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Research Article

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Abstract: The interactive effects of vernalization, day length and light intensity on the number of leaves and flag leaf area on the main shoot of five bread wheat (*Triticum aestivum* L.) cultivars (Çukurova-86, Atay-85, Lancer, Haymana-79 and Bezostaya-1) each with different biological characters, were investigated. The research was carried out in four independent experiments which were the combinations of two different day lengths (14 and 18 hour day^{-1}) and light intensities (13500 and 33750 lux) and vernalization periods. Vernalization treatment was applied for 0, 15, 30, 45 and 60 days at 2±1°C in a dark, cold room at 80% humidity and also 90 days only in the 14 hour and 13500 lux experiment. In the experiments, leaf emergence was completed in control and treated Çukurova-86 and Atay-85 and in Lancer, Haymana-79 and Bezostaya-1 after 30, 45 and 60 day vernalization treatments. The minimum leaf number was obtained with 14 hour and 13500 lux treatments. 13500 lux accelerated the transition of the apex from the vegetative to the reproductive stage through an effect probably similar to that of vernalization, only with 14 hour days. The maximum leaf number was obtained with 14 hour day and 33750 lux treatments. The number of leaves and flag area were lower due to the increase in vernalization periods in the spring cultivar and vernalized winter cultivars.

Key Words: Wheat, vernalization, day length, light intensity, leaf number, flag leaf area.

Bazı Buğday Çeşitlerinin Yaprak Sayısı ve Bayrak Yaprak Alanı Üzerine Vernalizasyon, Gün Uzunluğu ve Işık Şiddetinin Birlikte Etkileri

Özet: Farklı biyolojik karakterlerdeki beş buğday (*Triticum aestivum* L.) çeşitlerinin (Çukurova-86, Atay-85, Lancer, Haymana-79 ve Bezostaya-1) ana sap yaprak sayısı ve bayrak yaprak alanı üzerine vernalizasyon, gün uzunluğu ve ışık şiddetinin birlikte etkileri incelenmiştir. Bu araştırma iki farklı gün uzunluğu (14 ve 18 saat gün^{-1}) ve ışık şiddetinin (13500 ve 33750 lüks) kombinasyonlarından oluşan dört bağımsız deneme ve vernalizasyon sürelerinde gerçekleştirilmiştir. Vernalizasyon işlemi 2±1°C'deki karanlık soğuk odada, %80 nemde 0, 15, 30, 45 ve 60 günde, ayrıca yalnız 14 saat gün uzunluğu ve 13500 lüks ışık şiddetinde 90 günde de gerçekleştirilmiştir. Denemelerde, Çukurova-86 ve Atay-85'de kontrol ve tüm vernalizasyon uygulamalarında, Lancer, Haymana-79 ve Bezostaya-1'de ise 30, 45 ve 60 gün vernalizasyon uygulamalarında yaprak çıkışı tamamlanmıştır. En az yaprak sayısı, 14 saat gün uzunluğu ve 13500 lüks ışık şiddeti uygulamasında belirlenmiştir. On dört saat gün uzunluğu ve 13500 lüks ışık şiddeti muhtemelen vernalizasyonun etkisine benzer bir etki ile vegetatif evreden reprodüktif evreye geçişi hızlandırmıştır. En fazla yaprak sayısı 14 saat gün uzunluğu ve 33750 lüks ışık şiddeti uygulamasında elde edilmiştir. Yazlık çeşitte ve vernalize olmuş kışlık çeşitlerde vernalizasyon süresinin artmasına bağlı olarak yaprak sayısı ve bayrak yaprak alanı azalmıştır.

Anahtar Sözcükler: Buğday, vernalizasyon, gün uzunluğu, ışık şiddeti, yaprak sayısı, bayrak yaprak alanı.

Introduction

The term vernalization (low temperature induction) is best restricted to the specific promotion of flowering by a cold treatment given to the imbibed seed or young plant. For each plant the most suitable vernalization period must be determined separately. The effect of vernalization increases with the duration of exposure until the response is saturated at a duration which varies widely between species and cultivars (<10 to >100 days) (1). In cereal crops vernalization can be achieved by exposing imbibed grains or growing plants to temperatures of 0 to 3°C for winter wheat and 8 to 15 °C for early spring wheat (2, 3).

It is well known that the final leaf number is influenced by genotype, light intensity and temperature (4). Robertson et al., (5) who investigated the effects of

both continuous and intermittent low temperature regimes (-1, 5, 8, 11, 14 and 17°C) on the final number of leaves in winter wheat, reported that continuous vernalization at 5°C was the most effective in reducing the number, followed by 8, 11 and 14°C. A reduction in the final number of leaves at anthesis in Yeoman winter wheat was determined by Cooper (6) for vernalization periods up to 12 weeks at 0-5°C. A similar reduction in the number of leaves was also reported by Brooking (7) who vernalized Cappella Desprez winter wheat for 8 weeks at 2°C before floral transition. The reduction in the number of leaves is generally attributed to the increase in the vernalization period which shortens the duration of the phase of leaf primordia production (8). However, this effect can be observed only until the saturation period of the vernalization response; after this period no further reduction occurs.

