EFFECT OF BIOMASS AT DIFFERENT GROWTH STAGES ON YIELD AND AGRONOMIC CHARACTERS IN BARLEY (*Hordeum vulgare* L.) CULTIVARS

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Abstract

*Grain yield in barley is a complex character depending on a large number of environmental, agronomical and physiological characters. This research was carried out in Edirne (Turkey) region during 2015-2016 and 2016-2017 growing years. Experiment was set up with 22 cultivars in randomized completely blocks with four replications. Grain yields, plant height, days of heading, biomass, 1000-kernel weight, test weight and protein ratio and relationship among these characters were investigated. According to the results significant differences among genotypes were found based on studied characters. The mean yield was 652.7 kg da^{-1} and Sitara and Asparuh had the highest grain yield with 697.1 and 694.1 kg da^{-1}, respectively. Analysis of the traits and genotypes showed varied correlations in the two growing environments. Grain yield was negatively correlated with days of heading (r= -0.549**), protein ratio (r= -0.575**), and plant height. Also, grain yield was positively correlated with peduncle length(r=0.549*), test weight (r=0.425*), and 1000-kernel weight. Protein ratio was positively correlated with days of heading (r=0.528**), and plant height (r=0.557**). There was negatively relationship between number of kernel in spike with protein ratio (r= -0.575**), and 1000-kernel weight (r= -0.617**). Generally, correlations between grain yield and investigated physiological parameters were low although a few were slightly significant. A negative correlation between grain yield and biomass constantly increased from GS25 up to GS40 growth stage. So, correlation coefficients between grain yield and biomass were at GS25 r=-0.300, at GS30 r=-0.300, and at GS49 r=-0.300*. This was probably because increased in rainfall and temperature between GS25 and GS49 and caused speed up the development of biotic stress factors which consequently resulted in reducing grain yield. Higher canopy temperature at GS55 and GS69 negatively affected and reduced grain yield. The chlorophyll content showed slightly positive correlations with yield. These results suggest that higher chlorophyll content during heading stage positively affected grain yield.*

Key words: *Barley, biomass, yield, physiological traits, agronomic characters*

1. INTRODUCTION

Barley (*Hordeum vulgare* L.) is the major cereal in many dry areas of the world and is vital for the livelihoods of many farmers. Barley is an annual cereal crop and grown in environments ranging from the desert of the Middle East to the high elevation of Himalayas (Hayes et al., 2003). The development of varieties, which can be adapted to a wide range of diversified environments, is the ultimate goal of the plant breeders in barley improvement program (Vulchev et al., 2013; Valcheva et al., 2009). 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). This might probably be due to differences in growing season rainfall, which has been known to have considerable impacts on barley grain yield. Moreover, the highly significant GE interaction for grain yield indicates that the studied genotypes exhibited both crossover and non-crossover types of the interaction (Dyulgerova and Dyulgerov. 2016). 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 plant's expressing its maximum genetic potential. Severe grain losses are often caused by high or low temperatures,

