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Determination of Vernalization Responses in Some Winter Wheat Varieties Grown in Temperate Regions

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Abstract: This research was conducted in order to determine the vernalization periods of some winter wheat varieties improved and grown widely on transition regions of Turkey and having vernalization problems on some parts of these regions in some years. The research was carried out in outdoor conditions of Department of Field Crops, Faculty of Agriculture, Uludag University in Bursa. Bezostaja-1, Marmara-86 and Pehlivan varieties of winter wheat were used as plant material in the experiment. Seeds of the varieties were exposed to five vernalization periods (V_0 , V_{14} , V_{28} , V_{42} and V_{56} days). After vernalization, seeds were sown into pots on March 15 in each experiment year. In the experiment, parameters such as phyllochron, heading period and grain weight/spike were determined. According to the two-year results, V_0 (control) and V_{14} did not affect the parameters (except phyllochron) in Bezostaja-1 and Pehlivan varieties. On the other hand, V_0 did not have effect on the parameters (except phyllochron) of Marmara-86 variety. Varieties indicated differences in terms of the parameters determined in the experiment. The longer the vernalization period was, the shorter the phyllochron period and the heading period. In this study, grain weight/spike was used as criterion for determination of vernalization requirements of cultivars since this component is one of the most important components related to the seed yield. As a result, it was determined that Marmara-86 was less sensitive to cold treatment than other varieties and its proper vernalization requirement was 28 days (V_{28}). The most suitable vernalization period for Bezostaja-1 and Pehlivan was found to be 42 days (V_{42}). Attention must be paid when these cultivars are intended to be grown on cooler or warmer areas within or out of the transition regions.

Key words: Phyllochron, heading period, grain weight

INTRODUCTION

Vernalization, a requirement for plants to experience a period of cool conditions to accelerate flowering, is an important determinant of flowering date in winter wheat (Brooking and Jamieson, 2002). It is a well-known fact that vernalization influences the vegetative period in plant, spike emergence and the formation of basic agronomic characteristics (Cao and Moss, 1991; Slafer, 1996), yet wheat varieties have different vernalization requirements (Natrova and Natr, 1991; Rawson *et al.*, 1998). It has been reported in many studies that optimum vernalization period must be 50 days even between 50-90 days (González *et al.*, 2002) and the efficient vernalization temperature must be 2-10°C (Rawson *et al.*, 1998; Porter and Gawit, 1999).

Knowledge of the phyllochron for crop species is useful in formulating simulation models and for tracking plant development to determine when to apply management practices that depend on crop development stage. The effect of environmental changes on the rate of leaf emergence in wheat must be understood to make the accurate predictions of the cropping technologies. The

phyllochron of plants is strongly related to air temperature (Bauer *et al.*, 1984; Petroczi and Matuz, 2002). Other environmental factors such as daylength, water stress, carbohydrate reserves and nutrient stress have little effect on phyllochron (Petroczi and Matuz, 2002). While some researchers reported that the number of leaves in plants increased and there was a better development in leaves after vernalization (Kirby, 1992), some others said no difference was observed in phyllochron and leaf number of either vernalized or unvernallized wheat (Cao and Moss, 1991) and even vernalization decreased the phyllochron number in plant and leaf number on the main stem (Wang *et al.*, 1996).

It was reported that vernalization fastens early heading in wheat and makes it possible to obtain larger and full spikes prolonging the spike emergence period (Slafer and Rawson, 1994; Ortiz *et al.*, 1995).

Therefore, this research was conducted in order to determine the vernalization periods of some winter wheat varieties grown widely on transition regions of Turkey and having some vernalization problems in these regions in some years.

MATERIALS AND METHODS

The research was conducted in the experimental field of Department of Field Crops, Faculty of Agriculture, Uludag University in Bursa in 2001-2002. Bursa (40.2°N, 29.1°E) is located in the Southwest of Marmara Region in Türkiye. Bursa generally has a temperate climate.

In this experiment Bezostaja-1, Pehlivan and Marmara-86 varieties were used as plant materials.

The experiment was set up on outdoor place by using randomized complete block design (RCBD) with three replications. In the experiment five different vernalization periods (as day) V_0 , V_{14} , V_{28} , V_{42} and V_{56} were used as a variable factor. To activate the seeds physiologically before vernalization the seeds were soaked into sterile water for two days. For vernalization, 20 seeds of each variety were placed into Petri plates of 15 cm diameter including 3 mm sterile filter papers which were cutting fitting Petri plates. Before placing seeds, filter papers were saturated with sterile water in order to meet the moisture requirements of the seeds.