Vernalization accelerated ear emergence principally by causing earlier formation of double-ridges that resulted in fewer leaves and tillers (9). In vernalized cereal seedlings, the period from double ridges to ear emergence is affected by high temperature and photoperiodic regimes (9, 10, 11). Rowson and Zajac (12) have shown that the number of leaves decreased significantly with an increase in the vernalization period (0, 2 or 4 weeks) and photoperiods (9, 11, 13 or 15 hours) in Late Hartog spring wheat cultivars after a vernalization process at 4-5°C.

The timing of the change in the apex, from producing leaf primordia to floral primordia, depends on genetically determined responses to the photoperiod and to vernalization (13). In some spring wheat cultivars at heading, the number of leaves on the main shoot decreased as photoperiods were increased from a short to a long day (14). Similar results have been reported by Roberts et al., (10) for Arabi Abiad and Ager barley cultivars after vernalization at 2°C for 42 days; the number of leaves decreased and early ear emergence was observed in the long day experiment compared with the short day. Griffiths et al., (8) have found that in some Chinese wheat cultivars the number of leaves decreased in the long day experiment applied after 8 weeks of vernalization at 4°C compared with the short day experiment. Jones et al., (15) compared the growth behaviour of spring and winter wheat cultivars vernalized at 2.5°C for 12 weeks and then grown under long day conditions. Their results show that vernalization treatment increased the total aboveground dry weights in winter wheat cultivars but decreased it in spring wheat cultivars. The differences in dry matter production has been attributed to the differences in photosynthetic rates and leaf areas. The importance of leaf area on wheat growth and grain yield have long been recognized by Friend et al. (16). In their research, the leaf area was found to increase with higher light intensity and longer photoperiodic regimes. However, the influence of vernalization treatment on leaf area has not been investigated.

Light quality is accepted as one of the most important environmental factors which affect the onset of flowering in the plant (17). The effects of light quality on late flowering mutants of *Arabidopsis thaliana* (L.) Heynh. have been investigated by Martinez-Zapater and Somerville (18) and Bagnall (19). A reduction in the number of leaves of various mutants after vernalization has been observed with an incandescent supplement due to its high far-red component which positively affected the flowering time.

Although the individual effects of vernalization, day length and light quality or the interactive effects of vernalization-day length, vernalization-light quality on leaf number and flowering time have been investigated, the interactive effects of vernalization-day length-light intensity have not been investigated. Therefore, the aim of this study was to demonstrate the interactive effects of vernalization, day length and light intensity on the number of leaves and flag leaf area in some spring and winter wheat cultivars.

Materials and Methods

In this research, spring type Çukurova-86, and winter type Atay-85, Lancer, Haymana-79 and Bezostaya-1 bread wheat (*Triticum aestivum* L.) cultivars were used.

Four independent experiments were conducted in a controlled growth room at 25/20±1°C (day/night) and at 50-55% humidity with combinations of two different day lengths (14 and 18 hours. day^{-1}) and intensities (13500 and 33750 lux) and vernalization periods. In the experiments with different day lengths and light intensities, in the first 12 or 16 hours. day^{-1} of the main light regime 10000 or 25000 lux with a fluorescent/incandescent ratio of 100/35 (20) was applied. Then, an additional 3500 or 8750 lux incandescent illumination was applied for 2 hour.day^{-1} (Fig 1).

Wheat grains with a weight of 0.05±0.001 g (21) were selected and sterilized (22). After sterilization, the grains were germinated in a dark controlled cabin at 20±1°C until the germination phase-I (23), then were vernalized at 2±1°C and at 80% humidity in a cold, dark room. Vernalization treatment was applied for periods of

