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Biotic stress factors in barley (*Hordeum vulgare* L.) genotypes under various environmental conditions in Trakia region

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Abstract. *Barley is an important crop in Trakia region, Turkey and due to various environmental factors it can suffer some biotic stress and yield loss in the region. This research was carried out in two locations (Edirne and Tekirdağ) of Trakia region during 2013-2014 growing year. The experiment was set up with 25 advanced genotypes in completely randomized blocks with four replications at two locations. Grain yield, plant height, days to heading, leaf rust, net blotch, powdery mildew and relationship among these characters were investigated. According to the results, there was significant difference among genotypes for grain yield, biotic stress factors and other characters. The mean grain yield of the genotypes was 6866 kg ha-1. TEA1619-11 had the highest grain yield with 7667 kg ha-1. TEA2311-19 (7593 kg ha-1) and Harman (7593 kg ha-1) were the other highest yielding genotypes. Due to various environmental conditions, there was significant difference between locations. Mean yield in Edirne location was 7841 kg ha-1 and in Tekirdağ location it was 5891 kg ha-1. TEA1619-8 and TEA1619-9 sister lines had the shortest plant height and early genotypes had higher grain yield. Net blotch (Pyrenophora teres f. teres) is the mainly prevalent disease in Trakya region. Leaf rust and powdery mildew had negative effect and decreased grain yield. TEA1619-12, TEA1619-17, TEA2311-19 and TEA1980-25 genotypes were resistant at both locations. TEA1980-25 was an outstanding line to net blotch, leaf rust and powdery mildew. It was determined that increase of net blotch had negative effect and decreased the grain yield in the genotypes.*

Keywords: barley, genotypes, yield, biotic stress, environment effect

Introduction

Barley as well as wheat is one of the most significant plants of the cereal species (*Gramineae*), a plant of Hordeum and Sativum or Vulgare species (Khodabande, 2005). Barley can be cultivated in many parts of the world due to tolerance to non- environmental issues and the need of little moisture and adaptation to crop field (FAO, 2009). The development of varieties which can be adapted to a wide range of diversified environments is the ultimate goal of plant breeders in a barley improvement program (Vulchev et al., 2009; Valcheva et al., 2013). Grain yield in barley is a complex economically important trait resulting from the effect of the 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). In different environmental conditions, different characteristics affect the increasing of seed yield, the affect rate of these characteristics can be different depending on the barley 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).

Barley (*Hordeum vulgare* L.) is the major cereal in many different areas of the world and is essential for the livelihoods of many farmers. Barley is an annual cereal crop and is grown in environments ranging from the many of the area (Öztürk et al., 2018). Trakia region is located in the Northwestern part of Turkey. Barley is an economically important crop in that region with growing areas almost 70 000 hectares and over 5.0 t ha^{-1} grain yield. The average annual rainfall is about 560mm in the region, but during the growing season the distribution of this rainfall is not regular. Due to this fluctuation of rainfall biotic and abiotic stress could be caused (Öztürk et al., 2016). Net blotch (*Pyrenophora teres*), powdery mildew (*Blumeria graminis* f. sp. *hordei*) and some root rot are the main biotic stress factors affecting grain yield in the region (Aktaş, 2001; Öztürk et al., 2014). Under natural conditions, plants face the threat of infection by pathogens (including bacteria, fungi, viruses and nematodes) and attack by herbivore pests (Atkinson and Urwin, 2012). In this study, grain yield and main biotic stress factors of the barley genotypes were investigated and correlations among these parameters were investigated over two locations in Trakia region, Turkey.

Material and methods

The experiment was carried out at two locations in Edirne and Tekirdağ, Trakia region, Turkey in 2013-2014 growing years. The research was established with 25 genotypes, 5 of them local check and 20 advance lines, in a completely randomized block design with four replications. Each plot consisted of 6 rows 6m long with row spacing of 0.17cm, and plot area were $6m^{-2}$ at harvesting. Sowings were performed by using a plot drill and 500 seeds/m^2 were used at planting. Some climatic data are given in Table 1 and total rainfall and mean temperature were very close to each other at two locations.