drought, anaerobiosis, and such soil anomalies as excess salt (Cattivelli et al. 2017.) Breeding for stress tolerance/resistance requires assessment of the differential sensibility of relevant genotypes. It is only when the response of a genotype to a given stress is known that more detail analyses of the underlying physiological and/or genetic mechanisms of adaptation to stress can be undertaken. However responses to abiotic stresses are more frequently quantitative than qualitative and, therefore, this task is not trivial. Stress characterization is often addressed as a particular case of genotype by environment interaction (Cooper and Hammer 1996, Annicchiarico 2002, Voltas et al. 2002, van Eeuwijk et al. 2005). Identification of tolerant and susceptible genotypes can also be based on physiological measures directly related to stress response. Several indices have been proposed to describe yield performance of a given genotype under stress and non-stress conditions or in comparison with the average yield or the yield of a superior genotype (Fischer and Maurer 1978; Lin and Binn 1988; Yadav and Bhatnagar 2001). A number of physiological studies have identified some traits for which presence/expression is associated with plant adaptability to drought prone environments. Among them, traits such as small plant size, reduced leaf area, early maturity and prolonged stomatal closure lead to a reduced total seasonal evapotranspiration, and to a reduced yield potential (Fischer and Wood 1979; Karamanos and Papatheohari 1999). Depending on the stress conditions (timing and intensity) of the target environments, some adaptive traits can be considered for yield improvement under drought if they enable plants to cope with a stress event that tends to occur every year at the same growth stage. For instance, a good level of earliness is an effective breeding strategy for enhancing yield stability in Mediterranean environments where wheat and barley are exposed to terminal drought stress nearly every year. In this condition shortening crop duration, a typical escape strategy, can be useful in synchronizing the crop cycle with the most favorable environmental conditions. However extreme earliness might also lead to yield penalty, with earliness not being correlated to grain yield in Mediterranean environments nor in fertile conditions. In environments characterized by terminal drought an improvement of the grain filling capacity can also be achieved by increasing the mobilization of the vegetative reserves from stems to ears (Blum 1988). Stem length 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). Earliness is favourable characters in barley due to early maturating cultivars less affected by the diseases and other environment factors, followed after harvesting farmers produces second crops in same growing season. Barley is an economically important growing crop in Trakya region (Turkey). The amount of the rainfall during growing season (October-June) is enough but the distribution of this rainfall is not regular and variation in weather condition in the regions causes some biotic and abiotic stress factors (Öztürk et al., 2014). In this study, grain yield and some yield components, some physiological characters and correlation among these traits were investigated over two various growing cycle.

2. MATERIALS AND METHODS

The research was carried out with 22 winter barley cultivars during 2015-2016 and 2016-2017 growing season at Trakya Agriculture Research Institute, Edirne Turkey. Genotypes were selected 13 of them from Institute of Karnobat, Bulgaria, 1 from Macedonia and 8 from Trakya Agriculture Research Institute, Edirne, Turkey. A randomized complete block design with four replications was used. Each plot had 6 meter long, 6 rows, spaced 0.17 meters apart. Sowings were performed by using a plot drill and a seed rate of 500 seeds m^2 and fertilizer 150 kg ha^{-1} N and 40 kg ha^{-1} P_2O_5 was used.

Table 1. Climate conditions in Edirne location in 2015-2016 and 2016-2017 growing year

Months	2015-2016 Rainfall (mm)	2016-2017 Rainfall (mm)	2015-2016 Max. temp	2016-2017 Max. temp	2015-2016 Moisture (%)	2016-2017 Moisture (%)
October	52.6	44.4	26.2	28.8	81.7	69.5
November	26.2	3.2	25.1	15.4	81.7	72.9
December	0.3	3.2	14.9	15.4	83.6	72.9
January	114.8	67.8	18.4	8.4	84.5	83.7
February	91.4	43.4	22.2	20.6	85.5	80.0
March	54.8	51.0	23.3	25.5	77.5	73.0
April	116.1	65.6	31.8	28.6	66.6	63.1
May	81.4	85.0	32.2	30.0	71.8	65.4
June	10.2	44.4	38.4	40.0	61.8	74.4
Total/Mean	547.8	408.0	25.8	23.6	77.2	72.8

Data recorded on grain yields, plant height, days of heading, biomass, flag leaf area, 1000-kernel weight, test weight and protein ratio and relationship among these characters were investigated. Some climatic data was given in Table 1. Data were analysed statistically for analysis of variance the method described by Gomez and Gomez (1984). The significance of differences among means was compared by using L.S.D (%5) test (Kalaycı, 2005).

3. RESULTS AND DISCUSSION

Grain yield is a complex character depending on a large number of environmental, agronomical and physiological characters. Due to various environmental conditions it was found significant differences among genotypes and years based on yield and other investigated parameters. Because of the various environment condition grain yield in 2015-2016 growing cycle was lower than in 2016-2017.