Vernalization was done at 4°C temperature. Vernalization periods were arranged in such a way that all the vernalized seeds might be sown at the same time (March 15 of each experimental year). The most important reason for determining March 15 as the sowing date is that the weather temperature isn't below 10°C after this date and there is no possible vernalization threat of natural conditions. After vernalization treatments were completed, ten seeds of each treatment were transferred into the pots of 20 cm diameter and 30 cm height including 5 kg soil with 25% clay content. After germination, the plants were thinned to leave five plants in each pot. After this, all kind of the plant protection precautions were taken throughout the experiment.

Statistical calculations were performed according to ANOVA analysis in MINITAB and the differences between the means were compared with LSD (Least Significant Differences) at a 5% level of significance according to MSTATC. Since Phyllochron period of each variety was positively affected from all of the vernalization periods, all the varieties were compared with each other.

Average photoperiod, average temperature and total temperature values recorded considering the sunny days in each month during plant growth period were given in Table 1.

RESULTS AND DISCUSSION

There were differences in the response of varieties to vernalization periods in respect to the other parameters examined. As the responses of Bezostaja-1 and Pehlivan

Table 1: Average and total temperature per months and total photoperiods recorded for sunny days in the experimental environment

Month	2001		2002	
	Average	Total	Average	Total
March	14°C 200 h 33 m	168°C	12°C 186 h 25 m	160°C
April	14°C 169 h 36 m	308°C	15°C 173 h 40 m	330°C
May	17°C 307 h 34 m	408°C	17°C 310 h 05 m	412°C
June	24°C 354 h 10 m	600°C	23°C 351 h 43 m	550°C
July	28°C 373 h 24 m	780°C	28°C 374 h 23 m	816°C
Total	1404 h 37 m/2264°C		1395 h 36 m/2268°C	
Average	281 h 11 m/452.8°C		279 h 08 m/453.6°C	

Table 2: Phyllochron values of wheat varieties in experimental years (days)

Varieties	Years	
	2001	2002
Bezostaja-1	4.04a**	4.18a**
Pehlivan	4.14a**	4.07a**
Marmara-86	3.38b**	3.35b**

Table 3: The Effects of vernalization periods on phyllochron period (days)

Vernalization period	Years	
	2001	2002
V_0	5.25a**	5.41a**
V_{14}	4.32b**	4.06b**
V_{28}	3.83c**	3.54c**
V_{42}	3.31d**	3.17d**
V_{56}	2.55e**	3.14d**

**p<0.01, values with different letter (s) are significantly different at p<0.05 level

were the same, they were evaluated in themselves. On the other hand, the data of Marmara-86 were evaluated by itself.

Phyllochron period: Phyllochron periods of cultivars were significantly different from each other in 2001-2002. The Phyllochron periods of Bezostaja-1 and Pehlivan were the same and higher than that of Marmara-86 variety (Table 2).

The effect of vernalization periods was found to be statistically significant in both years. It was observed that when vernalization periods increase the phyllochron periods decreases. Thus, the longest phyllochron period was observed in plants of the seeds exposed to V_0 treatment and the shortest phyllochron period in plants of those exposed to V_{56} treatment (Table 3).

Heading period: In both years of the research, significant differences were observed among the heading periods of the cultivars. The heading period of Marmara-86 was the shortest and it was followed by Pehlivan and Bezostaja-1 respectively in an increasing trend (Table 4). Responses of cultivars to vernalization periods were found significant

Table 4: Heading periods of the cultivars in the 2 years (days)

Varieties	Years	
	2001	2002
Bezostaja-1	69.22a**	69.66a**
Pehlivan	67.00b**	66.22b**
Marmara-86	53.91ns	54.16ns

**p<0.01, ns: non significance, values with different letter (s) are significantly different at p<0.05 level

Table 5: The effect of vernalization periods on heading period (days)

Vernalization period	Years		Years	
	(Bezostaja-1 and Pehlivan-79)		(Marmara-86)	
	2001	2002	2001	2002
V ₁₄	-	-	61.33a**	61.60a**
V ₂₈	75.16a**	74.50a**	55.66b**	55.67b**
V ₄₂	67.16b**	67.83b**	51.60c**	51.63c**
V ₅₆	62.00c**	61.50c**	47.00d**	47.66d**

**p<0.01, values with different letter (s) are significantly different at p<0.05 level

Table 6: Grain weight per spike of wheat varieties in experimental years (gr)