Days to heading were calculated from the date of sowing till the date when 50% of the spikes had emerged. Sladoran, Bolayır, Martı, Harman and Lord were used as local check cultivars. In this experiment grain yield, plant height, days to

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Table 1. Rainfall, mean relative humidity and temperature at Edirne and Tekirdağ locations

Month	Edirne location			Tekirdağ location		
	Rainfall (mm)	Relative humidity (%)	Mean temperature (°C)	Rainfall (mm)	Relative humidity (%)	Mean temperature (°C)
October 2013	30.7	77.5	12.8	96.4	76.2	14.3
November 2013	73.9	86.7	11.0	36.6	79.0	12.9
December 2013	2.3	82.2	2.7	2.4	74.1	6.2
January 2014	74.9	87.4	5.5	44.0	85.0	8.0
February 2014	3.8	86.0	7.6	6.0	83.2	8.7
March 2014	124.5	81.4	10.1	65.2	81.6	9.9
April 2014	36.8	81.6	13.6	41.2	83.3	13.4
May 2014	61.7	76.6	18.6	65.2	80.3	17.5
June 2014	68.8	73.8	22.9	60.0	76.2	21.8
Total/Mean	477.4	81.5	11.6	417.0	79.9	12.5

heading, leaf rust, powdery mildew, and net blotch diseases were investigated. Also, correlations among these traits were examined. Modified Cobb scale (Peterson et al., 1948; Prescott et al., 1986) was used for powdery mildew and net blotch. Leaf diseases data were taken at GS35 and GS65 (Zadoks et al., 1974).

The statistical analyses of the measurement data were performed by using a statistical software and the differences among the means were compared with LSD at a 5% significant level (Gomez and Gomez, 1984; Kalaycı, 2005).

Results and discussion

Variance analysis showed highly significant differences among the genotypes, indicating the existence of a genetic variability of barley accesses related to the traits studied. According to the results obtained, significant differences were found among genotypes at Edirne location ($P<0.01$) and based on mean yield ($P<0.01$) (Table 2).

Grain yield is a complex character depending on a large number of environmental, agronomical practices and physiological characters. Edirne and Tekirdağ locations have various environmental conditions by months so there were significant differences between both locations. The mean yield of the genotypes was 6866 kg ha^{-1}. According to location, mean yield in Edirne and Tekirdağ location was 7841 kg da^{-1}and 5891 kg ha^{-1}, respectively. In Tekirdağ location high level infection of leaf rust during the grain filling period negatively affected and decreased grain yield. Based on the mean value of the genotypes, the highest grain yield was determined with 7667 kg ha^{-1} in TEA1619-10 line. TEA2311-19, Harman and Martı were other highest yielding genotypes. According to evaluation of the location x genotypes interaction, the highest yield was obtained with 8880 kg ha-1 in Harman cultivar and with 8845 kg ha^{-1} in Martı cultivar in Edirne location (Table 2).

Genotype response following exposure to biotic stress strongly depends on developmental stage and environmental condition. Net blotch (*Pyrenophora teres*), leaf rust and powdery mildew are the major diseases in barley production area in the region. All genotypes were assessed at two locations against diseases. Net blotch (*Pyrenophora teres*) is the main biotic stress factor in the region and it can cause significant grain yield losses in a certain growing cycle. Cultivar Harman and TEA1619-12, TEA1619-17, TEA2311-19 and TEA1980-25 were very tolerant to net blotch. Powdery mildew disease is caused by the fungus *Blumeria graminis* f. sp. *hordei* and is more common in the regions and high humidity conditions in April during shooting phase of barley plant favour disease development. Severe and early infection of the net blotch could be inducing yield losses. In this experiment cultivars Lord and Harman with TEA1765-6 and TEA1980-25 lines were tolerant to powdery mildew (Table 2). Also, TEA2075-18 and TEA1980-25 lines were tolerant to leaf rust in both locations.