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 (Ashfaq et al., 2003). According to results there was highly significant difference in yield between years and among genotypes due to various environmental conditions. Averaged across years and cultivars, the overall mean grain yield was 652.7 kg da^{-1}. Because of the favourable environment condition the mean yield was higher in 2016-2017 (824.4 kg da^{-1}) growing cycle than 2015-2016 (481.0 kg da^{-1}). Sitara and Asparuh had the highest grain yield with 697.1 and 694.1 kg da^{-1}, respectively. Unsuitable environment condition resulted in a mean yield decrease of 41%, however maximum decrease in grain yield (56.25%) was observed in cultivar Hazar and minimum decrease in yield (17.44%) in Orfey cultivar. Overall evaluation yield of genotypes and location, grain yield in barley was affected from genetic and environmental factors. Change in yield had been varied depending on different environmental conditions agronomic traits of the genotypes.

Depending on the stress conditions of the target environments, some adaptive traits can be considered for yield improvement under drought if they enable plants to cope with a stress event that tends to occur every year at the same growth stage. For instance, a good level of earliness is an effective breeding strategy for enhancing yield stability in Mediterranean environments where wheat and barley are exposed to terminal drought stress nearly every year. In this condition shortening crop duration, a typical escape strategy, can be useful in synchronizing the crop cycle with the most favorable environmental conditions. However extreme earliness might also lead to yield penalty, with earliness not being correlated to grain yield in Mediterranean environments nor in fertile conditions (Blum 1988). In the study days to heading was significantly ($p<0.01$) affected by genotypes and environment

condition. Maximum days to heading (118 days) were recorded in Obzor followed by Kuber (117.5 days) and Orfey (117 days). Martı, Hit, and Harman were the very early cultivars with 102.8, 103.8, and 104.3 days, respectively. Due to negative interaction between yield and days to heading this results showed that early genotypes had higher yield potential in the study.

Table 2. Mean grain yield and losses of the yield in genotypes based on both years

Entry No	Cultivars	Growing year		Mean yield (kg da^{-1})	Yield Losses (%)
		2015-2016	2016-2017		
1	Obzor	422.9 fgh	694.4 g	558.6 f	38.03 c-f
2	Perun	466.8 d-g	767.7 d-g	617.2 cde	39.03 c-f
3	Emon	382.2 h	797.2 b-f	589.7 ef	51.95 ab
4	Lardeya	511.3b-e	851.0 a-e	681.1 ab	39.72 b-f
5	Orfey	589.8 a	717.3 fg	653.5 a-d	17.44 g
6	Zagorets	564.0 ab	786.2 c-f	675.1 ab	28.15 fg
7	Imeon	458.5 d-g	822.0 a-e	640.3 a-e	43.96 a-e
8	Asparuh	482.8 c-f	905.4 a	694.1 a	46.66 a-d
9	Kuber	494.2 b-f	786.3 c-f	640.3 a-e	36.83 def
10	Sayra	420.8 fgh	844.5 a-e	632.6 b-e	50.06 abc
11	Deviniya	440.1 e-h	764.5 efg	602.3 def	42.26 b-e
12	Odisey	552.7 abc	823.9 a-e	688.3 ab	32.78 ef
13	Sitara	526.9 a-d	867.4 abc	697.1 a	38.73 c-f
14	Hit	496.8 b-f	837.8 a-e	667.3 abc	39.53 b-f
15	Martı	504.4 b-e	797.7 b-f	651.0 a-d	36.08 def
16	Harman	463.1 d-g	879.7 ab	671.4 abc	47.32 a-d
17	Bolayır	499.8 b-e	858.0 abc	678.9 ab	41.43 b-e
18	Hasat	514.0 a-e	849.6 a-e	681.8 ab	39.78 b-f
19	ABVD16-2012	450.1 e-h	873.5 abc	661.8 abc	47.18 a-d
20	Hazar	395.0 gh	909.3 a	652.2 a-d	56.25 a
21	ABVD4-2014	483.5 c-f	854.1 a-d	668.8 abc	43.44 b-e
22	ABVD19-2014	461.8 d-g	851.4 a-e	656.6 a-d	45.12 a-e
Mean (kg da^{-1})		481.0	824.4	652.7	41.0
C.V (%)		11.1	7.9	8.9	21.8
L.S.D: (0.05)		75.7**	87.9**	57.4**	12.6**

Reducing plant height has played an important role in improving crop yields. The success of a breeding program relies on the source of dwarfing genes. For a dwarfing or semi-dwarfing gene to be successfully used in a breeding program, the gene should have minimal negative effects on yield and perform consistently in different environments (Wang et al. 2014). Stem length 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). Our results indicated that taller plants (105.8 cm) were produced by variety Orfey and followed by Lardeya (105.0 cm). The mean plant height was 99.9 cm. Short plant was obtained in ABVD4-2014 (91.3 cm) and Hazar (92.5 cm) genotypes.