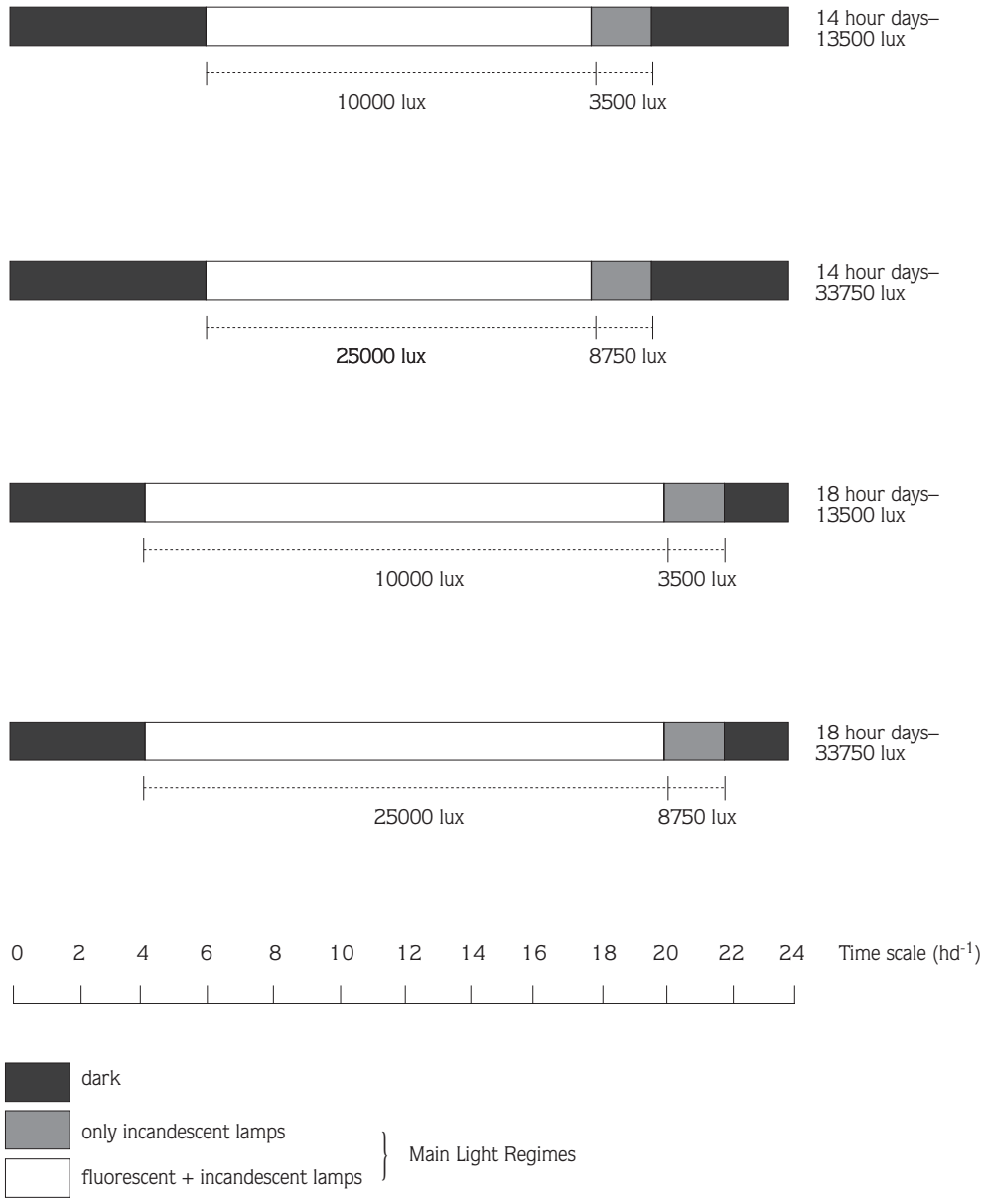

Figure 1. Diagram of the day length and light intensity regimes used for different experimental conditions in the growth room.

0 (control), 15, 30, 45 and 60 days in all the experiments and also 90 days only in the 14 hour day and 13500 lux experiment. The vernalized seedlings were transplanted into pots containing soil/sand/farmyard manure at a ratio of 4:3:2. The experiments were performed in a factorial design with three replicates in the growth room and the plants were sampled from each pot at sampling days i.e. 15-20; 30-35; 45-50; 65-70 and 80-85 days after transplantion. Then the expanded

leaf number of the main shoot $\sqrt{x.plant^{-1}}$ was noted. Flag leaf area ($cm^2.plant^{-1}$) of the headed plant was measured on the final sampling day with a planimeter. The length of the spike (from base to the top of the rachis) was measured with a millimetric ruler. Also, the number of days from transplanting to ear emergence was noted in all experiments.

The statistical analysis of the results was performed by using the SYSTAT package program and the differences between the means were compared with LSD (Least Significant Differences) at a 5% significance level.

Results and Discussion

a) The effects of vernalization, day length and light intensity on the number of leaves of the main shoot

Development of plants was completed in 80-85 days in all experiments except in 18 hour day -33750 lux experiment which was completed in 65-70 days. Therefore, the final sampling periods of all experiments were generally used in the discussion. Vernalization requirement for each cultivar used in this research was determined according to the vernalization period in which the longest spike was obtained (Table 1). The vernalization requirement of Lancer, Haymana-79 and Bezostaya-1 was determined to be 30, 45 and 30 days respectively. Therefore these cultivars are classified as winter type wheat cultivars. Although Atay-85 has been certified as winter type cultivar by The Turkish Seed Certification Center, no vernalization requirement was observed in Atay-85 or in spring type Çukurova-86 in the experiments.