Developing new barley cultivars with high and stable grain yield and resistance to biotic and abiotic stress factors is the main goal of the breeding program (Valcheva and Vulchev, 2013; Valcheva et al., 2013). The genotypes x year interaction suggested different responses of the cultivars to growing conditions. In this study, the tolerance or susceptibility of the advanced barley genotypes to net blotch, leaf rust and powdery mildew was compared at two different locations under field conditions. Net blotch and powdery mildew are major leaf diseases in barley in Trakia region. Linear regression was used to determine grain yield and the other investigated traits in Edirne location. There was a slightly negative relationship between grain yield and powdery mildew and *Pyrenophora teres* f *teres*. Also, there was a negative relationship between grain yield and days to heading (r^2= 0.356). Earliness is a very important trait in Trakia region so in this research early genotypes had higher grain yield. Leaf rust because of environment condition and earliness of barley genotypes is not an important disease on yield. Infection of leaf rust generally takes places during the heading and grain filling period in barley, so it does not affect grain yield in barley (Figure 1).

Tekirdağ is the highest yielding location in Trakya region but in some growing cycles various environment condi-

Table 2. Mean grain yield and Net blotch, Leaf rust and Powdery mildew of the genotypes according to location in 2013-2014 cycles

Entry No	Genotypes	Locations: Edirne (kg ha^{-1})	Tekirdağ (kg ha^{-1})	Mean Yield (kg ha^{-1})	PYR	LR	PM
1	Sladoran	8314^{a-d}	5639^{c-g}	6977^{a-g}	65-11	60S-100S	0-47
2	TEA1619-2	7473^{b-f}	6355^{a-d}	6914^{b-g}	73-22	20S-80S	46-32
3	TEA1765-3	7318^{c-g}	6196^{a-e}	6757^{c-h}	65-22	40S-70S	57-11
4	TEA1676-4	8715^{a}	5729^{b-g}	7222^{a-d}	52-21	20S-100S	44-34
5	Bolayır	7837^{a-f}	6216^{a-e}	7026^{a-f}	99-11	10S-80S	0-66
6	TEA1765-6	6940^{fg}	5647^{b-g}	6293^{ghı}	98-33	20S-80S	33-22
7	TEA1592-7	7996a^{-f}	5810^{b-g}	6903^{b-g}	99-43	10S-60S	44-44
8	TEA1619-8	7242^{d-g}	6205^{a-e}	6724^{c-h}	75-11	20S-100S	44-48
9	TEA1619-9	6957^{fg}	5347^{efg}	6152^{hı}	66-44	40S-100S	55-69
10	Martı	8845^{a}	5910^{a-g}	7378^{abc}	64-22	10S-40S	46-47
11	TEA1619-11	8628^{ab}	6706^{a}	7667^{a}	54-11	20S-60S	56-45
12	TEA1619-12	8256^{a-e}	5949^{a-g}	7103^{a-f}	21-22	10S-80S	57-44
13	TEA1619-13	8564^{ab}	5729^{b-g}	7146^{a-f}	53-32	60S-80S	55-45
14	TEA1765-14	6985^{fg}	6103^{a-f}	6544^{d-h}	53-11	20S-100S	68-22
15	Harman	8880^{a}	6100^{a-f}	7490^{ab}	43-32	60S-100S	34-32
16	TEA1676-16	8443^{abc}	5545^{c-g}	6994^{a-g}	52-11	80S-80S	45-0
17	TEA1619-17	7901^{a-f}	6522^{ab}	7211^{a-e}	21-32	10S-80S	68-48
18	TEA2075-18	7289^{c-g}	5700^{b-g}	6494^{e-h}	64-22	10S-20S	44-48
19	TEA2311-19	8782^{a}	6403^{abc}	7593^{ab}	32-11	40S-100S	22-47
20	Lord	7360^{c-g}	5497^{d-g}	6428$^{f-ı}$	64-22	5MS-40S	22-22
21	TEA2364-21	8183^{a-e}	5599^{c-g}	6891^{b-g}	32-89	20S-80S	33-77
22	TEA2312-22	7956^{a-f}	6003^{a-g}	6979^{a-g}	21-45	20S-80S	59-58
23	TEA2324-23	7148^{efg}	5907^{a-g}	6527^{d-h}	22-87	10S-60S	57-69
24	TEA2257-24	6212^{g}	5282^{fg}	5747^{ı}	32-56	5MS-60S	45-54
25	TEA1980-25	7789^{a-f}	5190^{g}	6489^{fgh}	11-32	5MS-0	0-34
Mean (kg da^{-1})		7841	5891	6866			
L.S.D (0.05)		116.2**	87.6^{ns}	72.2**			
C.V (%)		10.5	10.6	10.6			

