield and net blotch leaf disease.

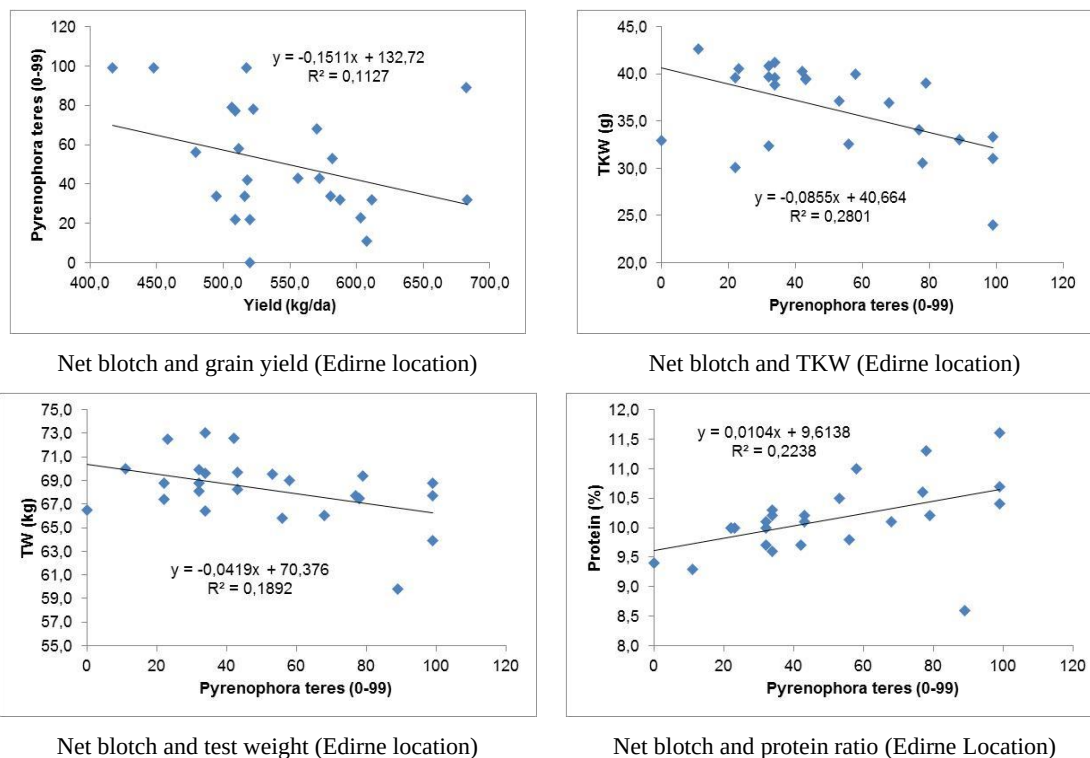


Figure 1. Relation between net blotch and yield and other parameters in Edirne location

Keşan location is located in coastal area in Trakya region, rainfall and humidity higher than other location. Because of this environment conditions level of the net blotch infection was higher so there was higher negatively relation between yield and net blotch leaf disease (Figure 2).

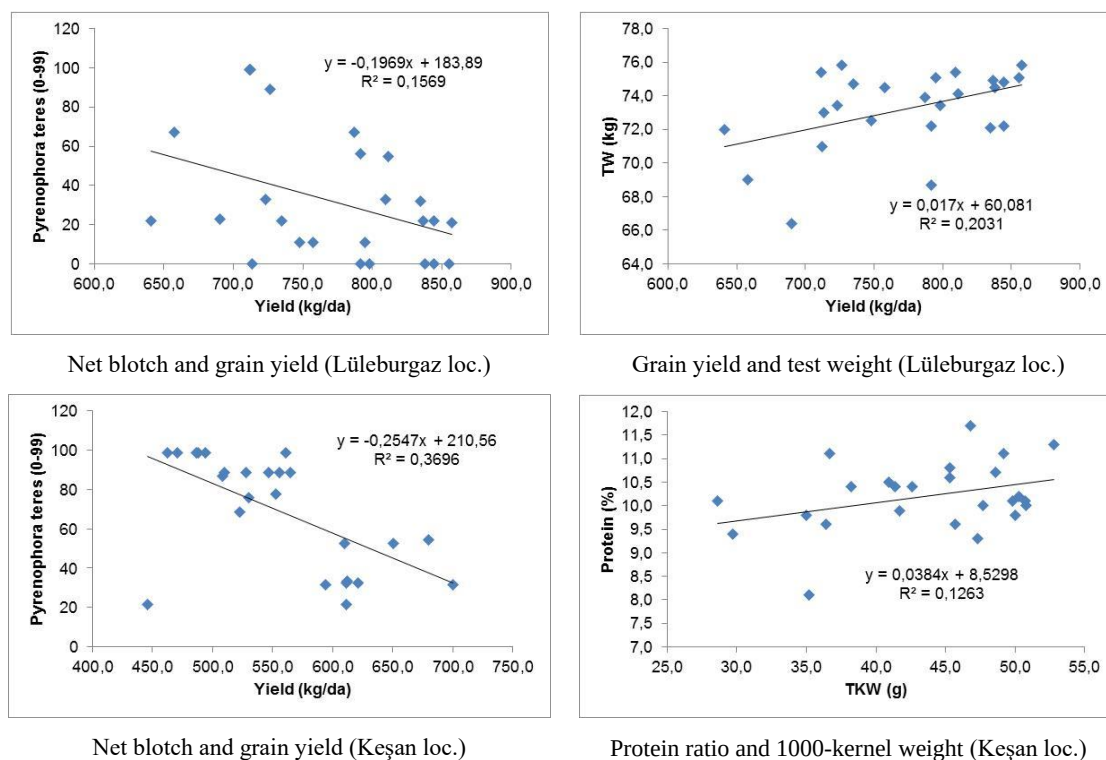
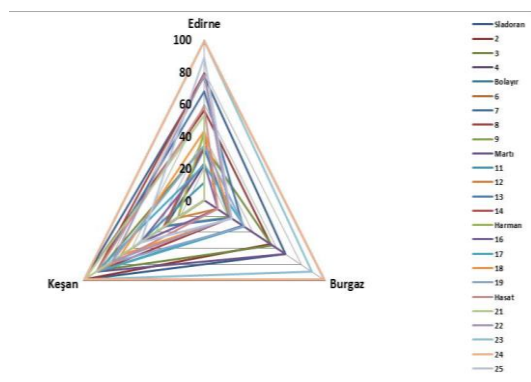
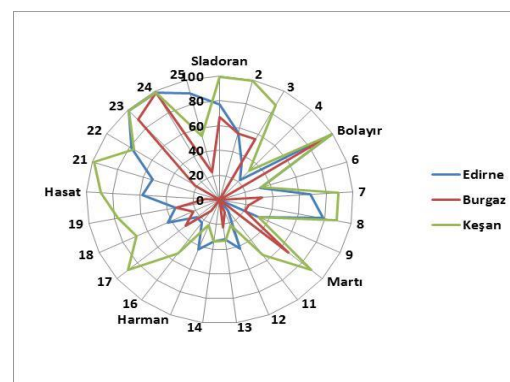