Significant (p<0.01) differences were observed in peduncle length and spike length in genotypes. The longest peduncle (28.73 cm) was measured in Martı followed by ABVD16-22 and Odisey, while short peduncle measured in Kuber and Obzor. Cultivars Imeon, Odisey, and Deviniya had the longest and Harman, Martı and Hazar shortest spike length.

Table 3. Mean physiological characters of the genotypes

Entry No	Cultivars	DH	PH	PL	SPL	FLA	SPAD GS55
1	Obzor	118.0 a	102.0 a-e	20.66 gh	6.11 e-h	6.99 c-f	50.60 c-g
2	Perun	115.8 a-d	103.0 a-d	22.96 d-h	7.04 b-e	6.04 d-g	48.20 e-h
3	Emon	114.3 cde	104.0 abc	21.96 e-h	6.16 d-h	8.63 b	53.63 abc
4	Lardeya	113.5 de	105.0 ab	23.74 def	6.31 c-g	4.94 gh	48.65 e-h
5	Orfey	117.0 ab	105.8 a	21.32 fgh	7.19 abc	6.87 c-f	49.98 d-g
6	Zagorets	116.0 a-d	99.5 b-e	21.24 fgh	7.11 a-d	4.48 h	48.20 e-h
7	Imeon	116.8 abc	97.8 def	20.38 h	8.05 a	5.60 fgh	51.10 b-f
8	Asparuh	116.3 abc	96.3 efg	24.18 cde	7.58 ab	6.36 c-g	47.58 fgh
9	Kuber	117.5 ab	99.0 cde	20.41 h	7.54 ab	5.13 gh	46.35 h
10	Sayra	113.0 e	99.0 cde	23.19 d-g	6.19 d-h	7.18 cde	51.55 b-e
11	Deviniya	116.5 abc	96.5 efg	22.03 e-h	7.57 ab	7.22 b-e	49.10 e-h
12	Odisey	115.0 b-e	102.8 a-d	26.77 ab	7.64 ab	6.07 c-g	49.13 e-h
13	Sitara	109.5 f	104.0 abc	23.67 def	6.08 e-h	5.92 e-h	47.43 gh
14	Hit	103.8 jk	101.0 a-e	23.52 def	7.11 a-d	7.18 cde	50.10 c-g
15	Martı	102.8 k	99.5 b-e	28.73 a	5.40 gh	10.36 a	52.90 a-d
16	Harman	104.3 ıjk	100.0 a-e	25.25 bcd	5.32 h	7.24 b-e	55.23 a
17	Bolayır	106.8 ghı	96.5 efg	25.34 bcd	6.01 fgh	7.25 b-e	53.08 a-d
18	Hasat	106.8 ghı	99.8 b-e	26.49 abc	6.24 c-h	6.71 c-f	54.45 ab
19	ABVD16-2012	107.0 fgh	99.3 b-e	26.86 ab	6.97 b-f	7.03 c-f	55.80 a
20	Hazar	109.3 fg	92.5 fg	21.98 e-h	5.46 gh	6.61 c-f	53.20 a-d
21	ABVD4-2014	106.3 hıj	91.3 g	24.65 bcd	5.81 gh	7.51 bc	54.33 ab
22	ABVD19-2014	108.0 fgh	104.0 abc	25.13 bcd	6.08 e-h	7.36 bcd	55.85 a
Mean		111,5	99.9	23.6	6.58	6.76	51.2
L.S.D. (0.05)		1.6**	4.1**	7.7**	10.4**	1.43**	4.8**
C.V. (%)		2.6	5.8	2.6	1.0	14.7	3.52

Note: *: P<0.05, **: P<0.01; DH. Days to heading, PH: Plant height (cm), PL: Peduncle length (cm), SPL: Spike length (cm), FLA: Flag leaf area (cm^2), SPAD: Chlorophyll content, GS: Growth stage