tions negatively affect and cause decreasing in grain yield. In Tekirdağ location it was determined that there was a slightly negative relationship between grain yield and *Pyrenophora teres* f *teres*. Also, there was a slightly negative relationship between grain yield and plant height and positive relation between days to heading and plant height (r^2= 0.161). These results showed that genotypes which have short plant height gave higher grain yield (Figure 2).

Correlation coefficients on the investigated parameters were determined by Pearson's correlation analysis (Tables 3 and 4). Some relationships between the investigated parameters were tested in the study and various correlations were found. There was a negative relationship between grain yield and days to heading (r= -0.597**). Leaf rust infection began in barley at the end of the grain filling period so there was no negative effect and relationship between leaf rust and yield was very low. Days to heading and plant height were positively correlated with each other. Leaf rust was also slightly correlated with days to heading and plant height (Table 3).

In Tekirdağ location various correlations among characters were found. Stem length is one of the most important initial selection criteria in barley breeding work, being a direct component of lodging resistance and an indirect component of both yield and quality (Madic et al., 2012). There was a negative relationship between grain yield with plant height (r= -0.337) and there was a positive correlation between days to heading and plant height. Grain yield was negatively correlated with *Pyrenophora teres* (r= -0.351). Due to late growth plant stage of infection of leaf rust negative relation between grain yield and leaf rust was not found in Edirne location. Leaf rust was slightly correlated with days to heading and plant height in both locations (Tables 3 and 4).

Conclusion

Net blotch (*Pyrenophora teres*), leaf rust and powdery mildew are the major diseases in barley production in Edirne and Tekirdağ locations, Trakia region. Because of the various environmental conditions there were differences among genotypes and locations based on yield and biotic stress factors. Infection of biotic stress level varied based on environment factors negatively affecting grain yield based on infection lev-