Vernalization affects not only the final number of leaves and flag leaf emergence on the main shoot but also the timing of ear emergence (14). Vernalization causes early ear emergence with a lower number of leaves through faster transition from the vegetative to the reproductive stage. In this research the increasing vernalization periods also caused a significant decrease in

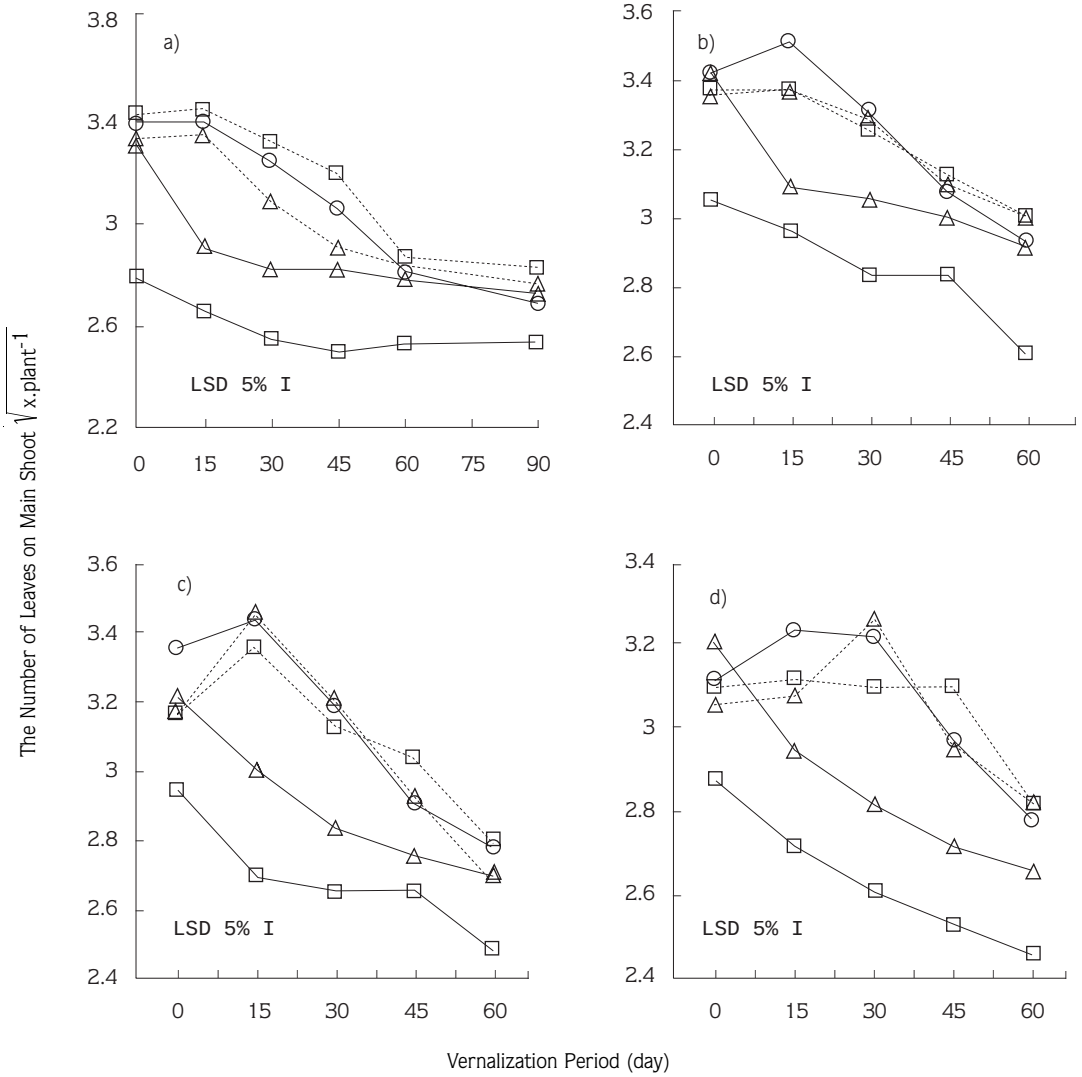

Figure 2. Effects of vernalization periods on the final number of leaves in some wheat cultivars under 14 hour days -13500 lux (a) and 33750 lux (b) and 18 hour days -13500 lux (c) and 33750 lux (d) (Çukurova-86, Atay-85, Lancer, Haymana-79, Bezostaya-1).

Table 1. Effect of different vernalization periods, day length and light intensity on the duration of ear emergence and the length of spike some wheat cultivars.