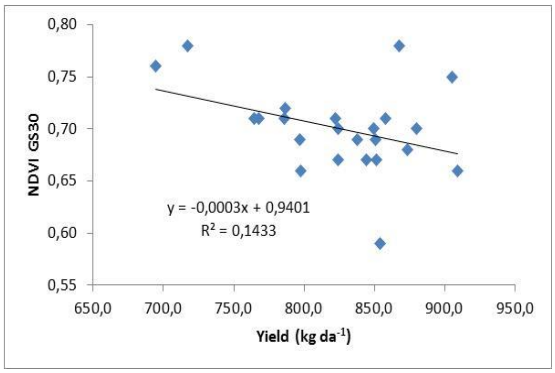
Related barley (*Hordeum vulgare* L.) lines, with small and large leaf areas were developed and used to study the effect of leaf area on photosynthesis, light penetration, and grain yield. In yield trials large leaf lines exceeded small leaf lines in flag leaf area by 70% and in LAI by 25%. Lines with small leaves produced more heads and higher grain yields than lines with large leaves when plants did not lodge. Where lodging occurred, however, large leaf lines had higher kernel weights and were higher yielding (Berdahl et al. 1971). In the study significant (p<0.01) differences were observed in flag leaf area in genotypes. Martı had the largest flag leaf area (10.36 cm^2) and followed by Emon (8.63 cm^2) cultivar.

Biomass (NDVI) was taken at five times from GS25 up to GS85 plant growth stages and NDVI gradually increased from GS25 up to GS55 and then decreased. NDVI is a good indicator of biomass and yield. Biomass had more effect on grain yield at GS85 growth stages than other stages. The higher NDVI was scaled at GS25 and GS30 in Sitara, at GS40 in Orfey, at GS55 in Bolayır and at GS85 in Sayra cultivars. Increasing in biomass in genotypes promoted and accelerated infection of biotic stress factors so this negatively affected and led to decreasing in grain yield. Canopy temperature was taken two different growth stages in genotypes at GS 55 and GS69. There were not significant differences among genotypes but canopy temperature negatively affected grain yield. The mean CT was 30.1 ^{o}C at GS55 and 20.1 ^{o}C at GS69 growth stages.

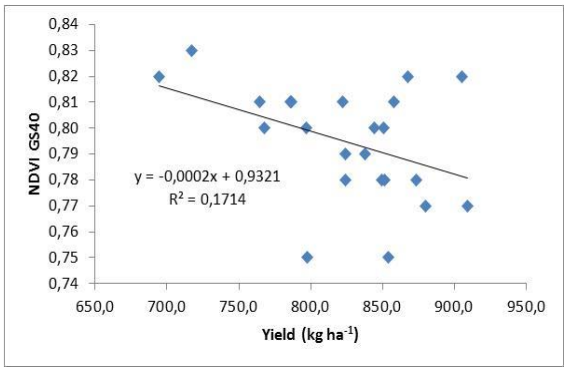
Table 4. Mean grain yield and yield losses of the cultivars in 2016-2017 cycle