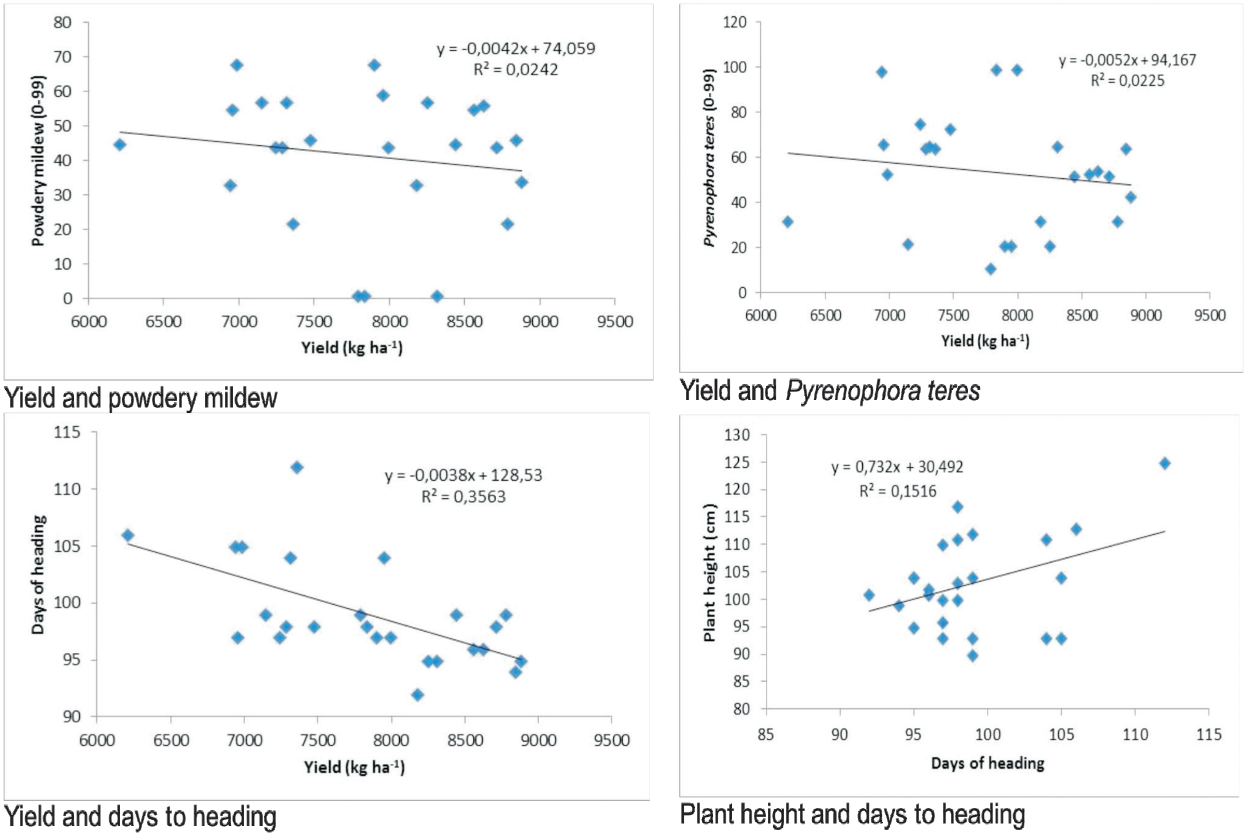

Figure 1. Relation between yield, leaf diseases and days to heading in Edirne location