Cultivars	Vernalization Periods (day)	14 hour days – 13500 lux		14 hour days – 33750 lux		18 hour days – 13500 lux		18 hour days – 33750 lux	
		Days from Transplanting to Ear Emergence (day)	Length of Spike (mm/main shoot)	Days from Transplanting to Ear Emergence (day)	Length of Spike (mm/main shoot)	Days from Transplanting to Ear Emergence (day)	length of Spike (mm/main shoot)	Days from Transplanting to Ear Emergence (day)	Length of Spike (mm/main shoot)
Çukurova-86	0 (Control)	64	49.4±1.17	63	76.0±1.41	60	64.8±1.96	48	62.9±1.85
	15	55	47.8±0.55	55	67.8±1.38	49	56.2±1.30	41	54.3±1.03
	30	52	43.1±1.02	51	62.1±1.65	45	52.1±0.77	36	51.0±1.18
	45	48	41.0±1.48	46	58.4±0.93	45	46.8±0.98	33	50.3±1.17
	60	46	39.6±0.71	43	51.3±1.77	41	40.9±0.99	32	43.2±1.54
Atay-85	0 (Control)	94	53.3±2.79	81	90.6±2.12	68	71.3±2.26	60	74.5±1.77
	15	72	78.4±1.90	69	103.8±1.85	56	72.1±2.17	46	69.1±1.56
	30	66	69.4±1.23	60	83.8±1.22	51	67.9±1.38	41	60.3±1.59
	45	62	63.3±2.05	58	80.0±1.90	50	64.2±0.83	38	55.3±0.82
	60	61	56.9±1.08	56	76.4±1.75	47	59.0±1.70	37	48.6±1.31
Lancer	0 (Control)	–	–	–	–	–	–	–	–
	15	–	–	–	–	–	–	–	–
	30	75	59.1±1.84	85	66.2±0.76	73	61.7±1.72	69	59.0±2.57
	45	66	46.1±0.98	66	69.1±2.08	55	49.4±1.16	50	54.1±1.24
	60	54	44.0±1.30	55	56.9±1.90	45	44.1±0.48	38	45.8±1.31
Haymana-79	0 (Control)	–	–	–	–	–	–	–	–
	15	–	–	–	–	–	–	–	–
	30	78	60.6±2.38	82	71.9±2.68	70	60.2±1.22	57	53.8±0.81
	45	74	78.8±2.60	66	80.7±0.37	60	74.0±1.17	48	66.8±1.55
	60	59	55.6±2.22	56	77.4±2.76	46	54.1±0.86	39	55.6±0.80
Bezostaya-1	0 (Control)	–	–	–	–	–	–	–	–
	15	–	–	–	–	–	–	–	–
	30	80	64.9±1.74	84	80.0±2.87	70	65.0±1.35	59	62.4±0.97
	45	57	47.4±1.02	58	71.9±0.82	51	54.1±2.27	42	56.1±1.02
	60	55	41.8±1.90	50	59.8±0.62	47	45.9±1.16	37	49.0±0.69

* Mean Values of 9 plants

the number of leaves of Çukurova-86 and Atay-85 (Fig 2). The minimum final number of leaves of Çukurova-86 was determined to be 7 both with 14 hour days and 13500 lux in 45 day and 14 hours days and 33750 lux in 60 day vernalization periods. The above condition was attributed to faster transition from the vegetative to the reproductive stage in 13500 lux light intensity, probably through an effect similar to that of vernalization. This hastening effect disappeared with 33750 lux and hence, the same final number of leaves was obtained in the 60 day vernalization period. Similar results were also observed for Atay-85 but with the minimum final leaf number of 8.

In 18 hour day treatments, the minimum final number of leaves (6 for Çukurova-86 and 7 for Atay-85) was obtained in 60 days of vernalization with 13500 lux and 45 days with 33750 lux. These results showed that the hastening effect of 13500 lux, similar to that of vernalization, disappeared with 18 hour days. This revealed the fact that the hastening effect of 13500 lux could only be observed with 14 hour days.

On the other hand, the final number of leaves in both the light intensity conditions of 18 hour day treatments was lower than that of 14 hour day treatments (Fig. 2). It can be said that the vernalization and the day length influence the final number of leaves. After vernalization, 18 hour days reduce the transition period from transplanting to anthesis, resulting in early ear emergence due to rapid apical development (9). Hence Çukurova-86 and Atay-85 were developed with shorter spike lengths and lower number of leaves with 18 hour day treatments (Table 1 and Fig. 2). Similar results were obtained also by Hoogendoorn (24) and Pugsley (25) who found the minimum number of leaves to be six in spring type wheat.

Since winter wheat cultivars Lancer, Haymana-79 and Bezostaya-1 were at the vegetative stage and could not pass to the reproductive stage during the whole experimental time after 0 and 15 days of vernalization, ear emergence was not completed and the number of leaves increased until the last sampling day (Fig. 2). However, the number of leaves of these cultivars decreased due to the increase in the vernalization period after the required vernalization had been provided for each cultivar. Also in the winter cultivars the hastening effect of vernalization was observed after the required vernalization periods. Consequently, excessive vernalization caused early ear emergence and a low number of leaves due to its hastening effect on the switch from the vegetative to the reprodutive stage. However, the number of leaves decreased to a certain minimal number irrespective of vernalization period indicating that the vernalization response had been saturated. In this research, plants were headed with a minimum of 9 leaves in the 14 hour day -33750 lux experiment with 45 day vernalization periods, but plants exposed to 60 days of vernalization were headed with only 7 or 8 leaves. In the 14 hour day -33750 lux treatment, the plants were headed with a higher number of leaves, probably because the plant development was slow in 14 hour days and the required radiation was provided by 33750 lux. The number of leaves however decreased due to the increase in day length and light intensity and vernalization periods. Hence, the number of leaves decreased from 9-11 to 7-9 in Lancer, from 9-11 to 8-9 in Haymana-79 and from 10-12 to 7-8 in Bezostaya-1 wheat cultivars. Hoogendoorn (24) and Brooking (7), reached similar conclusions and reported that winter wheat grown under long day (≥16 hour.day^{-1}) conditions has at least seven or eight leaves.