Entry No	Cultivars	GS25 NDVI	GS30 NDVI	GS40 NDVI	GS55 NDVI	GS85 NDVI	GS55CT	GS69CT
1	Obzor	0.72 abc	0.76 a	0.82 a	0.81 ab	0.53 b-e	29.85 abc	20.23 a
2	Perun	0.69 a-d	0.71 ab	0.80 ab	0.81 ab	0.54 b-e	30.33 abc	20.50 a
3	Emon	0.68 a-d	0.69 ab	0.80 ab	0.81 ab	0.50 c-f	30.28 abc	20.23 a
4	Lardeya	0.68 a-d	0.69 ab	0.80 ab	0.81 ab	0.58 a-d	30.13 abc	19.58 a
5	Orfey	0.75 ab	0.78 a	0.83 a	0.81 ab	0.59 a-d	30.10 abc	20.68 a
6	Zagorets	0.72 abc	0.71 ab	0.81 ab	0.81 ab	0.62 abc	30.58 ab	19.50 a
7	Imeon	0.71 abc	0.71 ab	0.81 ab	0.80 ab	0.58 a-d	30.30 abc	19.90 a
8	Asparuh	0.73 abc	0.75 a	0.82 ab	0.82 ab	0.61 abc	29.93 abc	20.23 a
9	Kuber	0.68 a-d	0.72 ab	0.81 ab	0.81 ab	0.64 ab	30.18 abc	20.55 a
10	Sayra	0.66 a-d	0.67 ab	0.80 ab	0.81 ab	0.67 a	30.20 abc	19.38 a
11	Deviniya	0.68 a-d	0.71 ab	0.81 ab	0.81 ab	0.59 a-d	29.95 abc	20.10 a
12	Odisey	0.67 a-d	0.67 ab	0.78 ab	0.80 ab	0.65 ab	29.88 abc	19.83 a
13	Sitara	0.76 a	0.78 a	0.82 ab	0.80 ab	0.58 a-d	30.13 abc	20.20 a
14	Hit	0.67 a-d	0.69 ab	0.79 ab	0.81 ab	0.53 b-e	29.40 c	20.25 a
15	Martı	0.62 cd	0.66 ab	0.75 b	0.80 ab	0.39 f	30.33 abc	19.75 a
16	Harman	0.68 a-d	0.70 ab	0.77 ab	0.82 ab	0.39 f	30.73 a	20.48 a
17	Bolayır	0.67 a-d	0.71 ab	0.81 ab	0.83 a	0.43 ef	29.83 abc	21.08 a
18	Hasat	0.66 a-d	0.70 ab	0.78 ab	0.80 ab	0.43 ef	29.48 bc	19.83 a
19	ABVD16-2012	0.65 a-d	0.68 ab	0.78 ab	0.80 ab	0.44 ef	30.13 abc	19.98 a
20	Hazar	0.66 a-d	0.66 ab	0.77 ab	0.80 ab	0.58 a-d	29.50 bc	19.68 a
21	ABVD4-2014	0.58 d	0.59 b	0.75 b	0.79 b	0.42 ef	30.35 abc	20.63 a
22	ABVD19-2014	0.63 bcd	0.67 ab	0.78 ab	0.79 b	0.48 def	30.43 abc	19.38 a
Mean		0.68	0.70	0.79	0.81	0.53	30.1	20.1
L.S.D. (0.05)		12.6	13.7	5.7	2.5	16.1**	2.6	6.5
C.V. (%)		0.12	0.13	0.065	0.027	0.12	1.12	1.84

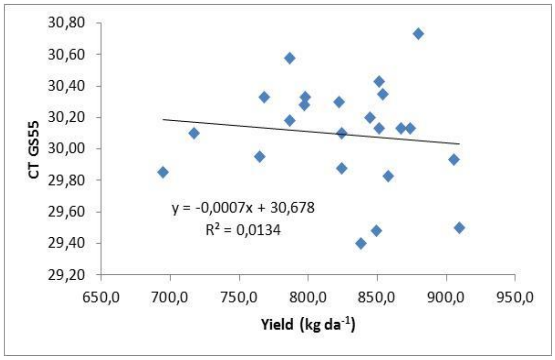
Note: *: P<0.05, **: P<0.01; NDVI: Normalized different vegetative index, CT: Canopy temperature (^{o}C), GS: Growth stage