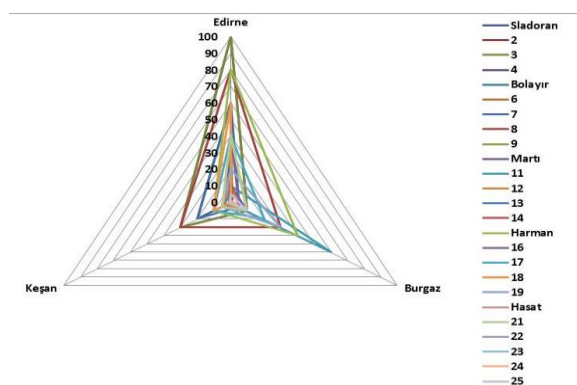
Figure 2. Relation between net blotch and yield and other parameters in Lüleburgaz and Keşan location



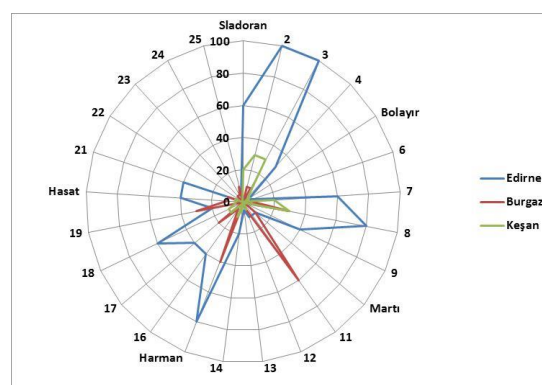
Net blotch leaf disease infection based on location and genotypes



Net blotch leaf disease infection location and based on genotypes



Leaf rust infection based on location and genotypes



Leaf rust infection based on location and genotypes

Figure 3. Net blotch and leaf rust infection level based on location and genotypes

Net blotch (*Pyrenophora teres*) is the mainly biotic stress factors affecting grain yield in Trakya region in barley production. Infection of the disease severity varies based on genotypes and environment factors. The disease develops during vegetative plant growth stage depending on environment condition and causes premature death of leaves and post-maturation straw breakage. In this experiment Keşan was the location the highest level of the epidemics occurred. Cultivar Harman and 6 genotypes (entry number 4, 6, 9, 12, 13 and 14) were tolerant to net blotch across three locations.

Yield and quality losses caused by leaf rust of barley in Trakya region are generally low because the crops is seldom infected before heading in Trakya region. Infection of the leaf rust disease severity varied and Edirne location has been found suitable environment condition for leaf rust in barley. Cultivar Bolayır, which was developed by institute breeding program, and 7 genotypes (entry number 6, 12, 13, 22, 23, 24 and 25) were very tolerant to leaf rust under field condition across three locations.

4. CONCLUSION

The overall results indicated that there is genetic variability present in the studied material. There were significant differences among genotypes and location for examined characters. The highest yielding location was Lüleburgaz. Overall result of this study indicated that sixty genotypes were tolerant to *Pyrenophora teres* and leaf rust across all locations. The correlation coefficient varied according to level of the disease infection. Grain yield was negatively correlated with *Pyrenophora teres* in three locations. Net blotch disease of barley negatively affected and decreased in 1000-kernel weight and the highest correlation coefficient was determined in Edirne location where disease infection was higher. Also, in Edirne location net blotch highly affected and decreased test weight of the genotypes.

The grain yield was positively correlated with 1000-kernel weight at three locations and negatively significant correlated with protein ratio in Edirne, and slightly correlated in Keşan location. Early genotypes was more susceptible to net blotch so net blotch and days of heading was negatively correlated at three locations. Also it was found highly significant positive relation between test weight and TKW across all location. Test weight was positively correlated with protein ratio at three locations. These results showed that genotypes x environment interaction were highly significant for biotic and abiotic stress factor.

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