In this research within the required vernalization periods, the number of leaves the cultivars for different day lengths and light intensities are plotted against five different sampling days (Fig. 3). The final number of leaves of Çukurova-86 and Atay-85 was obtained in control plants at 65-70 days and 80-85 days respectively (Fig. 3 a, b). The maximum number of leaves was obtained with 14 hour -33750 lux and the minimum with 14 hour -13500 lux treatments. Although the number of leaves in 18 hour days with both light intensities were found to be the same, leaf emergence was completed earlier with 33750 lux. Compared with the 14 hour day treatments, 18 hour days accelerated the development of the apex resulting in a lower number of leaves for Çukurova-86 and Atay-85. Although the minimum number of leaves was expected with 18 hour day treatments due to the accelerating effect of long days on apex development, in this research the minimum number of leaves was obtained with the 14 hour day -13500 lux treatment. This was probably caused by the hastening effect of 13500 lux in 14 hour days on the transition of the apex from the vegetative to the reproductive stage. The number of leaves which can emerge is determined at this stage (9). In the preceding discussion the effect of 13500 lux in 14 hour days was found to be identical with the effect of vernalization. As a result, spring type cultivars, Çukurova-86 and Atay-85, were substantially influenced by 13500 lux but only with 14 hour days.

Since the transition period from the vegetative to the reproductive stage is longer in 14 hour days and the hastening effect of 13500 lux disappeared with 33750 lux, the maximum number of leaves was obtained with the 14 hour day -33750 lux treatment. In addition to the maximum number of leaves, the longest spike was also obtained with the 14 hour day -33750 lux treatment (Table 1). After the transition from the vegetative to the reproductive stage was achieved, the 33750 lux provided the necessary radiation for spike development. In 18 hour day treatments, however, the periods, that is the double ridge and the reproductive stage, occurred in shorter time intervals than in 14 hour day treatments. Therefore, although the required radiation was also provided in 14 hour days, spike development was determined to be at an inadequate level.

In required vernalization treatments where the longest spike of Lancer and Bezostaya-1 (30 day vernalization period) was obtained, leaf emergence was completed in 14 hour day experiments in 80-85 days, and in 18 hour day experiments in 65-70 days (Fig 3c and 3e). Although the maximum and the minimum number of leaves were noted to be high with 14 hour day -33750 lux treatments and low with 14 hour day -13500 lux treatments respectively, the number of leaves with 18 hour day -13500 and 33750 lux treatments was almost the same in both cultivars. Early progression to the reprodutive stage in 14 hours day length -13500 lux light intensity compared with 33750 lux light intensity is probably the main reason for the lower number of leaves in 13500 lux light intensity.

In required vernalization treatments where the longest spike of Haymana-79 (45 day vernalization period) was obtained, leaf emergence was completed in 65-70 days, and almost the same number of leaves was recorded in all the experiments (Fig 3d). After the required vernalization period (45 days) had been provided for Haymana-79, it was observed that the number of leaves did not change in treatments of different day length and light intensities. Hence, it can be