Varieties	Years	
	2001	2002
Bezostaja-1	0.59b*	0.64b*
Pehlivan	0.64a*	0.68a*
Marmara-86	0.55ns	0.60ns

**p<0.05, ns: non significant

Table 7: The effects of vernalization periods on grain weight per spike of wheat varieties (g)

Vernalization period	Varieties			
	(Bezostaja-1 & Pehlivan-79)		(Marmara-86)	
	2001	2002	2001	2002
V ₁₄	-	-	0.31b**	0.44b*
V ₂₈	0.54b**	0.61b**	0.60a**	0.63a*
V ₄₂	0.66a**	0.65a**	0.60a**	0.65a*
V ₅₆	0.64a**	0.68a**	0.63a**	0.65a*

*p<0.05, **p<0.01, values with different letter (s) are significantly different at p<0.05 level

with respect to heading period. Responses of Bezostaja-1 and Pehlivan to vernalization periods were in the same trend and they were not affected from a two week vernalization treatment (V₁₄). Accordingly, it was possible to compare them statistically with each other. Marmara-86 was affected from all of the vernalization periods. In general, as the vernalization period lengthened the heading period shortened in all of the cultivars in both years (Table 5). As a result, the shortest vernalization period was V₁₄ for Marmara-86 and V₂₈ for Bezostaja-1 and Pehlivan, while the longest heading periods for cultivars occurred at the shortest vernalization periods, respectively.

Grain weight/spike: There were significant differences in grain weight/spike of cultivars in the experimental years. The grain weight/spike of Pehlivan was higher than that

of Bezostaja-1 when compared statistically and higher than that of Marmara-86 when compared numerically (Table 6).

In both year, all of the vernalization periods significantly affected the grain weight/spike of cultivars. In Bezostaja-1 and Pehlivan, the two week period (V₁₄) did not have any effect on grain weight/spike. The highest grain weight/spike was produced at 42-day vernalization period in Bezostaja-1 and Pehlivan which at this point cultivars were cold saturated (Table 7). Besides, Marmara-86 was cold saturated at 28-day vernalization treatment. In each cultivar after saturation point, excess vernalization did not have any effect on grain weight/spike.

Every one of the cultivars produced normal leaf and developed vegetatively under unvernaliaed (V₀) condition. Thus, under unvernaliaed (V₀) conditions, we were able to determine the phyllochron periods of the cultivars in each experimental year. However, there were no positive responses determined in reproductive parameters of cultivars under unvernaliaed conditions.

Influence of vernalization treatments had different reflections on the parameters of the varieties used in this experiment. Indeed, while the influence of the shortest vernalization period (V₁₄) on Marmara-86 was found significant, it was ineffective when Bezostaja-1 and Pehlivan were concerned. This indicates that Marmara-86 is less sensitive to cold treatments than Bezostaja-1 and Pehlivan. Under the light of this result, it might be suggested to be careful when Bezostaja-1 and Pehlivan are cultivated in temperate and hot climates due to their longer period of vernalization treatment. Mahfoozi *et al.* (2001) reported more or less the similar results and conclusions in their studies.

There were significant differences among heading periods of cultivars. It is thought that these results might be occurred from genotypes of cultivars. In terms of the effects of vernalization periods on heading periods of varieties, Bezostaja-1 and Pehlivan were affected from three applications (V₂₈, V₄₂, V₅₆) out of four vernalization periods, but Marmara-86 was also affected from all four vernalization periods (V₁₄, V₅₆). Within the affected limits, while the vernalization period becomes shorter, the heading periods of cultivars become longer. As a general rule, early heading appeared at long vernalization periods. Ernalization fastens early heading in wheat and makes the spike emergence period longer reported by Slafer and Rawson (1994) and Ortiz *et al.* (1995).

Phyllochron periods of Bezostaja-1 and Pehlivan were similar but they were longer than that of Marmara-86. This result leads us to conclude that phyllochron periods of varieties might depend on genotype as well as environmental conditions.

Vernalization requirement for point of saturation of each cultivar was determined according to the vernalization period in which the heavier grain weight of each spike was first obtained. The vernalization requirement of Bezostaja-1 and Pehlivan was determined to be 42 days and that of Marmara-86 to be 28 days. Therefore, the first two cultivars, Bezostaja-1 and Pehlivan, are classified as winter type cultivars, the latter as semi-winter type wheat cultivar. Present results were in agreement with the results of some researchers (Ekinici and Terzioglu, 1998).

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