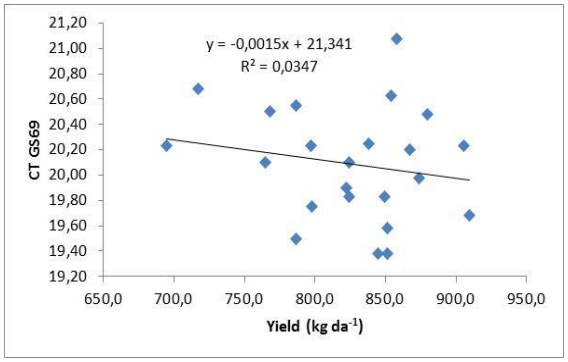
NDVI GS30 and grain yield in 2016-2017



NDVI GS40 and grain yield in 2016-2017



CT GS55 and grain yield in 2016-2017

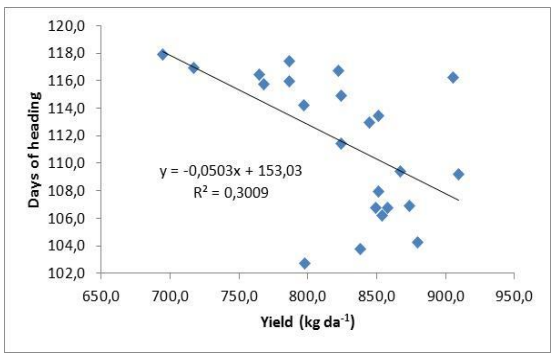


CT GS69 and grain yield in 2016-2017

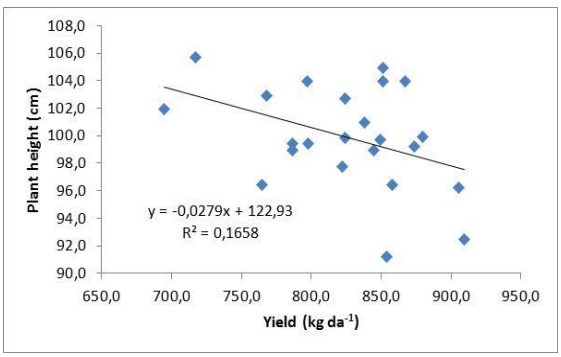
Fig. 1. Relation between yield with biomass at GS30 and GS40 and canopy temperature at GS55 and GS69

In grain yield slightly inverse correlations were found for the biomass during tillering (GS30 and GS40). So, there was a slightly negative relationship between grain yield and biomass at GS30 (R^2=0.143) and GS40 (R^2=0.171). Canopy temperature during GS55 and GS69 had slightly negative relation with gran yield in barley genotypes (Figure 1).

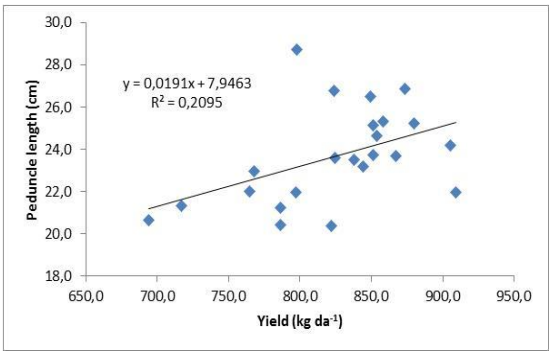
There was a negative relation between grain yield and days of heading (R^2=0.300) and plant height (R^2=0.165). These result showed that genotypes which have short plant height had higher grain yield (Figure 2). The peduncle length and chlorophyll content showed slightly and significant effect compared to the grain yield. It is apparent that peduncle length (R^2=0.209) and chlorophyll content at GS55 had the slightly significant effect on grain yield in barley genotypes (Figure 2).



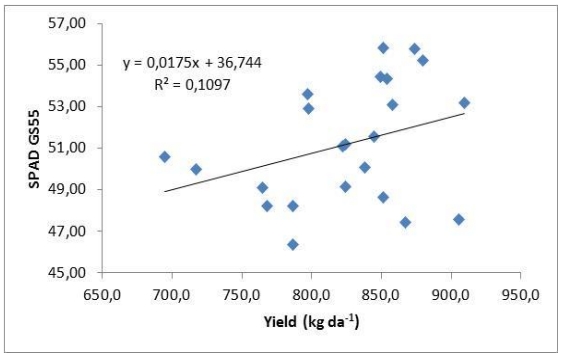
Days of heading and grain yield in 2016-2017



Plant height and grain yield in 2016-2017



Peduncle length and grain yield in 2016-2017



SPAD GS55 and grain yield in 2016-2017

Fig. 2. Relation between yield and days of heading, plant height, peduncle length and chlorophyll content at GS55

Results of the correlation analysis between yield and other parameters were listed in Table 5 and 6. Correlations among characters were evaluated for genotypes included in the study. Grain yield was negatively correlated with days of heading (r= -0.549**), protein ratio (r= -0.575**), and plant height (r= -0.407). Also, grain yield was positively correlated with peduncle length(r=0.549*), test weight (r=0.425*), and 1000-kernel weight (r=0.245). Protein ratio was positively correlated with days of heading (r=0.528**), and plant height (r=0.557**). There was negatively relation between number of kernel in spike and protein ratio (r= -0.575**), and 1000-kernel weight (r= -0.617**).