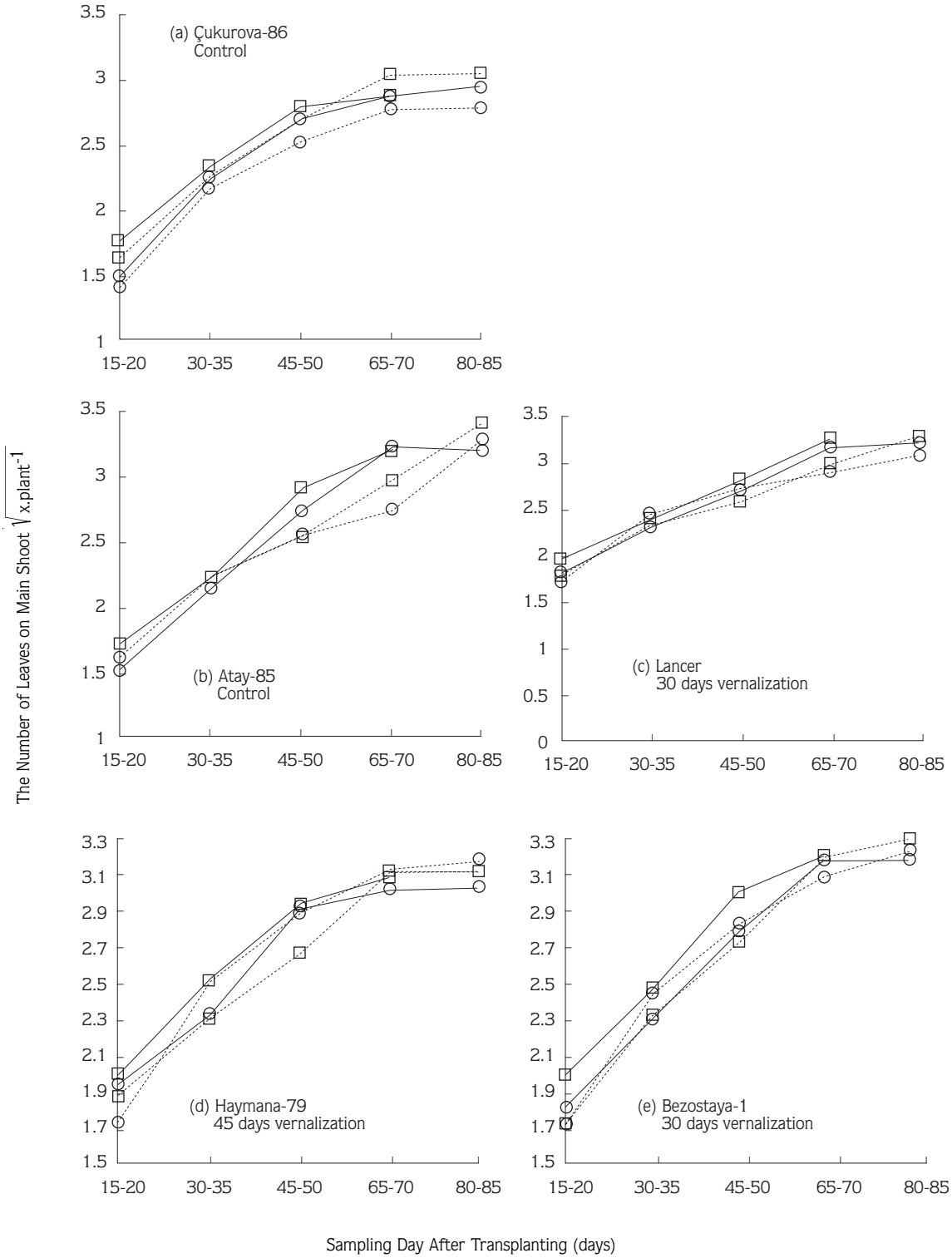

Figure 3. Variation of the number of leaves on the main shoot in vernalization periods in which the longest spike length was determined in some wheat cultivars under different day length and light intensity conditions (14 hour days-13500 lux --⊙--; 14 hour days-33750 lux ---□-- ; 18 hour days -13500 lux —⊙— ; 18 hour days -33750 lux —□—)

concluded that in this research the number of leaves was not sensitive to different day lengths and light intensities. Although almost the same number of leaves was determined in all experiments, leaf emergence was completed in a shorter time with 18 hour day treatments than with 14 hour day treatments, and also with 18 hour day -33750 lux treatments compared with 13500 lux high light intensity treatments.

b) The effect of vernalization, day length, and light intensity on flag leaf area on the main shoot

The flag leaf was taken as a reference leaf to investigate the effects of photoperiod, light intensity and vernalization on leaf area ($cm^2.plant^{-1}$), since it has the highest effect on the storage and transportation of photosynthetic products after anthesis (26).

Flag leaf emergence was observed in plants of Çukurova-86 and Atay-85 in the control and in all vernalization periods, and in Lancer, Haymana-79 and Bezostaya-1 in 30, 45 and 60 day vernalization periods. The flag leaf area was measured within 80-85 days of the sampling time in all the experiments except for 18 hour day -33750 lux (65-70 days), because the development of plants was completed in 65-70 sampling days (Table 2).

The flag leaf area of Çukurova-86 decreased due to the increase in vernalization periods in all experiments

Table 2. Effects of vernalization periods on flag leaf area ($cm^2.plant^{-1}$) in some wheat cultivars under different day length and light intensity conditions.

Cultivars	Vernalization Period (day)	14 hour days		18 hour days	
		13500 lux	33750 lux	13500 lux	33750 lux
Çukurova-86	0 (control)	8.92±0.49	9.24±0.75	8.63±0.43	6.56±0.23
	15	6.61±0.41	8.11±0.53	7.62±0.16	5.79±0.19
	30	4.89±0.34	7.59±0.40	6.24±0.15	5.68±0.31
	45	4.66±0.28	6.62±0.40	6.01±0.36	5.10±0.36
	60	4.39±0.18	5.02±0.31	5.68±0.32	4.81±0.50
	90	4.22±0.12	–	–	–
Atay-85	0 (control)	14.44±0.51	15.74±0.49	10.34±0.40	6.96±0.21
	15	13.78±0.95	17.63±1.25	8.64±0.36	6.81±0.70
	30	11.68±0.71	17.24±0.51	7.52±0.15	6.77±0.41
	45	9.50±0.46	15.92±0.82	7.92±0.26	5.91±0.28
	60	7.44±0.40	12.31±0.46	6.33±0.11	4.59±0.40
	90	6.83±0.22	–	–	–
Lancer	0 (control)	–	–	–	–
	15	–	–	–	–
	30	15.00±1.05	17.64±0.64	10.22±0.59	6.36±0.31
	45	9.22±0.55	12.64±1.21	6.07±0.40	5.61±0.35
	60	5.89±0.31	12.47±0.49	5.97±0.37	4.57±0.29
	90	5.78±0.28	–	–	–
Haymana-79	0 (control)	–	–	–	–
	15	–	–	–	–
	30	16.00±0.41	18.63±0.83	7.98±0.38	6.51±0.23
	45	10.57±0.21	12.24±0.71	9.78±0.62	5.99±0.23
	60	9.00±0.58	8.31±0.46	6.10±0.33	5.01±0.26
	90	8.89±0.35	–	–	–
Bezostaya-1	0 (control)	–	–	–	–
	15	–	–	–	–
	30	13.00±0.21	13.62±1.12	12.43±1.23	9.11±0.52
	45	9.06±0.68	12.42±0.69	7.53±0.45	7.00±0.31
	60	6.67±0.37	10.19±0.34	6.44±0.46	5.71±0.18
	90	6.44±0.18	–	–	–
LSD (%5)		*1.37	*1.80	*0.84	*1.09
		**2.23	**1.90	**1.37	**0.95