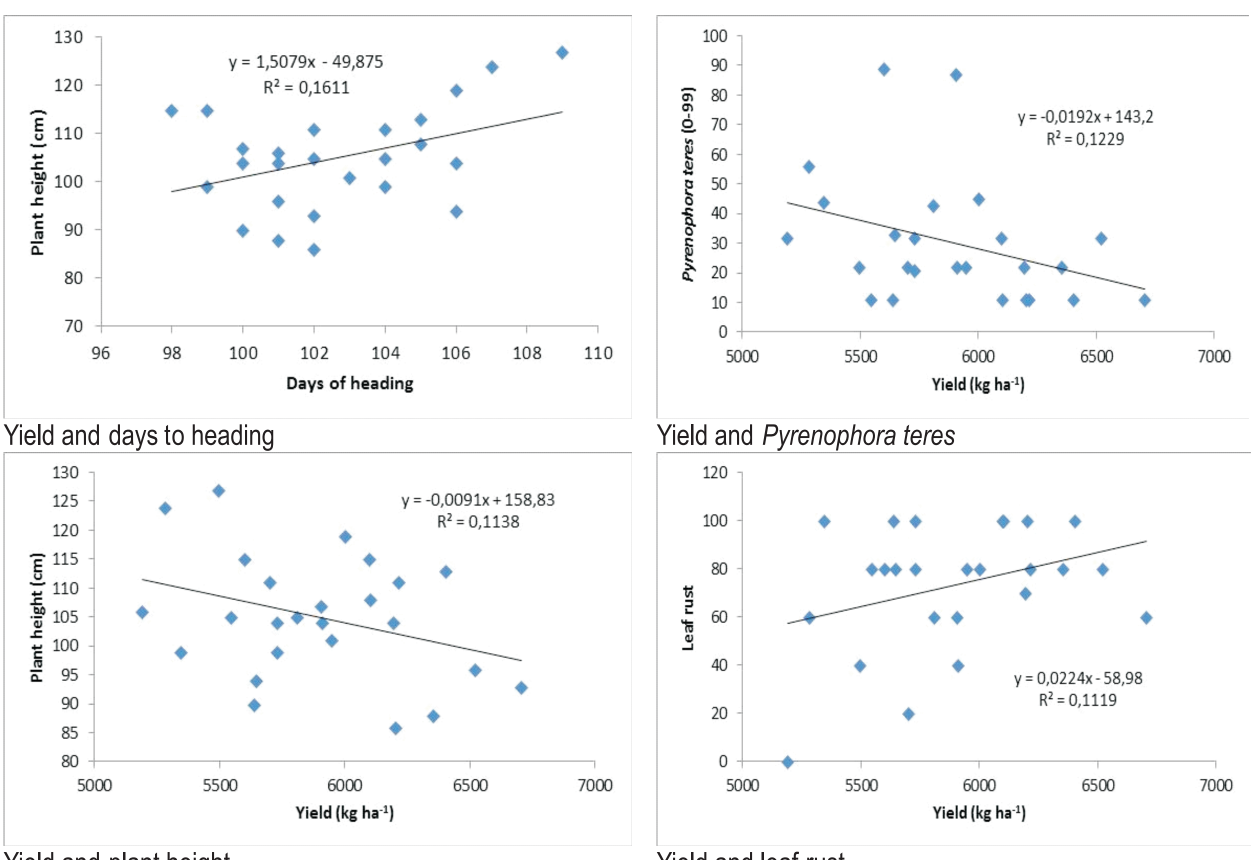

Figure 2. Relation between yield and leaf disease, days to heading, plant height in Tekirdağ location

Table 3. Correlation coefficient among the investigated parameters in Edirne location

Traits	GY	DH	PH	PYR	PM
DH	-0.597**				
PH	0.024	0.389			
PYR	-0.150	0.073	0.152		
PM	-0.155	0.032	-0.221	-0.200	
LR	0.402*	-0.233	-0.221	0.053	-0.041

Note: Significance levels $p<0.05$, $p<0.01$ by * and **, respectively. Grain yield (kg ha^{-1}), DH: Days to heading, PH: Plant height (cm), PM: Powdery mildew (0-99), LR: Leaf rust, PYR: Net blotch (0-99)

Table 4. Correlation coefficient among the investigated characters in Tekirdağ location

Traits	GY	DH	PH	PYR	PM
DH	-0.045				
PH	-0.337	0.401*			
PYR	-0.351	-0.256	0.341		
PM	-0.004	-0.423*	0.103	0.560**	
LR	0.335	-0.171	-0.293	-0.137	0.044

Note: *: $P<0.05$, **: $P<0.01$; GY: Grain yield (kg ha^{-1}), DH: Days to heading, PH: Plant height (cm), PM: Powdery mildew (0-99), LR: Leaf rust, PYR: Net blotch (0-99)

el of biotic stress factors. The overall evaluation showed that grain yield of genotypes in barley was affected by genotype, environment and its interaction. The highest yielding location was Edirne and the highest yielding genotype was TEA1619-11 line followed by TEA2311-19 and Harman genotypes. Genotypes response following exposure to biotic stress strongly depends on developmental stage and environmental condition. Infection of the net blotch was higher in Edirne location while leaf rust was higher in Tekirdağ location. Infection of the powdery mildew was almost similar at both locations. TEA1980-25 was tolerant to net blotch, leaf rust and powdery mildew. There was a slightly negative relationship between grain yield and powdery mildew and net blotch (*Pyrenophora teres* f. *teres*). Early types of genotypes had higher grain yield. Leaf rust in barley because of environment condition was not an important biotic stress factor in yield during this experiment at both locations.

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