Generally, correlations between grain yield and investigated physiological parameters were low although a few were slightly significant. A negative correlation between grain yield and biomass constantly increased from GS25 up to GS40. That is why, correlation coefficients between grain yield and biomass were r=-0.300 at GS 25, r=-0.300 at GS30, and r=-0.300* at GS49. Higher canopy temperature at GS55 and at GS69 negatively affected and reduced grain yield and there was negatively slightly correlation between grain yield and GS55 and GS69.

Table 5. Correlation coefficient among investigated parameters

Traits	GY	DH	PH	PL	SPL	NKS	TKW	TW
DH	-0.549**							
PH	-0.407	0.217						
PL	0.458*	-0.722	-0.026					
SPL	-0.279	0.646**	0.103	-0.375				
NKS	0.030	-0.036	-0.291	-0.021	-0.213			
TKW	0.245	-0.237	0.138	0.476*	0.025	-0.617**		
TW	0.425*	-0.267	-0.169	-0.044	-0.006	-0.393	0.363	
PRT	-0.575**	0.528**	0.557**	-0.218	0.380	-0.570**	0.254	-0.108

Note: *: P<0.05, **: P<0.01; GY: Grain yield (kg da^{-1}), DH. Days to heading, PH: Plant height (cm), PL: Peduncle length (cm), SPL: Spike length (cm), NKS: Number of kernel in spike, TKW: 1000-kernel weight (g), TW: Test weight (kg), PRT: Protein ratio (%)

Table 6. Correlation coefficient among investigated parameters in 2016-2017 growing cycle

Traits	GY	GS25 NDVI	GS30 NDVI	GS40 NDVI	GS55 NDVI	GS85 NDVI	GS55 SPAD	GS55 CT
GS25 NDVI	-0.300							
GS30 NDVI	-0.379	0.931**						
GS40 NDVI	-0.414*	0.863**	0.855**					
GS55 NDVI	-0.074	0.430*	0.461*	0.500*				
GS85 NDVI	-0.191	0.524*	0.345	0.600**	0.088			
GS55 SPAD	0.331	-0.631**	-0.541**	-0.646**	-0.289	-0.761**		
GS55 CT	-0.116	-0.035	-0.095	-0.085	-0.051	-0.128	0.081	
GS69 CT	-0.186	0.154	0.275	0.224	0.477*	-0.276	-0.092	-0.048

Note: *: P<0.05, **: P<0.01; GY: Grain yield (kg da^{-1}), NDVI: Biomass, GS: Growth stage, SPAD: Chlorophyll content, CT: Canopy temperature (^oC)

4. CONCLUSION

Grain yield in barley is a complex character depending on a large number of environmental, agronomical and physiological characters. According to the results significant differences among genotypes were found based on studied characters. Sitara and Asparuh had the highest grain yield. Correlations among characters were evaluated for genotypes included in this study. Grain yield was negatively correlated with days of heading, protein ratio, and plant height. Also, grain yield was positively correlated with peduncle length, test weight, and 1000-kernel weight. Protein ratio was positively correlated with days of heading, and plant height. There was negatively relationship between number of kernel in spike with protein ratio, and 1000-kernel weight. Generally, correlations between grain yield and investigated physiological parameters were low although a few were slightly significant. A negative correlation between grain yield and biomass constantly increased from GS25 up to GS40 growth stage. This was probably because increased in rainfall and temperature between GS25 and GS49 and caused speed up the development of biotic stress factors which consequently resulted in reducing grain yield. Higher canopy temperature at GS55 and at GS69 negatively affected and reduced grain yield and it was found negatively slightly correlation. These results suggest that higher chlorophyll content during heading stage positively affected grain yield and higher biomass negatively affected grain yield.

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