*LSD values of Çukurova-86 and Atay-85 in all vernalization periods.

**LSD values of the all cultivars in 30, 45 and 60 days of vernalization.

(Table 2). The decrease in flag leaf area was found to be significant with 13500 lux with both 14 and 18 hours day treatments from 0 to 30 day vernalization periods, while with 33750 lux the decrease in flag leaf area significant until the 45 day vernalization period. The flag leaf area of Atay-85, however, decreased due to the increase in vernalization period, starting from 15 day vernalization with the 14 hour day -33750 lux treatment and from the control period in all other treatments (Table 2). Variations in flag leaf area in vernalization periods, in which the longest spike length was obtained, were also investigated the results of which are illustrated in Table 3. The largest flag leaf area obtained in the control period 14 hour day -33750 lux treatment for Çukurova-86 was 9.24 cm^2, for Atay-85 15.74 cm^2, and the smallest flag leaf area obtained with the 18 hour day -33750 lux treatment for Çukurova-86 was 6.56 cm^2 and for Atay-85 6.96cm^2. Friend et al. (16) reported that the flag leaf area in wheat increased in short days compared with long days and in high light intensity compared with low light intensity. Similar results were obtained in this research, and the flag leaf area in Çukurova-86 and Atay-85 was higher in 14 hour days compared with 18 hour days and in the 14 hour day -33750 lux treatment compared with 13500 lux. The largest flag leaf area was obtained with 14 hour day -33750 lux conditions, since the rate of leaf emergence was slower with 14 hour days and the required radiation was provided by 33750 lux. On the other hand, a smaller flag leaf area was obtained with the 18 hour day -33750 lux treament, which was in fact due to rapid growth and development in the plants.

The flag leaf area of the winter type wheat cultivars of Lancer and Bezostaya-1 was significantly smaller due to the increase in the vernalization period starting at 30 day vernalization in all experiments (Table 2). Similar effects were observed in Haymana-79 with the 14 hour day -33750 lux treatment starting at 45 days and in the other experiments starting at 30 day vernalization. The largest flag leaf area with the 14 hour day -33750 lux treatment for Lancer was 17.64 cm^2, for Haymana-79 12.24 cm^2 and for Bezostaya-1 13.62 cm^2. The smallest flag leaf area with the 18 hour day -33750 lux treatment for Lancer was 6.36 cm^2, for Haymana-79 5.99 cm^2 and for Bezostaya-1 9.11 cm^2. Similar effects observed in the 14 hour day -33750 lux treatment were also to be seen in Haymana-79, Lancer and Bezostaya-1. These results were in agreement with Friend et al. (16) who reported that the flag leaf area in Marquis wheat was smaller due to rapid development in continuous illumination in the high light intensity treatment.

With all treatments flag area was generally observed to be smaller due to the increase in the vernalization period and this noted decrease in size was found to be bigger in long day than in short day treatments. According to Friend (27), leaf development is influenced by environmental conditions such as day length, light intensity, temperature and so on and growth can be controlled genetically. In comparison with the other experimental conditions, the maximum decrease in flag leaf area of all cultivars with the 18 hour day -33750 lux treatment, caused little change in the size of the flag leaf area due to the increase in the vernalization period. Genetical control of leaf size of plants was probably slowed down by the effects of experimental factors, that is vernalization, on flag leaf area which was at its minimum in terms of size with 18 hour days -33750 lux.

Table 3. Flag leaf area ($cm^2.plant^{-1}$) in vernalization periods in which the longest spike length was determined in some wheat cultivars under 14 hour days -13500 and 33750 lux, and 18 hour days -13500 lux for 80-85 days and 18 hour days -33750 lux for 65-70 days.

Cultivars	Varnalization period (day)	14 hour days 13500 lux	14 hour days 33750 lux	18 hour days 13500 lux	18 hour days 33750 lux
Çukurova-86	0	8.92±0.49	9.24±0.75	8.63±0.43	6.56±0.23
Atay-85	0	14.44±0.51	15.74±0.49	10.34±0.40	6.96±0.21
Lancer	30 days	15.00±1.05	17.64±0.64	10.22±0.59	6.36±0.31
Haymana-79	45 days	10.57±0.21	12.24±0.71	9.78±0.62	5.99±0.23
Bezostaya-1	30 days	13.00±0.21	13.62±1.12	12.43±1.23	9.11±0.52

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